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**CONCEPT OF INTERDISCIPLINARY APPROACH TO
RESEARCH OF HUMAN SEXUALITY**
MEZIOBOROVÝ PŘÍSTUP K VÝZKUMU LIDSKÉ SEXUALITY

Doctoral thesis

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V Praze dne

Jakub Binter

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Abstract

Human sexuality research can only enter the world of modern rigor if it no longer adheres to questionable and often outright fallacious data analysis and hypothesis constructing. It is insufficient to merely consider the acquisition of previously unused parameters as a modernization. Some of the paradigm shifts I present in this thesis will modernize human sexuality research.

Beyond a traditional comparison of stimuli, primarily pairwise, modern methods, such as neural networks, allow for the detection of interrelatedness that cannot be tested via *a priori* hypotheses. With the immersion of individuals into VR-type environments, stimuli presented by avatars, etc. can generate responses that will further insights into the working of the sexual mind. Individuals inadvertently reveal behaviors when they are involved in an entertainment setting. The overlap between VR for research and VR for entertainment is a further modernity that researchers can use.

Sadly, the tradition of using fallacious statistical methods, such as NHST for hypotheses rejection(s) and correlation analyses of categorical variables (because the mapping into computable integers is impossible) is still widespread. Introduction of more recent distributions (Dirichlet), rigorous applications of Bayesian statistics, dimension reduction techniques, and clustering algorithms will move the field forward.

The availability of modern devices (wearables) allows for fast, inexpensive and almost unlimited data collection of metrical variables. Use of online questionnaires allows for both anonymity and inclusion of samples beyond traditional WEIRD data sets. Online behavior tracking by the use of cookies introduces a third way of data acquisition which supplies heretofore unknown accuracy.

Human sexuality research benefits from modern approaches not only by the above improvements, but encompasses paradigm shifts because of the necessary abandonment of traditional hypotheses constructs. By merging methodologies adopted from other fields, the resulting multidisciplinary framework is a decisive feature of the modernization. Insights that can be gained with vast, multi-dimensional data sets necessitate the adoption of paradigms that become more comparable to those of modern natural science.

Abstrakt

Jedinou možností, jak se výzkum lidské sexuality stane rigorózním, v moderním slova smyslu, je odklon od metod, které jsou známy svou nespolehlivostí a testování na nich založených hypotéz. Pouhé rozšiřování zdrojů nových dat není řešením a nemělo by být považováno za modernizaci oboru. Změny paradigmat, z nichž některé budou diskutovány v této disertační práci, modernizují výzkum lidské sexuality.

Je třeba jiných metod, než je pouhé porovnávání stimulů – často párových. Skutečně moderní metody, jako jsou umělé neuronové sítě, nám dovolí odhalit vzájemnou provázanost zkoumaných vlastností, na rozdíl od vytváření hypotéz *a priori*. S tím, jak se populace stále více sžívá s prostředím virtuální reality (VR), s využitím stimulů tvořenými avatary a počítačem generovanou grafikou budeme zřejmě pozorovat další neočekávaná odhalení fungování lidské sexuality. Taková odhalení jsou nevyhnutelná, když jedinec jedná podle vlastní touhy se bavit. Právě prolnutí na zábavu a na výzkum soustředěné VR může být dalším impulzem pro výzkum sexuality.

Je s podivem, že je neustále udržována tradice užívání metod statistické analýzy, které jsou známy svou nespolehlivostí, jako je testování statistických hypotéz za účelem hypotézy zavrhnout a užívání korelační analýzy pro hledání vztahů mezi kategorickými proměnnými (protože jejich konverze do počitatelných čísel je nemožná). Využívání novějších distribucí (Dirichlet), rigorózní aplikace Bayesovské statistiky, technik redukce rozměrů a klastrovacích algoritmů je to, co výzkum lidské sexuality posune vpřed.

Dostupnost moderních zařízení (jako nositelné elektroniky se senzory) z nich dělá ideální rychlý, levný a snadný zdroj metrických dat. Užití online dotazníků dovoluje anonymitu a zařazení vzorků mimo takzvané WEIRD populace. Sledováním skutečného chování online pomocí například trackování, tzv. cookies, je pak třetím zdrojem dat, u kterého (na rozdíl od dotazníků) si můžeme být jisti jeho přesností.

Výzkum lidské sexuality může zapojením nových přístupů profitovat. A ne pouze těch, které byly zmíněny výše, ale také změnou paradigmatu a oproštěním se od tradičního testování hypotéz. Splýváním s různými dalšími, zejména technickými, metodologickými přístupy a dovozením vzniku multidisciplinárního přístupu je klíčovým faktorem modernizace oboru. Poznatky, které tak bude možné získat, budou v mnohém srovnatelné s těmi, které jsou typické pro přírodní vědy.

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1 Introduction: Is There a Human Sexuality Research Paradigm?

The beginning of the genus *Homo* was at least 2.3, but possibly 2.6 millions of years ago (Villmoare et al., 2015). The existence of psychological adaptations (as we understand them today) has an approximately 12-thousand-year history (Symons, 1992). Mating and production of offspring is an elementary activity of any mobile fauna. The systematic research of human sexual behavior is only 135 years old; it began with *Psychopathia sexualis* by Richard von Krafft-Ebing (1886).

Initially, and for a long time, the majority of sexuality researchers originated from Europe (among them Bloch and Hirschfeld). Much later, North America also produced leaders in this field (e.g., Kinsey, Masters and Johnson, Freund). Europe and North America, being heavily industrialized and economically at the forefront, had a very specific cultural environment. This shaped the paradigm of sexual research to a large degree, notably its orientation towards science (largely natural science), and towards a systematic approach based on data collection — both metrical and observational — leading to a large overlap with the medical and biological fields. Human sexuality research was oftentimes inspired by insights gained from animal research and derived the theories from comparative studies between humans and other mammals. This resulting large overlap with primarily animal-oriented studies led to the emergence of ethology and sociobiology (Harlow, Madlafousek, Wilson, Kolářský, Phaus).

Historically, this development did not mean that social sciences and therapeutic approaches would not get involved in the field. It was none other than Sigmund Freud who rippled the seemingly smooth waters of approach to a claimed understanding of human sexuality — irrespective of whether this ‘rocking the boat’ was good or bad. Freud certainly inspired many to pursue research topics (and it is claimed, still does) as we can see in relatively recent examples (Hartmann, 2009). Freud’s field of work also inspired developmental psychoanalytic Bowlby to further Harlow’s researches on attachment alongside with Ainsworth to research the emotional side of sexuality; the latter is recently gaining more and more attention.

These socio-biological, anthropological and psychological approaches have led to the development of a novel field of study: evolutionary psychology (Tooby, Cosmides). Some branches of sexuality research today adopted this evolutionary framework. However, there are still many researchers who do not connect the two fields and to this day only focus on testing hypothesis based on Freud’s psychoanalysis (Brody & Costa, 2008).

These developments have come to shape the current paradigm from a theoretical point of view. But the methodology of sexuality research should also be discussed, as it deals with two main sources of information acquisition about human sexuality. The most typical method of sex research would use questionnaires, suitably adopted from general psychological research. Typically, they are standardized questionnaires to allow for comparisons between samples drawn from varied populations. Currently, for example, there were 22 different standardized questionnaires used for studying sexual addiction (Karila, et al., 2014).

The invention of questionnaires is sometimes attributed to Galton (Fancher, 2009) who is also considered one of the founding fathers of psychometrics (Jensen, 1982; Goldstein, 2012). Spearman introduced factor analysis in 1904. To this very day it has remained one of the evaluation methods of questionnaire structure. One further analytical tool is Cronbach's alpha, also still in use despite mathematicians' publications showing its uselessness (Sijtsma, 2009). For those who remain oblivious to the underlying mathematics, all items belonging to one scale or subscale have to score higher than 0.7 (Taber, 2018) — ideally higher, but not too much higher. In this same vein, we can see that the interrelation between measures mapping similar topics is considered another valued outcome; in the context of the research presented in this text, it claims to have demonstrated such interrelation for sexual satisfaction measures (Mark et al., 2014).

There are potentially very many sources of error when the questionnaires are completed by participants. The designer of the questionnaire has to be aware of these when constructing it, especially if behavior aspects are to be targeted via the queries (Schwarz & Oyserman, 2001). The advantage of questionnaires is its ease of data collection; more recently, this has even become easier due to the existence of online tools for data collection.

A small part of sexuality research is experimental. Therein, one measures, on the one hand, physiological responses on the peripherals of the tested individuals (e.g., electroencephalography, galvanic skin response, heart rate variability, temperature, etc.), as well as, on the other hand, internal ones: the hormonal (typically testosterone) and other biological markers. Even rarer is the use of brain-scans, such as fMRI. Whenever diagnostic decisions have to be made, these measured metric responses dominate (Müller et al., 2014; Murphy, et al., 2015; Knott et al., 2016; Murphy & Fedoroff, 2019; Murphy et al., 2021).

For testing of physiological responses in the context of sexuality research, erotic and pornographic stimuli are often used, mainly visual (stills) or audiovisual (clips). These are primarily produced by the commercial pornography industry. The physiological responses have been generally better tested on males, whose physiological (genital) sexual response is highly concordant their preferences, while testing females is, to a large degree, less conclusive, because females seem to exhibit a discrepancy between physiological arousal and preference (Suschinsky et al., 2009). There are recent studies that show that vaginal lubrication is not a revealing indicator, but a specific type of lubrication is the decisive factor (Suschinsky et al., 2009). Sexual orientation is one of the predictors of reactivity, again predominantly in men (Chivers et al., 2007).

The current paradigm of sexuality research can be characterized as mainly acquiescing its foundations in psychological research, sharing the majority of the methodologies with it. The studies relying on physiology and biological markers are used as stepping stones when testing hypotheses, but are invariably accompanied by considerably large numbers of questionnaire evaluations. The tools used for measurements are improving (better MRI scanners, EEG devices with more electrodes, novel techniques of arousal measurement — including measurements from a remote field, such as a tear

drop strip). The main aim of the research within the current paradigm is to find relationships (expressed as correlations) or differences (derived via ANOVA and/or *t*-tests) between two groups, two conditions, etc. The paradigm therefore rests on a ritualized form of testing (Gigerenzer, 1998b). The herein proposed paradigm shift evolves from two developments. On the one hand, the incorporation of many more laboratory-based measurements (necessitating a shift from how hypotheses can emerge and be modified with subsequent research) and, on the other hand, a disposal of fallacious statistical approaches. Novel statistical approaches, most prominently those involving neural networks, can lead to inferences that need not rely on testing hypotheses, neither novel nor established. As I document in an extensive piece below, the discovery of more than two clusters of individuals for the same empirical data collection regimen implies that comparison approaches (characteristic of many current, ritualized hypotheses) become impossible. At the same time, developing hypotheses that predict the number of clusters is an artificial intelligence approach. Modern statistical methods that incorporate metric data generate what can be called an inference-based paradigm, not one which derives from traditional humanities-based (or humanities-derived) perceptions of humanness.

In this exposé, I specifically avoid discussions of belief-based and politically-oriented studies. Authors of gender studies and of feminist advocacy base their paradigms on constructivism-derived philosophical positions (granted, primarily political philosophy). Many claim these approaches constitute a paradigm shift of its own. Due to space limitations, I also exclude sexuality research concerning individuals with non-binary and fluid sexuality. There is just not enough space in this thesis to take these approaches into account. The proposed paradigm shifts I document and elaborate on herein are topics that relate to sexuality of the overwhelming majority of the population. Needless to say, these paradigm shifts could very well be extendable to other manifestations of human sexuality.

2 Stimuli Standardization for Human Sexuality Research

2.1 Prior: Unsystematic Stimuli Selection

Stimuli used in sex-research are oftentimes pornographic materials that were created as downloadable commercial products for consumers that were later also chosen by the researchers (Chivers et al., 2010; Prossinger et al., 2021). The prudence of such an approach is justified because the sex-industry market is overwhelmingly large and economically very viable. Some basic numbers: one third of all internet searches are related to pornography; every fourth respondent to studies has pornography stored in their mobile devices; one third of the internet content is pornographic (Smutny & Šulc, 2018).

In sex research, *auditory sexual stimuli* are rarely investigated — arguably because the major source of the arousal for consumers of pornographic materials is visual stimulation (Chivers et al., 2010). Thus, we rarely find published studies of auditory stimuli, specifically for cases of unusual sexual preferences, where creation of visual stimuli borders on ethics limiting such research (Miner et al., 1995; Hawk et al., 2007). Last year, when the impact on psycho-physiological arousal was published, a comparable impact of audio-visual and solely auditory stimulation was also found (Ramos et al., 2021).

Nonetheless, there is an important role of the auditory aspect of pornography in audio-visual production. The auditory component of arousal, namely the roars and screams during orgasms, remains an understudied topic with a large potential of finding interesting insights. In one of our studies, we have demonstrated that individuals who watch BDSM pornography are unable to distinguish between orgasmic-pleasure and pain-induced screams, but are well aware of their high intensity; perhaps it leads to a super-stimuli response, a mechanism responsible for a change of preferences and compulsive behavior (Boschetti et al., 2021).

There are also rare cases of *olfactory stimuli* being involved, rarely in direct sexual responsiveness, but rather on partner preference — males finding visual and olfactory cues equally important while for females the olfaction is the single most important information carrier, albeit in a mostly negative sense. (If the smell is perceived negatively, the rest will not matter.) This female reaction is probably caused by the major histocompatibility index (Herz & Cahill, 1997). Auditory stimulation was found to be not as important (Karthikeyan & Locke, 2015), even though it is known to be also linked to attraction (Saxton et al., 2009; Valentova et al., 2019). Future technologies may bring the possibility of affecting olfaction; currently, there are attempts but they have not yet yielded satisfactory results. Sexual stimuli in the form of *texts* are, of course, also available, and we tested those specifically on female participants — an approach which is beneficial since explicit visual triggers are avoided and imagination is given space (Krejčova et al., 2016). If, in the future, augmented reality can be combined with texts, they may create unique types of stimuli.

Visual (stills) and audio-visual (clips) stimuli are by far the most employed stimuli in human sexuality research. There exists a long history of discussing how visual stimuli should be created, and it is rarely well described as a problem of sex-research. It is known that each of the laboratories involved in such research only uses their proprietary materials and none of the stimuli are made available to others, justified (in their view, perhaps) by fear of criticisms.

It is known that, generally, women respond well (based on analyses of self-rated responses and on measures of physiological arousal) to the same materials that men find preferable (Mosher & MacIan, 1994). We should remain aware of a possibly large self-selecting mechanism when we expect female research participants to enter a sterile, hospital-like room, allow for devices to be connected to their bodies (one usually inserted into their vagina), because most females would abhor such a situation. Similar effects may be detected when using online studies (see below a discussion about sampling and self-selection bias). There is a growing market for so-called female pornography which highlights the sensual topics and interest in female arousals (Grana, 2002; Mosher & MacIan, 1994). Generally, women now consume pornographic materials much more often than in the past, and benefit from doing so in several ways; examples include sexual openness and their improved ability to define their sexual preferences and needs (Daskalopoulou & Zanette, 2020).

It should not be surprising that one of the key stimuli is the physical attractiveness of the potentially interesting other. It seems that during human evolution physical attractiveness provided a means to filter potential partners who are healthy and are able to successfully reproduce (Weeden & Sabini, 2005). However, concepts of physical attractiveness and sexual desire have often been conflated. An attractive individual may not be *de facto* sexually desirable or vice versa. Other effects also contribute; nonverbal behavior is very important, mainly during courtship, and is often responsible for triggering greater sexual desire.

The difference between physical attractiveness and sexual desire can be compared to the distinction between liking and wanting. Reward-based behavior comprises three dissociable components; responses to pleasurable stimuli (liking) are based on prior experience (learning) and are linked to the motivation to act (wanting; Berridge, 1996). This mechanism has been applied to the appraisal of sexual stimuli (Janssen et al., 2000); stimulus is affectively assessed before being conveyed to memory for potential sexual reward; it can then prime attentional resources towards relevant indicators, thus giving rise to subjective sexual arousal.

Moreover, the majority of research on partner preferences has focused on the details of single determinants. However, decisions pertaining to partner choice derive from multiple sources (Wells et al., 2013). Although female face and body attractiveness have been shown to correlate, and it has been proposed that information from the face and body together provide a more accurate estimate of phenotypic quality (Thornhill & Grammer, 1999), the face in isolation better predicted long-term mating preferences, while body perception was more important for evaluating short-term mating

events (Currie & Little, 2009; Confer et al., 2010). This is an important insight to sexual stimuli creation whenever intending to elicit briefly-lasting sexual response.

Body shape mainly informs about the actual health state of the person; facial appearance may carry information about long-term partnership features — including personality traits — since facial shape is a more stable physical feature when compared to body shape (Herman et al., 2009). In the study by Thornhill & Grammer (1999), the claim was that face and body of a female constitute a single ornament.

The results of a recent study of a Czech population (Hladký et al., 2017) showed that ratings of female physical attractiveness and sexual desirability are positively and strongly correlated. Face effects were greater than physical attractiveness ratings while body effects were greater than ratings of sexual desire. Hence it was inferred that sexual desire is more directly connected to the short-term relationship strategy, while physical attractiveness is connected to the long-term relationship strategy. It was argued that the variance in each model was attributable to the variance of the (numerical) differences between stimuli and individuals' specifics. However, the inclusion of rater sex did not improve either model; there were no apparent differences between the ratings by males and females. Based on these outcomes, as well as those of other previous studies (Bauser et al., 2011; McKone et al., 2013; Szatmári & Lábadi, 2015) one must conclude that the face and the body do not form a single ornament as had been suggested previously (Thornhill & Grammer, 1999). While perceiving, these two areas — the face and the body — are evaluated by different cognitive mechanisms and they differently impact the overall rating. Furthermore, the two ratings independently predict overall attractiveness.

The independence of physical attractiveness and sexual desirability is more evidenced when the movement (nonverbal behavior) is part of the shown context. In addition to context, which is indeed important in estimation of attractiveness and desire by others, it is always the nonverbal behavior of women which predicts the outcome of courtship (Beach, 1976; Perper, & Fox, 1980). Therefore, in physiological measurements of sexual arousal, movements as visual stimuli are more important than appearance (Binter et al., 2016; Říha et al., 2016).

In one study of a Czech population (Binter et al., 2018), we investigated the ratings by both female and male raters of women as to their sexual desirability, their physical attractiveness and their non-verbal behavior in four situations (clothed during an interview, naked during stills, naked during foreplay, and naked during penetrative sex). The outcome was unexpectedly different for male and female raters. During stills, foreplay and penetrative sex, ratings were homogeneously high for some women. The inhomogeneity that we observed for these was only in the 'clothed' situation; therein, males rated them highly, and females did not. We note that non-verbal behavior contributed negligibly.

The stimuli in real-world images can be messy. Improvements can be achieved by using computer-generated stimuli. These can be derived from scans of a real human to allow for a higher degree of

realism (Feng et al., 2017). Even though the process of generating the stimuli is yet to meet the engineer's dream — fast, of high quality, and inexpensive — several ways are being suggested to speed up the process (Achenbach et al., 2017).

Another option is to generate avatars (also for VR) that extract and emphasize (perhaps over-enhance) the important arousal-relevant stimuli, and techniques to efficiently produce them are being reviewed (Binter et al., 2016).

What is so special about VR? The answer is so-called immersion. Immersion is the degree to which the user is feeling the sensory fidelity. Stimuli perception is more immersive when VR is used (for example, when it is made available with a head-mounted display). It is not only immersion but also presence that is an important measure of subjective psychological response to presence in VR (Bowman & McMahan, 2007). It is important to highlight that it is not necessarily the aim of the VR to be photo-realistic.

That VR impacts the physiological responses of the individuals differently can be also objectively measured; concretely: galvanic skin response (under sympathetic control only and can be activated both in vivo and in VR environments) and heart-rate-variability, which is under both sympathetic and parasympathetic control, and solely activated in vivo (Wilhelm et al., 2005). These responses should allow for designing safety-fuses for VR environments that would help decrease the danger of psychological damage (Binter et al., 2020).

2.2 Future: Interrelatedness of Stimuli

The current investigation of stimuli, as characterized in the previous section, results in presentation of studies as to the relative strengths of the stimuli. These studies compare stimuli but do not, as we will demonstrate shortly when describing the usefulness of AI for stimuli analyses, consider interrelatedness of stimuli. Comparison of the relative effects of stimuli is not a study of interrelatedness of stimuli.

If stimuli (we are focusing on those pertaining to sexual desirability) are interrelated, then the concept of 'type' is useful (Štěrbová et al., 2019). The concept deals with real-world effects, such as in long-term partnerships, yet it is not unreasonable to extend this 'type' concept to 'types' of porn actors and actresses. The reactions by the sex industry to market preferences is, as always, a very reliable field study about stimuli pertaining to human sexuality. Types and type preferences are reflected in frequencies of sold porn videos and downloaded porn clips. The offerings are subdivided into categories such as hair color, race (primarily skin pigmentation), body type (skinny, obese, puerile, ...) and so on. The categories on offer are not, please note, solely restricted to the types of sexual activities (or combinations thereof) shown. The 'type' categories in the for-sale market are thus a very reliable — and non-controversial — indicator as to the existence human sexuality related stimuli.

Interestingly, such mechanisms were discovered prior to the advent of porn movies and porn clips: in so-called 'sex magazines', among which Playboy and Hustler are probably the best known. Their

varying the types of women displayed in the centerfold from issue to issue indicated variations in preferences (Regan, 2021).

Computer-generated stimuli allow for the variation and accommodation of all pertinent stimuli, be it hair, race, body type, age, presence or absence of pubic hair. Whenever age categories are taken into account, the presence or lack of pubic hair becomes very important — a first indication that stimuli are interrelated. Those programming pornography for the virtual reality market must, almost by definition, include interrelatedness of stimuli when producing computer-generated characters (Renaud et al., 2014). Saleable products are therefore not solely successful because of the effective 3D background, or the plot, but also the interrelatedness of stimuli reflecting consumer preferences. As a consequence, researching the interrelatedness of stimuli in the porn industry market is a promising endeavor.

Neural network methods are the most fitting purview for interrelatedness analysis. The paradigm shift from analyzing human responses to sexuality-pertinent stimuli to responses based on their interrelatedness is a goal I claim needs to be pursued. Neural networks can and do find interrelations (see details in Section 3.2) that humans cannot. The fear of a ‘black box’ scenario is, however, unwarranted. There exists a suite of statistical analyses methods that reveal the interrelatedness in an informative way — without requiring the investigator to numerically reproduce the weightings in some external manner (for most recent insights, see, Hernandez et al., 2022).

I present an example that illustrates how multidisciplinary approaches can produce a paradigm shift in human sexuality research in the case of visual stimuli. Consider the problem of whether the appearance of women posing naked in a photo studio, hoping to be cast as a participant in a porn video. It is clear that the director of the video cannot choose women that he/she finds sexually arousing, because then he/she is guessing how arousing the hired woman would be for prospective buyers of the video. One set of stimuli generate saliences — regions of the image where texture is pronouncedly different from the surrounding pixels. There exist three algorithms (called Itti algorithms; Itti & Koch, 2001) that can detect such regions; these are called saliences. Not only do these saliences vary from female to female, but they can be altered by the female with suitable interventions (such as shaving off pubic hair, having tattoos, wearing bejeweled piercings, and so on) and these regions vary in their effect of sexually arousing the onlooker. The crucial point is that the regions can vary among females that have the same sexually arousing effect on a subset of all potential consumers of the video.

In the context of human sexuality research, a rather radical departure from established project methodology is precipitated. Why? Because the Itti algorithms involve neural networks. Neural networks perform independently of the user in the sense that a user cannot control the weightings of the edges between the nodes and thus cannot control the output. A traditional human sexuality researcher may postulate the arousal effect of, say, tattoos; but the effect is not discoverable in this way, because the tattoos interplay with the other saliences of the naked woman’s image — and the interplay not only varies from woman to woman but also varies from viewer to viewer.

3 Statistical Method Advances for Human Sexuality Research

3.1 Prior: Fallacious Methods and Limitations of Current Methods

3.1.1 Fallacious NHST: Null Hypothesis Significance Testing

The Neyman-Pearson statistical approach to quantitative data analysis is based on *null hypothesis* (or *significance*) testing (NHST). NHST has been the most prevalent method of testing in the last 70 years in all fields of social sciences and is — sadly — still ubiquitous. The criticism and rejection of this ‘method’ appeared within a few years of its presentation (Nickerson, 2000). Sadly, the rejection of its rejection had political overtones (Fisher versus Neyman, who was a Polish Jew) and was based on not realizing that hypotheses purportedly being tested were conditional probabilities (specifically: probabilities of the data, given the hypotheses) and not probabilities of a hypotheses (which are Bayesian probabilities).

The null hypothesis itself has been defined in various ways (all of which are fallacious):

1. The residual hypothesis that cannot be rejected unless the test statistic used in the hypothesis testing problem lies in the critical region for a given significance level (Carver, 1978, p. 242).
2. ... in particular, especially in psychology, the hypothesis that certain observed data are a merely random occurrence. (Borowski & Borwein, 1991)
3. A particular hypothesis under test, as distinct from the alternative hypotheses, which are under consideration. (Kendall & Buckland, 1957)
4. ... the logical contradictory of the hypothesis that one seeks to test. If the null hypothesis can be proved false, its contradictory is thereby proved true. (English & English, 1958)
5. Symbolically, we shall use H_0 for whatever hypothesis we shall want to test and H_A for the alternative hypothesis. (Freund, 1962)
6. Except in cases of multistage or sequential tests, the acceptance of H_0 is equivalent to the rejection of H_A , and vice versa. (Carver, 1978)
7. The null hypothesis states that the experimental group and the control group are not different with respect to [a specified property of interest] and that any difference found between their means is due to sampling fluctuation. (Carver, 1978)

According to its designers, the purpose of presenting a null hypothesis is to test, based on level of significance, the presence or lack of support, typically between two samples drawn at random (e.g., in case of a t -test the difference between the means of the two samples). The confidence level (almost exclusively labeled α) is supposed to provide us with a criterion on which we base our rejection of the null hypotheses; the criterion is whether, when $p \leq \alpha$, then the result is statistically significant at level α .

Continuing with this saga of fallaciousness: The outcome is then twofold. Either $p \leq \alpha$ (then H_0 is to be rejected) or it is not (in which case there is insufficient evidence for the null hypothesis to be rejected) (Gill, 1999; Krueger, 2001). The following is a bizarre summary of the NHST paradigm (Carver, 1978):

There are two ways to be right: rejecting the null hypothesis when it is false (when the samples were drawn from different populations) and failing to reject it when it is true (when the samples were

drawn from the same population). There are also two ways to be wrong: rejecting the null hypothesis when it is true and failing to reject it when it is false. The first of these two ways to be wrong is usually referred to as a Type I error, and the second as a Type II error, after Neyman and Pearson (Neyman & Pearson 1933a).

By definition, a Type I error can be made only when the null hypothesis is true. The value of p that is obtained as the result of NHST is the probability of a Type I error on the assumption that the null hypothesis is true.

The unconditional probability of the occurrence of a Type I error is the product of and the probability that the null hypothesis is true. Failure to make this distinction between the probability of a Type I error conditional on the null being true and the unconditional probability of a Type I error has been the basis of some confusion, which I discuss further below. Similarly, by definition, a Type II error can be made only when the null hypothesis is false. The probability of occurrence of a Type II error—when the null hypothesis is false—is usually referred to as β (Greek letter beta). The unconditional probability of occurrence of a Type II error is the product of β and the probability that the null hypothesis is false, p is generally assumed to be larger than p but not known precisely.

Closely related to the concept of statistical significance is that of power (Chase & Tucker, 1976; Cohen, 1977; Rossi, 1990), which is defined as $(1 - \beta)$. Power is the probability of rejecting the null hypothesis conditional on its being false, that is, the probability of detecting an effect given that there is one, or the probability of accepting the alternative hypothesis conditional on its being true. It is possible to compute power to detect an effect of a hypothesized size, and this is what is typically done: One determines the probability that a specified sample size would yield significance at a specified alpha level given an effect of a hypothesized magnitude.

The danger of the adopting the fallacy is greater for certain fields than it is for others. One of the most affected one is, according to Gigerenzer (Gigerenzer, 1998a), psychology. Here it is important to highlight the fact that psychology (and the majority of current sexuality research relies heavily on the psychological approach to hypothesis creation and testing) has multiple items prone to the misuse of NHST. First, the test where $\alpha = .05$ implies a greater tolerance to failing to reject the null hypothesis when it is false (Rindskopf, 1997).

Gerd Gigerenzer (a German statistician at the Max Planck Institute of Human Development, and a highly vocal propagator of the fallacious use of NHST) extends the critique beyond its fallaciousness to its ritualized use:

“Null hypothesis testing provides researchers with no incentive to specify either their own research hypotheses or competing hypotheses. The ritual is to test one's unspecified hypothesis against “chance,” that is, against the null hypothesis that postulates “no difference between the means of two populations” or “zero correlation.” (Gigerenzer, 1998a, p. 200).

Cohen (1994) went even further and described the situation in following words:

“[The NHST] has not only failed to support and advance psychology as a science but also has seriously impeded it.” (p. 997).

Schmidt and Hunter (1997) went even further than Carver and stated that:

“Statistical significance testing retards the growth of scientific knowledge; it never makes a positive contribution.” (p. 37).

3.1.2 Questionnaire studies

Self-administered questionnaires and surveys are frequently used methods for collecting data concerning individuals' perceptions. A questionnaire consists of a set of fixed queries developed by a researcher concerning some specific topic or research theme. Open-ended questions, on the other hand, are used in qualitative research. Types of (administered) questionnaires can be further subdivided according to the format in which the responses are offered: multiple choice, Likert scale rating, and ranking queries. The quantitative data collected through questionnaires and surveys are analysed with regard to the types of answers collected (and, in the preliminary bean-counting phase, the frequencies of the responses to a given query). Through the use of online questionnaires and a careful sampling process, it is possible to collect vast data sets, possibly representative of the general population, or of a specific community underrepresented in the general population; the latter is important when investigating some specific sexual behaviour or paraphilia (Mustanski, 2001). Collecting data through internet-available questionnaires offers an economic advantage (as well as being less time-consuming). The quality of the data may be impacted, however; this happens when large surveys with many queries impact attention and motivation by overwhelming the participants (Fenton, 2001). The lack of control over when and how the questionnaire is to be completed, together with the impossibility of the researcher supplying further explanations when needed (because he/she is not present during the questionnaire administration), highlight the importance of carefully selecting the words used and the instructions supplied.

There are three major problems relating to the current use of questionnaires. Typically, questionnaire standardization was achieved by computing and interpreting Cronbach's alpha. However, Cronbach's alpha never achieves what it was designed for (Sijtsma, 2009).

In the case of Likert scale type responses, statisticians pointed out more than 60 years ago one grave error of using Cronbach's alpha for ordinal variables; the following quote from Blalock's book *Social Statistics* (Blalock, 1960) well demonstrates the problem:

“It should be pointed out that numbers may be arbitrarily associated with each category, but this fact in no way justifies the use of the usual arithmetic operations on these numbers. The function of numbers in this case is exactly the same as that of names, i.e., the labeling of categories. It would obviously make absolutely no sense to add social security numbers or room numbers in a hotel. Although we would never be tempted to carry out such a ridiculous operation, there are other instances in social science research where the absurdity is by no means as obvious.” (p. 13).

By far the most standardized questionnaires supply ordinal responses (ordinal responses are also nominal responses). Typical examples are scaled (for example, degree of agreement on 5-point Likert-type scale, perceived degree of sexual attractiveness exhibited by supplied images, etc.) The table below shows a 5-point version of SOI-R (Penke & Asendorpf, 2008), in which the responses are coded in following manner:

Ordinal Categories Response In Sub- Scale

	Behavior	Attitude	Desire
A	Zero	Strongly disagree	Never
B	One	Disagree	Very seldom
C	Two to three	Neutral	About once a month
D	Four to seven	Agree	About once a day
E	Eight or more	Strongly agree	Nearly every day

Table A selection of 5-point responses to a SOI-R questionnaire

The further problem when using Cronbach's alpha is that the computed numerical value does not test internal consistency — even though it often advertised as doing so (Taber, 2018).

The inherent problem of questionnaire evaluation arises when proceeding to compute *indexes*. In the erroneous method, after each individual has provided his/her responses, an index is calculated by first mapping the responses into cardinal integers (this is what Blalock describes as ridiculous) and then adding these or computing an average.

For example, if the query offers a 7-point Likert scale, and a linear mapping into cardinal integers is used, then a computed index is contained in the discrete set of integers between 1 and 7, inclusive. If there are several queries — five, say —, each with a 7-point response scale, the traditional mapping will generate a set of cardinal integers with elements between 5 and 35. Implied in such a calculation is, furthermore, the (highly questionable) assumption of equal weighting of each query.

To be concrete: the score (or index) of 26, say, as the sum of the responses to seven questions (each response on a 7-point scale) can be achieved by scoring $2 + 3 + 4 + 5 + 4 + 4 + 4 = 26$ or $2 + 7 + 4 + 1 + 4 + 1 + 7 = 26$, and many, many more; in total, there are $\frac{1}{2} \times 7^2 \times 7! = 123480$ possible combinations that yield the sum 26. This multiplicity issue becomes even more evident when only one response is extreme (e.g., $1 + 1 + 1 + 1 + 1 + 1 + 7 = 11$ versus $1 + 7 + 1 + 1 + 1 + 1 + 1 = 11$). Even though the total score for both these cases is the same (11), it is not difficult to argue that the response sets $\{1,1,1,1,1,1,7\}$ and $\{1,7,1,1,1,1,1\}$ are very different.

It is also not uncommon for subscales to be used (branching options). This makes any kind of traditional data analysis impossible and inferences dubious.

3.2 Future: Bayesian Statistics and Neural Network Methodology

3.2.1 Bayes Theorem

Knowledge of Bayes Theorem makes the fallacy inherent in NHST manifest: Given a hypothesis $\mathcal{H}$ (do not call it the ‘null hypothesis’, because there is nothing special about it) and a data set D . Bayes Theorem relates two conditional probabilities (namely: $P(D|\mathcal{H})$... the probability of observing the data, given the hypothesis, and $P(\mathcal{H}|D)$... the probability of the hypothesis, given the data) with two probabilities ($P(D)$... the probability of observing the data and $P(\mathcal{H})$... the probability of the hypothesis being true). Bayes Theorem states that

$$P(\mathcal{H}|D) \times P(D) = P(D|\mathcal{H}) \times P(\mathcal{H}).$$

(The multiplication signs have been added in order to enhance readability).

The quantity $P(D|\mathcal{H})$ is the hypothesis *used* in NHST. It is *not* $P(\mathcal{H})$. Rewriting Bayes Theorem:

$$P(\mathcal{H}|D) = \frac{P(D|\mathcal{H})}{P(D)} \times P(\mathcal{H})$$

makes the fallacy in the NHST formalism manifest. The NHST fallacy assumes that the factor $\frac{P(D|\mathcal{H})}{P(D)}$ is 1 (and it isn’t; the mistake of setting this fraction equal to 1 is known as the Prosecutor’s Fallacy — so named because it is the basis of many erroneous verdicts occurring in court proceedings when Bayes Theorem is not or is incorrectly applied). I note that Bayes Theorem shows that $P(\mathcal{H})$ (the probability of a hypothesis being true/valid) *cannot be tested with an experiment*, as it does not contain any information that can be gathered from an experiment (because the data set does not appear in the mathematical expression).

I also want to point out that Bayes Theorem is a theorem in mathematics (as are, for example, the Pythagorean Theorem, Fermat’s Last Theorem, the Four-Color Theorem, or the Fundamental Theorem of Algebra). Bayes Theorem is valid in many branches of data analyses — even ‘outside’ Bayesian statistics.

Bayesian statistics relies on Bayes Theorem (as do all other paradigms in statistics), but Bayesian statistics deals with conditional probabilities when data has been collected/obtained. Its advantage (see below) over statistics using the Laplace paradigm is its usefulness even for small data sets (which cannot be dealt with within the confines of the Laplace paradigm).

3.2.2 Prosecutor's Fallacy

A celebrated and pernicious example of how the Prosecutor's Fallacy can lead to a miscarriage of justice is the case of the solicitor Sally Clark, whose two sons died shortly after their births (in 1996 and 1998, respectively) while they were sleeping in their crib. According to the defense, the boys died of SIDS (Sudden Infant Death Syndrome, popularly known as 'Cot Death'); according to the prosecution, on the other hand, Sally had murdered her two sons. The prosecution named the *pediatrician* Sir Roy Meadow as an expert (observe that he was not a statistician); he subsequently calculated the probability that the sons died of SIDS as $1 \text{ in } 72250000 = 8500^2$ (1 in 8500 was the estimated probability of SIDS of one child at the time of the trial). Despite the numerous other flaws in this calculation (constant probability for two subsequent events, independence of events, etc.), the main one we are concerned with here is the violation of Bayes Theorem. Sir Roy had calculated $P(D|\mathcal{H})$, the probability of observing two cot deaths, given the hypothesis that SIDS occurs 1 in 8500. He did not calculate the probability $P(\mathcal{H}|D)$, the probability of the hypothesis being valid, given the two observed cot deaths. Bayes Theorem requires him to calculate the denominator in Bayes Theorem, which would be obtained by integrating over all probabilities of all (competing) hypotheses. Based on the dramatically low probability presented by Sir Roy (and accepted by the judge and the jurors), Sally Clark was convicted of murder. The case was well covered by the press and professional statisticians were very upset. The President of the *Royal Society of Statisticians* wrote to the Lord Chancellor that there had been a miscarriage of justice; the reason being that Sir Roy was not a statistician and he was not the expert the prosecution claimed him to be — and that his calculations were incorrect, and that he violated Bayes Theorem in his presentation during the trial. After considerable delay(s), a retrial took place, in which Sally Clark was acquitted. Sadly, she was not acquitted because of the Prosecutor's Fallacy having been committed. Also sad: Sally Clark's death was brought on by the psychological problems incurred by her three-year-long imprisonment and subsequent alcohol poisoning due to heavy drinking.

Arguably, any researcher using NHST has blood on his/her hands.

3.2.3 Bayesian probability

As pointed out in Bayes Theorem, probability calculations in Bayesian statistics become technically quite involved.

Bayes Theorem, written in in a way so as to be convenient for statistical analysis is:

$$P(\mathcal{H}|D) = \frac{P(D|\mathcal{H})}{P(D)} P(\mathcal{H}).$$

We note that many hypotheses (actually: all hypotheses) must be used to calculate $P(\mathcal{H}|D)$; more specifically, this expression (the probability of a hypothesis, given the data) must be calculated for every competing hypothesis. The most difficult computation involves the denominator in Bayes Theorem: $P(D) = \int P(D|\mathcal{H})d\mathcal{H}$, in which the integral is over the domains of all hypotheses. (In one introductory Bayesian statistics text, the author (Lambert, 2018) uses the phrase "The devil is in the denominator.") As Bayesian statistics has become a method of choice for many challenging problems,

a vast literature exists on how to use Bayes Theorem as well as how to calculate this integral (the most often methods used are: Random Walk, Metropolis, Gibbs Sampling, and Hamiltonian Monte Carlo). This text does not intend to present a crash course in Bayesian statistics (such a course doesn't exist). So I adopt the following approach. I present an example of how Bayesian statistics is used in a straightforward problem, which — it turns out — is very useful for the psychology research I will be presenting.

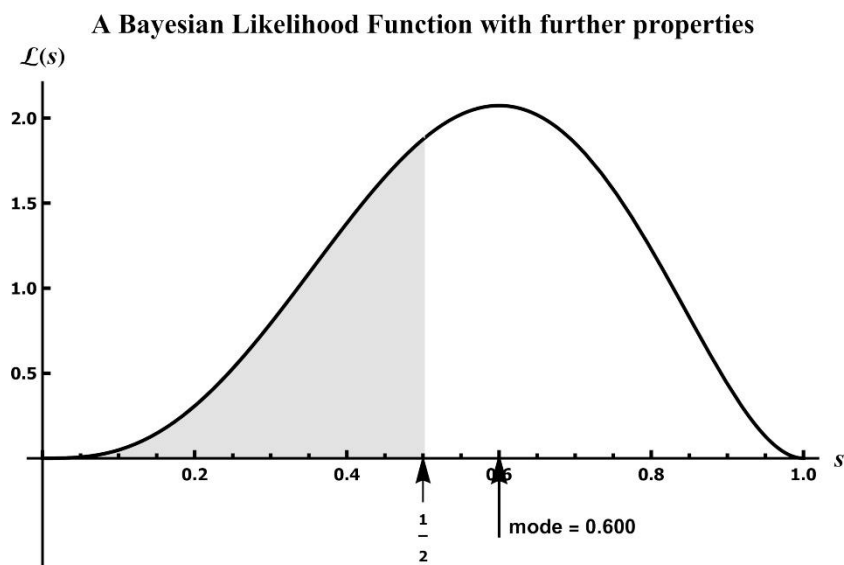
In Bayesian statistics, probability is a random variable. (In the Laplace paradigm, probability is a number — the limit of a ratio $P_{\text{Laplace}} \rightarrow \left(\frac{N_{\text{favorable}}}{N_{\text{All}}} \right)_{N_{\text{All}} \rightarrow \infty}$ i.e. as the sample size N_{All} approaches infinity.)

Consider a game of football (soccer in USA parlance). The challenge is: what is the probability that the winning team was successful due to chance? The teams are Team A and Team B. If Team A scores a goal, the probability is s ; if Team B scores a goal, the probability is $(1 - s)$. Note that, in both cases, $0 \leq s \leq 1$ and therefore $1 \geq (1 - s) \geq 0$.

If team A scores 3 goals, then the probability is s^3 . If Team B scores 2 goals, then its probability is $(1 - s)^2$. The likelihood function (of the probability s) is

$$\mathcal{L}(s) = \text{constant} \times s^3 \times (1 - s)^2$$

The constant normalizes the likelihood function: $1 = \int_0^1 \mathcal{L}(s) ds$. (In this case, $\text{constant} = 3600$)



The graph of the likelihood function of the example (Team A wins against Team B with a score 3:2). s is the probability of success of Team A; the ML (most likely) probability that Team A has won is 0.600. Note that, in Bayesian Statistics, any probability of success can have occurred. The shaded area under the likelihood curve is the probability that $s \leq \frac{1}{2}$ (numerically, $\int_0^{\frac{1}{2}} \mathcal{L}(s) ds = \frac{11}{32} \approx 0.34375 \dots$). This means that the probability that Team A was the winner of the match due to chance is (roughly) $\frac{1}{3}$ — not a very small probability. Fans of Team A will not be too happy with this Bayesian insight. However, when thinking about the match and the data, a total of 5 goals is not very decisive; so — arguably — Team A was quite fortunate. The graph also shows that statistically rigorous statements for small sample sizes can be made — when using Bayesian Statistics.

How does this relate to Bayes Theorem? If I rewrite Bayes Theorem in the following way:

$$P(\mathcal{H}|\mathcal{D}) = \text{evidence} \times P(\mathcal{H})$$

then it is obvious that the data has updated the probability of $\mathcal{H}$. For this reason, a useful rewrite of the formula is:

$$P_{\text{post}} = P(\mathcal{H}|\mathcal{D}) = \text{evidence} \times P_{\text{prior}}$$

where $P_{\text{prior}} = P(\mathcal{H})$ is called the prior (of the hypothesis; i.e. before collecting any data/evidence) and $P_{\text{post}} = P(\mathcal{H}|\mathcal{D})$ is the posterior (i.e., the conditional probability of $\mathcal{H}$ after data has been collected). Note the many mistakes that are made by users of NHST because their fallacious approach ignores these many mathematical truisms.

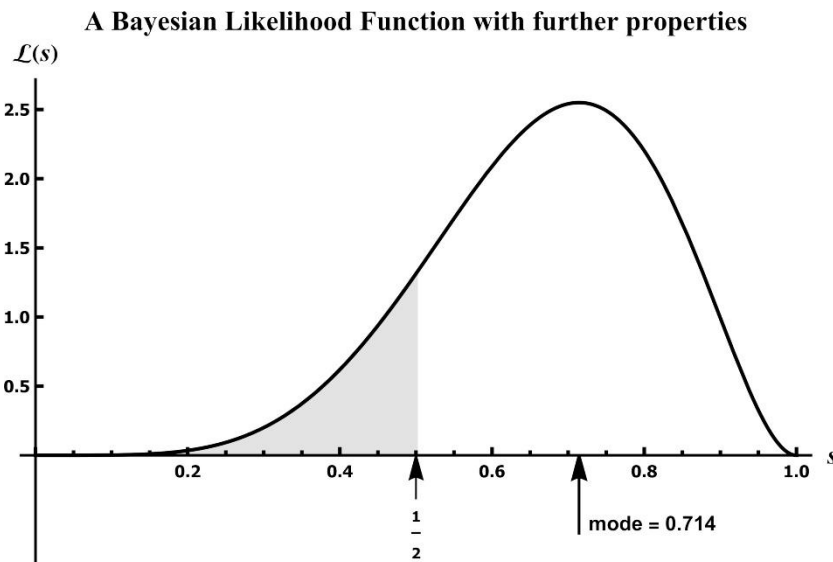
After additional data has been collected, the posterior probability becomes the prior probability for a further refinement of the likelihood function of the conditional probability of $\mathcal{H}$.

Consider, again, the football match. If Team A scores a further two goals, then:

$$P_{\text{post}} = P(\mathcal{H}|\mathcal{D}_{\text{score}=5:2}) = \text{constant} \times (1 - s)^2 \times s^5$$

as I have used in the graph below. A word of caution: the *constant* in the above equations changes whenever a further goal has been scored. That doesn't matter, because I can integrate to find the normalizing *constant* after having collected all the data.

The graph below shows the change in Bayesian probability (both the curve of the likelihood function and the value of the maximum likelihood).



I note that the ML probability has shifted to $s_{\text{ML}} \rightarrow 0.714 \dots$ (a respectable probability). More important for the analyst of the football match (and for the fans of Team A) is the change in probability that Team A was the winner due to chance. The shaded area is now 14.4%. Team A is the decisive winner, although the probability of this event being due to chance is still not significant at the 5% level. The 5% significance level is something of a religious creed (Gigerenzer, 1998b); In Bayesian statistics, one need not specify a significance level; one simply compares these probabilities

due to chance for different data sets. In the football match of this example, the probability of the win by Team A due to chance decreased from 34% to 14%, and the ML probability of the win by Team A shifted from 0.600 to 0.714. Fans of Team A can be jubilant about Team A's performance! Note that the shift in the probability of the evidence (the data set) can be dealt with at any sample size; one observes that the reliability of the observation not being due to chance increases with increasing sample size. The probability calculated in the Laplace paradigm is hopelessly below any reliability for such a small sample size (shift from $N = 5$ to $N = 7$) — and therefore not allowed.

There is another benefit, of using Bayesian statistics to calculate the probability due to chance.

Consider rolling an icosahedral die (a Platonic solid with twenty equilateral triangles as faces). The probability (in the Laplace paradigm) of observing *any* face is 5%. Therefore, in the religious zeal of adhering to the significance level of 5%, any throw of the die is significant — a clearly ridiculous interpretation of the (single!) observation.

A further limitation of the Laplace paradigm is apparent when the cardinality of the event space is huge. Consider a draw in Lotto. The chance of correctly drawing 6 correct numbers out of 45 (in Austria) or out of 49 (Germany) is

$$\frac{45!}{6!(45-6)!} = 8145060 \text{ (Austria) and } \frac{49!}{6!(49-6)!} = 13983816 \text{ (Germany)}$$

If one wants to determine whether the mechanism that produces the winning sample of 6 is fair via the Laplace paradigm, then one would need to repeatedly produce a drawing of a number. Even for a rough guess of checking the reliability (fairness) of the drawing mechanism, one would have to produce way beyond 81450600 (more than 80 million) repeats — a coverage of only a factor 10, please note. Not only is such an approach of checking for the fairness of the mechanism impossible, due to lack of time; but also the mechanism cannot mechanically stay reliable for so many repeats — the balls would become seriously deformed, eroded, etc. as would the transparent sphere holding all balls. In other words: the fairness is no longer guaranteed, and so the repeats are not the same in the sense of sampling from a statistical population. The very important conclusion for psychology and related fields is: it is impossible to ensure repeats from the same statistical population (many observations in psychology have a very small number of repeats).

3.2.4 Bayesian Likelihoods for more than a binary outcome

Consider a data collection scenario, in which more than a binary outcome is possible. A binary outcome is, for example, biological sex (s for chromosome spectrum XX, say and $(1 - s)$ for chromosome spectrum XY). If, as in one data collection scenario, there are 3 outcomes, such as “agree”, “neutral”, and “disagree”, then one can simply generalize the Bayesian statistics analysis. We have 3 probabilities: s_1 , s_2 , and $s_3 = (1 - (s_1 + s_2))$ and we observe n_1 , n_2 , and n_3 outcomes. The likelihood function is then

$$\mathcal{L} = \mathcal{L}(s_1, s_2, s_3) = \frac{(n_1 + n_2 + n_3 + 3)!}{(n_1 + 1)!(n_2 + 1)!(n_3 + 1)!} s_1^{n_1} s_2^{n_2} s_3^{n_3}$$

This likelihood function is a somewhat unusual way of writing the *pdf* (probability density function) of the Dirichlet distribution with three parameters and three random variables.

This limitation to 3 probabilities is, of course, only for presentation reasons. A graph of this likelihood surface will be presented below.

If a data analysis includes a query with 7 responses on a Likert scale, say, then the Bayesian likelihood function becomes

$$\mathcal{L} = \mathcal{L}(s_1, s_2, \dots, s_7) = \frac{(n_1 + n_2 + \dots + n_7 + 7)!}{(n_1 + 1)! (n_2 + 1)! \dots (n_7 + 1)!} s_1^{n_1} s_2^{n_2} \dots s_7^{n_7}$$

I note that the likelihood function (and the *pdf* of the Dirichlet distribution) has no limit to the number of responses that can be collected — as long as the number of options is finite!

Technical note (which will be important in the discussion of Neural Networks): The *pdf* of the Dirichlet distribution does not require the parameters to be (cardinal) integers — they can be non-integer real numbers. In general, for n responses,

$$pdf(Dir(\alpha_1, \dots, \alpha_n), s_1, \dots, s_n) = \frac{\Gamma(\alpha_1 + \dots + \alpha_n)}{\Gamma(\alpha_1) \times \dots \times \Gamma(\alpha_n)} s_1^{\alpha_1-1} \times \dots \times s_n^{\alpha_n-1}$$

In this formula, I have inserted the $\times$ symbol to improve readability.

The graph below shows an example of the likelihood function of a Dirichlet distribution for three variables. The details that produced this graph are in the figure caption.

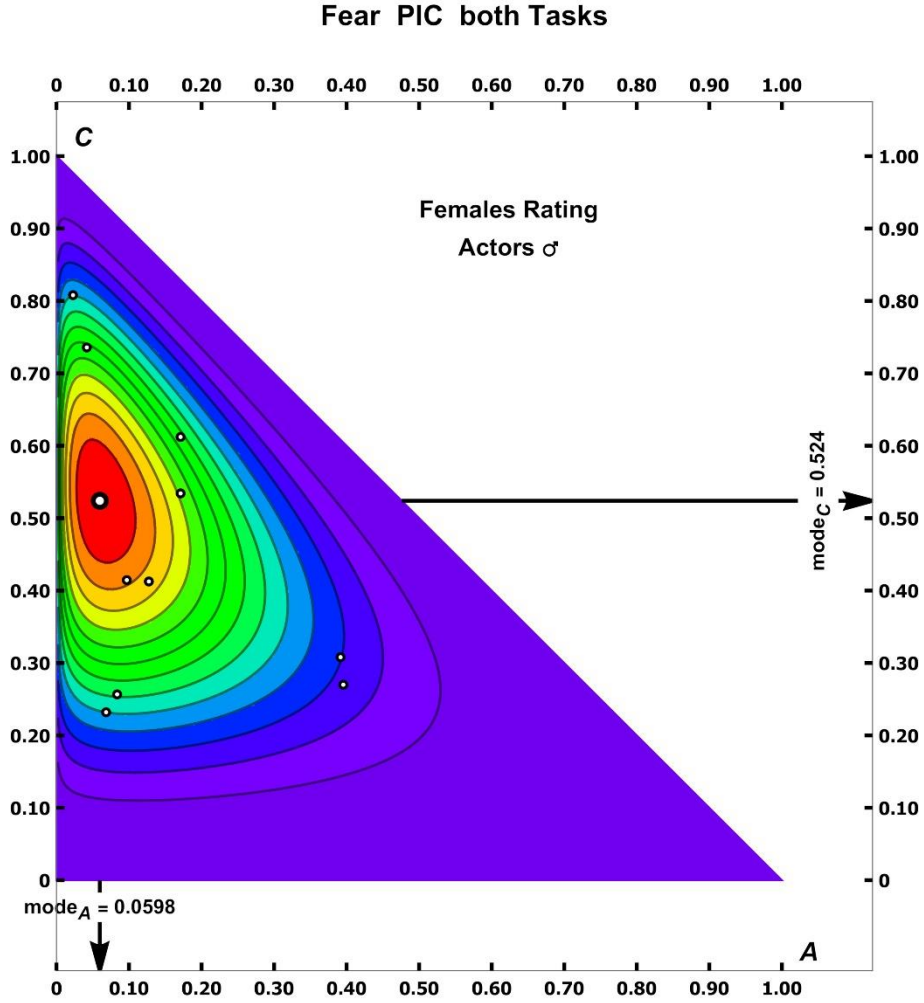


Figure A contour plot of the likelihood surface of a Dirichlet distribution. The Dirichlet distribution is based on three variables, hence its likelihood surface can be rendered in a 2D graph. The data set is the rating of five actors, each expressing fear visually (hence ‘PIC’) twice (hence ‘both’), by 532 females. s_A is the (Bayesian) probability that fear is being confused with the expression of pleasure, s_C is the (Bayesian) probability that fear is being expressed, and s_B is the Bayesian probability that neither fear nor pleasure is being expressed in the faces of the actors. Note that the sample size of female raters is large, but the number of facial expressions is small. The contour lines are in steps of $\frac{1}{14}$ of the maximum likelihood, purple is lowest, red is highest. The data points are small dots with a white center, the mode of the likelihood function is the large dot (with a white center). We observe, for this data set, that females are not likely to rate the actors as expressing pleasure, but the likelihood of the actors expressing fear is 52.4% — not a very convincing expression of fear in the perception of the 532 females. The likelihood surface is defined only over the rendered triangle, because, since $s_B = (1 - (s_A + s_C))$, it follows that, for $s_B = 0$, $0 = (1 - (s_A + s_C))$ or $s_C = 1 - s_A$, which is the equation of a straight line with slope -1 and intercepts $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$. Therefore, the likelihood function, defined by the three conditions $0 \leq s_A \leq 1$, $0 \leq s_B \leq 1$, and $0 \leq s_C \leq 1$, can only be rendered in the (colored) triangle.

3.2.5 Outliers, Noise, and the Curse of Dimensionality

Every time data is processed, there is some amount of information gained (signal) and there is a fraction of noise (Zhu & Wu, 2004; Aggarwal, 2013). Data collected from the real world not only have flaws, mistakes and corruptions (abnormalities, discordants, deviants, anomalies, mistakes, etc.); there is also a noise contribution that cannot be attributed to a descriptive source. The noise contribution is a

consequence of the 2nd Law of Thermodynamics — noise is due to the fact that the entropy of a system cannot be zero (Boltzmann, 1877). A typical ritual employed to deal with such noise by disciples of the NHST fallacy is to remove outliers and fill in missing data with the mean or the median of the collected data (Kwak & Kim, 2017).

In the fallacious NHST paradigm, outliers are often used to check the quality of the data and control for unexpected events (Barnett & Lewis, 1984). The main reason is that, in most cases when NHST is used, it is applied to a comparison of means. Means are very sensitive to outliers (Yang & Berdine, 2016). The underlying problem is that this approach assumes the data is drawn from a statistical population that is normally distributed. Numerous authors (see, for example, MacKay, 2015) have pointed out that real world data is hardly ever normally distributed.

The missing data issue is also an important part of data handling in case of NHST testing because missing data reduce the statistical power and complicate drawing a statistical inference (Kwak & Kim, 2017). I note that the formulae for statistical power rely on the assumption of a normally distributed statistical population from which the data has been drawn. Whenever the statistical population from which the data has been drawn is non-normally distributed, power calculations are void of validity. Bayesian methodology is immune to this issue, because, for one, there are techniques based on random number use, concretely MCMC (Markov Chain Monte Carlo), and secondly, there are other inference methods (Murphy, 2012) that rely on the distribution of the data available. MCMC is a method that allows for sufficiently reliable inferring of missing values because these have been obtained from posterior distributions.

3.2.6 Use of Feature Vectors as Codes

The mapping of test scores into vectors has for a long time been known as the way to do away with the fallacy (Murphy, 2012). Different test scores differ by which component of a response vector is nonzero (only one!); the response vectors are then linearly independent; this algorithm is called ‘one hot encoding’. Because these vectors with different nonzero components are orthogonal, no linear combinations of response vectors can be used to construct a further response vector (and therefore no indices can be computed). If there are 4 possible responses (for ease of explanation) to a query, then the mapping A, B, C, D into the linearly independent vectors (1 0 0 0), (0 1 0 0), (0 0 1 0), (0 0 0 1) does not allow linear dependency. One-hot encoding is therefore used extensively in the statistical analysis of categorical variables, especially when applying AI (artificial intelligence) methods, discussed further below.

The feature vectors obtained by a concatenation of the test score vectors have a (very) high dimension, so a conventional analysis using SEM or some other model will be invalid because of the ‘curse of dimensionality’. The ‘curse of dimensionality’ occurs because, as sample sizes increase and, as the number of variables increases, the variance increases. (Variances are additive, and they are squares of scores, so the total variance can never decrease.) In the real world of field work, such as questionnaire administration and response analysis, noise due to the larger variance buries the signal, unless methods I present below are employed to recover the signal that I, the human sexuality researcher, am interested in.

Components for each participant’s feature vectors are not linearly independent, and the feature vectors of all participants have (nonlinear) interdependencies among one another as well. It is these two interdependencies we are interested in.

3.2.7 Neural Networks

Neural networks derive their name from computer programmers and algorithm developers’ initial attempts to reproduce the cognitive behavior of brains. The data consists of vectors — one for each data point in the sample, and each component of these vectors is inputted into a node (historically called the neuron) of the input layer. Each input neuron/node outputs a signal to every node of the next layer. The strength of the output can (and usually does) vary from node to node of the next layer. Each node of the next layer then outputs its signal to every node of a further layer.

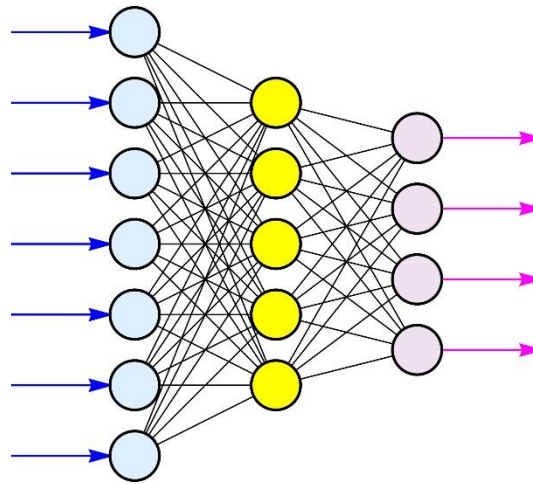


Figure: An example of a very simple neural network. This network consists of three layers, with the nodes colored in light blue, yellow and light purple. There are seven nodes of the first layer, five nodes in the hidden layer and four nodes in the output layer. The seven inputs are represented by seven blue arrows; the four outputs are represented by 4 magenta arrows. Each node of one layer is connected with every node of the next layer. The connections between the nodes (called edges) have weights. These weights multiply the output of a node with some number, which is then the input of the node in the next layer. There are $7 \times 5 = 35$ connections between the input layer and the hidden layer; there are $5 \times 4 = 20$ connections between the nodes of the hidden layer and the output layer. The neural network algorithm optimizes the weights of the edges.

Comments: a) The number of nodes in the input layer equals the number of components of the feature vector. b) The number of nodes in the second layer is chosen by the programmer designing the neural network. c) The number of layers in the neural network is chosen by the programmer designing the neural network. d) The number of nodes of the last layers (the output layer) is determined by the analysis desired by the user of the neural network. (For example, if the input feature vector has 102 components — in the real world of neural network applications nowhere near an unusually large number of components — and the strategy is to overcome the curse of dimensionality by using the neural network to dimension-reduce, then the output layer will have the number of nodes equal to the dimensions of the dimension-reduced feature vectors.) e) Neural networks can (and practically always do) output signals that are nonlinearly related to the input signal. There exist many options on how to do this; most often the output is then multiplied by sigmoid function. f) The neural network is trained by computationally adjusting the weights of the connections between nodes.

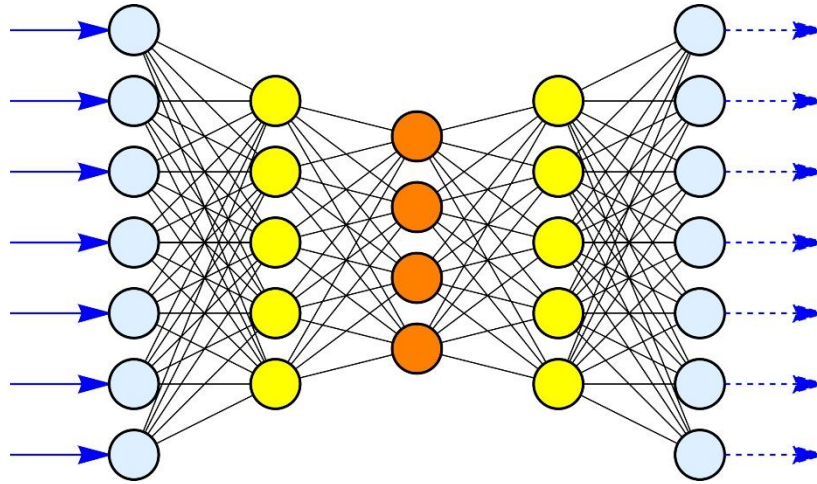


Figure: An graph of a very simple autoencoder. This neural network consists of five layers, colored in light blue, yellow, orange, yellow and light blue. There are seven nodes in the first layer and in the last layer, five nodes in two hidden layers and four nodes in the middle (also hidden) layer. The seven inputs are represented by seven blue arrows; the outputs by blue dashed arrows. The autoencoder attempts to generate an output that is as close (usually in a least-squares sense) as possible to the input. The encoding in the orange layer is then a mapping into a dimension-reduced space (here: from 7D to 4D).

For the example of analyzing the responses of the SOI and BIS/BAS questionnaire: We generate dimension-reduced feature vectors by using a multi-layered neural network (specifically: an auto-encoder with seven layers). For all combinations of SOI and BIS/BAS, we dimension reduce to 2D and to 3D. For all SOI-R and BIS/BAS combinations: (a) We search for clusters in the dimension-reduced feature vector space, using the unsupervised Spectral and DBSCAN algorithms. We thus have 4 cluster spectra for each combination. (b) We maximize size of clusters by choosing membership probabilities above 20% in the clusters of each combination. (c) We “backtrack” for positions of cluster membership to feature vector positions. (d) We construct heat maps of the chosen clusters.

3.2.8 Clustering Dimension-Reduced Feature Vectors

Dimension-reduced feature vectors are points in the dimension-reduced feature vector space. In psychology research and, in particular, in human sexuality research, these points are not uniformly distributed in this space.

The task is to then find clusters of these points based on some criterion (usually nearness). There are many clustering algorithms that have been developed over the years (an incomplete list includes: *K*-means, *K*-medoid, agglomerating, DBSCAN, Jarvis-Patrick, spanning tree, Gaussian mixture, spectral, mean shift, neighborhood contraction). For each cluster detected by the clustering algorithm, a heat map is constructed. The comparison of the heat maps then offers insights into the mechanisms that generate the clustering of the data set.

3.3 Exemplary Exposition: CGN

In the following example, we search for Gender Nonconformity of Italian Women who responded to 7 queries in a questionnaire. I emphasize that the analysis of the data set (the many responses) demonstrates how my research team generated one-hot encoded vectors, dimension-reduced the concatenated feature vectors and then used KDE (Kernel Density Estimation) using a algorithmically optimized Parzen window to find clusters.

One outcome (“discovery”) is the presence of 4 clusters. The heat maps show the degree of similarity in the responses of women in each of the clusters.

Statistical Methods Using Artificial Intelligence (AI) Reveal a Previously Unknown Four-Cluster Structure in Women's Childhood Gender Nonconformity

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Keywords: Childhood gender nonconformity (CGN), kernel density estimation (KDE), feature vector reduction, auto-encoder neural network, age of first masturbation, age of first intercourse

Abstract

There exists an ongoing debate concerning gender nonconforming (GNC) behavior in childhood. Most research has been focusing on samples of sexually non-typical individuals. We, on the other hand, analyze the responses by 357 young post-puberty females from northern Italy to the queries of the Childhood Gender Nonconformity questionnaire, irrespective of the females' typicality status. Furthermore, the sampled individuals are demographically homogeneous regarding religiosity, religious practice, degree of urbanization and education level. Their response scores are realizations of categorical variables, so the conventional linear mapping of ordinal integers into cardinal (computable) integers is fallacious and therefore cannot deliver statistically rigorous results. We overcome this fallacy of linear mapping by using a suite of Artificial Intelligence algorithms after constructing feature vectors by one-hot-encoding the response category scores of each participant: (a) dimension reduction with an unsupervised auto-encoder neural network, (b) kernel density estimation of the projection on a two-dimensional manifold, and (c) using likelihood contours to identify clusters. We find that there are four such clusters of CGN membership (three — 53.7% in total — with nonconformity) with various occurrence probabilities. We observe the differing inhomogeneity of response distributions within these three distinct clusters via heat map analysis. These distribution properties of the three clusters containing the gender-nonconforming females enhances understanding of specific types of challenges experienced by them. This understanding will undoubtedly enable better targeting-their needs in future supportive approaches. Our detailed description of how to apply these novel AI methods for statistical analysis should enable discoveries in many types of questionnaires.

1. Introduction

1.1 Gender Non-Conformity

With “gender non-conformity” (GN), the literature refers to a construct of (dis)agreement between the culturally defined set of gender roles, expectations, scripts, attitudes and behavioral displays exhibited by an individual and the cultural, social roles, behaviors, cognitions, and preferences that the individual of a certain sex is expected to display (van Caenegem et al., 2015).

During childhood, the gender non-conformity indicators are motor behaviors, physical appearance, interests, speech patterns, wardrobe choice, and play-friend preferences (Rieger et al., 2020).

Furthermore, gender non-conformity is one of the main features of gender dysphoria (American Psychiatric Association, 2013). The diagnostic criteria for gender dysphoria in children include some of the items queried by the Childhood Gender Non-Conformity Questionnaire (Rieger et al., 2008; its outcomes are analyzed in this paper), such as preference for typical boys’ clothes, their activities, their toys and boys as playmates. These items are indicative but not definitively predetermining the diagnosis of gender dysphoria, since without significant distress and impairment in other important areas of functioning, the differential diagnosis would be Non-Conformity to Gender Roles (American Psychiatric Association, 2013).

Some studies showed that, in both men and women, the non-conforming behaviors displayed during childhood are often related to non-heterosexual orientation during adulthood (Lippa, 2008; Mathy & Drescher, 2020) but there is no definitive, unique theory regarding the relationship between non-conforming behaviors in childhood and adult sexual orientation (Bailey et al., 1994). There are fractions of a population with heterosexual orientation in adulthood that were gender non-conforming as children. Consequently, the associations with other characteristics, such as socio-sexuality (Bártová et al., 2020), prevalence of mental disorders (Gordon et al., 2017), self-perception (Zentner & von Aufsess, 2020), and career choice (Broussard & Warner, 2019) change gender by adulthood.

Moreover, the GNC construct seems to have broad implications that differ in the two sexes, since the female non-conforming behavior is usually less restricted and less penalized by other members of society (Broussard and Warner, 2019; Skidmore et al., 2006). Additionally, males questioning their masculinity could have stronger implications for their status, social power and acceptance by peers (Carter et al., 2019). On the other hand, in women, conformity to the gender role includes conformity to a quasi-normative ideal of appearance and, consequently, has been shown to increase negative body imaging and body consciousness and also contribute to body objectification, sexual objectification, and eventually to eating disorders (Aparicio-García and Nieto, 2019; Sigel and Calogero, 2019).

There are cultural differences in perception of “otherness” regarding sexual typicality (Semenyna et al., 2017) but there are also varying perceptions of gender-nonconforming individuals’ perceptions of

other non-conforming individuals, mainly driven by western stereotypes of sex-typicality (van Beusekom et al., 2020).

1.2 Problems Concerning Conventional Statistical Methods

Reliably assessing psychological and cognitive features that measure the behavior indicators or attitudes related to these features has been a point of contention in the psychological and social sciences. Indeed, these features are often not directly observable and hence difficult to measure and quantify. One attempt to solve this problem was to develop numerous scale and rating systems, most often as evaluations of responses to psychological tests or questionnaires. Most of them, it is assumed, measure cognitive phenomena (as constructs) relying on qualitative assessments of postulated indicators of these.

Already 61 years ago, Blalock (Blalock, 1960) wrote an admonishing paragraph: “It should be pointed out that numbers may be arbitrarily associated with each category, but this fact in no way justifies the use of the usual arithmetic operations on these numbers. The function of numbers in this case is exactly the same as that of names, i.e., the labeling of categories. It would obviously make absolutely no sense to add social security numbers or room numbers in a hotel. Although we would never be tempted to carry out such a ridiculous operation, there are other instances in social science research where the absurdity is by no means as obvious.” Consequently, one shortcoming of mapping the categories (ordinal integers, such as hotel room numbers) into computable integers is the dependency of the outcome on the mathematical function used for the mapping. To wit: the CGN responses are categorical variables and summing cardinal number labels is therefore a fallacious diagnostic method for quantitative research dealing with the statistics of categorical random variables. We show how to remove this fallacy in this paper.

A further fallacy occurs when constructing indices. In the widely-used Likert scale (Joshi et al., 2015), each item is considered as a separate component of the putative true score of the construct. By this definition, therefore, the putative score must be a vector. If one (erroneously) calculates the trace (the sum of response scores) then a single numerical measure of the construct is all that is left. This sum — or some other linear combinations of responses — decreases the error of measurement, it is claimed. The argument goes: the errors average approximately to zero, as the errors are assumed to be randomly normally distributed; consequently — so the argument — after multiple observations they will become negligible. Alas, the traces are not normally distributed (Fig. 2); the trace calculation is devoid of mathematical and statistical cogency.

The CGN scale (as many others) consists of many responses that map various domains of non-conforming behaviors or preferences into cardinal integers (the response labels). After the individual has responded to all the queries on Likert-type scales (in our version 7-point scales were used) the conventionally used score is generated by summing the responses. This allows for a continuous scale

ranging from 7 to 49. This procedure is fallacious because it does not take in account which responses drive the score.

To be concrete: the score of 26, say, as the sum of the responses to seven questions (each response on a 7-point scale) can be achieved by scoring $2 + 3 + 4 + 5 + 4 + 4 + 4 = 26$ or $2 + 7 + 4 + 1 + 4 + 1 + 7 = 26$, and many, many more (there are 56854 different possibilities; see Appendix II). This multiplicity issue becomes even more evident when only one response is extreme (e.g., $1 + 1 + 1 + 1 + 1 + 1 + 7 = 11$ versus $1 + 7 + 1 + 1 + 1 + 1 + 1 = 11$). It is not difficult to recognize that the two response sets $\{1,1,1,1,1,1,7\}$ and $\{1,7,1,1,1,1,1\}$ are very different even though they both score the same sum (11) with the wide-spread linear mapping $\{A \rightarrow 1, B \rightarrow 2, C \rightarrow 3, D \rightarrow 4, E \rightarrow 5, F \rightarrow 6, G \rightarrow 7\}$. Conforming with the usual nomenclature, we call this total sum for the responses the index; this index assumes, of course the linearity of the mapping of Likert scale responses into cardinal (computable) integers.

1.3 Resolving the Fallacy

Recognizing this fallacy is a first step in moving forward to applying modern statistical analyses that do not fall victim to it. The rejection of the aforementioned linear mapping and its attendant fallacy is achieved by using vector mappings instead (details will be elaborated below).

Our scoring the questionnaire responses in the modern, rigorous way (being standard in AI publications) does not infer this fallacy. Vector mappings may even be counter-intuitive to many. Technological progress both in computational power and in the availability of novel algorithms have enabled rigorous statistical analysis of categorical variables using vector mappings. We present a suite of AI algorithms (these include vector mappings) that succeed in analyzing CGN differences between individuals and to define these in a proper manner. We discover CGN categories by using this modern statistical approach.

2. Materials

Descriptor	Age (years)	
Range	18–46	
Sample Mean	21.1	
IE	20.7	
Mode	19.7	23.9
HDI _{95%}	16.2–27.7	
ML Distribution (<i>pdf</i>)	$0.715 \times \mathcal{Ga}(208.6, 0.0945)$	
	$0.285 \times \mathcal{Cau}(23.96, 1.377)$	

Table 1 The descriptors, estimators, and the mixture distribution parameters of the ages of the 355 females that responded to the CGNC questionnaire. Only the (arithmetic) mean is a point estimator. We use ML to estimate the mixture distribution (a Gamma distribution $\mathcal{Ga}$ plus a Cauchy distribution

Cau) and derive the descriptors (mode, expectation value and $HDI_{95\%}$) from it. $HDI_{95\%}$ (Baguley, 2012; Kruschke, 2015) is the 95%-CI (confidence interval) about the mode; it corresponds to, but is very different from, the 95%-CI ($\pm 1.96\sigma$) for the normal distribution. The sample was collected in Italy in 2019 via Facebook online advertisements in websites related to dating and life as a couple. The criteria for inclusion were ages between 18 and 65 years. The questionnaire consisted of the seven standardized CGN questions, age duration of relationship (if it existed at time of questionnaire), and the categorical variables listed in Table 3. 357 questionnaires were completed.

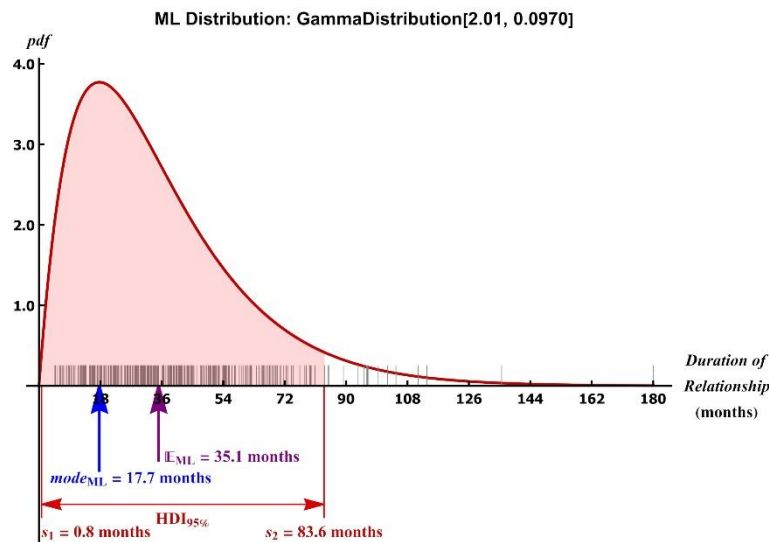


Figure 1 The probability density function (*pdf*) of the ML distribution of the duration of the relationships of the participants. The rug plot illustrates the raw data points. The $HDI_{95\%}$ interval is the confidence interval for asymmetric distributions at 95% confidence level, which indicates that essentially the full range of duration has been observed.

Age distribution predictors and point estimators are listed in Table 1 and the ML probability density function with parameters and the uncertainty interval are shown in Fig. 3. Most of the participants (85.1%) were in a long-term relationship, the statistical descriptors of relationship duration are listed in Table 2 and the probability density function is shown in Fig. 1. The majority of the participants self-identified as exclusively or predominantly heterosexual (87.5 %). The education level of the majority was equivalent to completion of secondary school (66.9 %) or higher (21.2 %) (Table 3). The distribution matrix of municipality size, education level, religious beliefs are listed in Table 3.

Descriptor	Relationship duration (months)
Range	2–180
Average	35.15
Mode	17.69
Expectation E	35.07
$HDI_{95\%}$	0.776–83.57

Table 2 The descriptors of the duration of the relationship of the participants. The ML distribution of the duration (scaled to the interval 0–1) is a Gamma distribution (Figure 1). The average is the point estimator of the data registrations by the participants; it is well approximated by the expectation $\mathbb{E}$ of the ML distribution.

The responders were anonymous. The questions were posed in Italian (see APPENDIX I). The translation of the questionnaire was checked by trained psychologists with appropriate language skills via comparison with the original after back-translation into English. The participants read an informed consent form prior to participation and were required to tick the option of agreement with terms and conditions. We collected the responses using Google Forms, an online data collection tool.

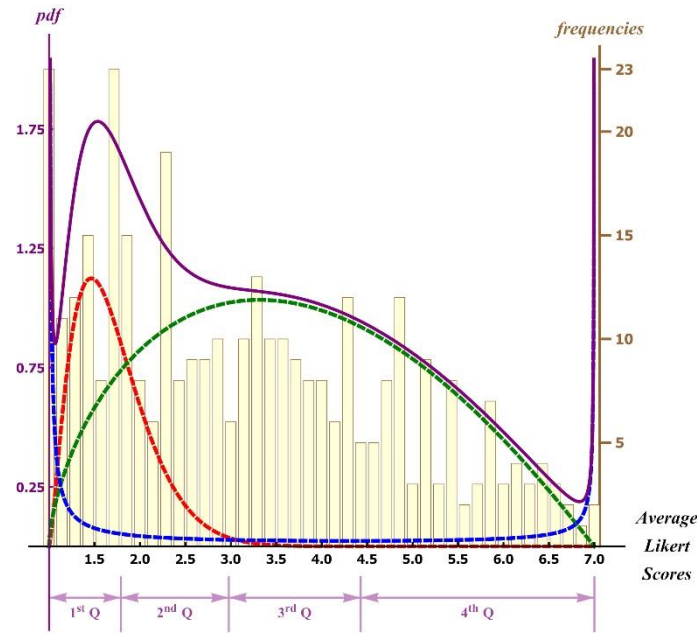


Figure 2 The histogram of average Likert score responses of the survey analyzed in this study. This is a histogram (yellow rectangles), not a bar chart, because the scores are the result of having — fallaciously — converted response categories to cardinal numbers. Cursory visual inspection shows that Likert scores are not normally distributed; assuming the linear mapping of categorical variables into computable (cardinal) integers, the ML distribution (purple) is the sum of three Beta distributions (red, blue, green), where, for the parameter estimation of the distribution(s), the Likert scale scores from 1–7 were re-scaled to the interval 0–1. For all distribution parameter estimations, a Jeffreys prior was used (resulting in poles at Likert scores 1 and 7). The intervals labeled (purple) below the abscissa are the quartile ranges. Vertical axes ticks on the right are frequencies; vertical axes ticks on the left are likelihood values.

3. Methods

3.1 Categories as Random Variables

The lack of statistical cogency is due to erroneously assuming that numerical scores of test item responses are cardinal numbers. They are not; rather they are ordinal and therefore no numerical operations using them exist.

It is easy to recognize this error described by Bablock (1960). Rather than mapping the categorical responses into computable integers, replace responses numbered “1”, “2”, “3”, with “A”, “B”, “C”.

Because the ‘numbers’ are actually labels (Blalock, 1960) of categorical variables (as are verses in a Gospel chapter, say, or surahs in the Quran), no numerical operations are possible (or permitted). As a consequence, it is fallacious to assume that they are sampled from a normally distributed statistical population. Categorical variables cannot be normally distributed.

3.2 One-hot Encoding the Responses

The mapping of test scores into vectors has long been known as the way to do away with the aforementioned fallacy (Murphy, 2012). If, for example, there are 4 possible responses to a query, then the mapping A, B, C, D into the vectors (1 0 0 0), (0 1 0 0), (0 0 1 0), (0 0 0 1) does not allow linear dependency, nor calculation of sums/indices. Different test scores differ by which component of a response vector is nonzero (only one!); the algorithm is called ‘one hot encoding’. Because these vectors with different nonzero components are orthogonal, no linear combinations of response vectors can be used to construct a further response vector. One-hot encoding is therefore used extensively in the statistical analysis of categorical variables, especially when applying AI (artificial intelligence). We also use it in this paper.

3.3 Response questionnaires and ANNs (artificial neural networks)

Questionnaires consist of sets of queries (‘indicator statements’), not questions. Presented response options assess the extent of agreement or disagreement with an indicator statement. Clearly, researchers interested in cognitive and/or emotional features of humans must construct these indicator statements; these query the extent of agreement with the proposition(s) derived from theory constructs. In this paper, we do not challenge the putative nature of propositions nor of theory constructs. We note that is unlikely for a single query to capture unobservable features sufficiently. The conventional way to overcome this difficulty is to use the responses to a set of queries and then register the spectrum (not: distribution!) of responses, individual by individual. These response sets will be elements of some unknown statistical population, which we specify later.

Because this empirical approach relies on the claim that there exist statements that relate in a to-be-determined extent with unobservable (latent?) variables, the approach of one-hot encoding is a great empowerment. The different response vectors that encode the categorical variable realizations can be concatenated into a feature vector, whose components are therefore no longer independent. Fallacious approaches, such as using a pre-determined (and statistically unjustified) distance metric between cardinal numbers generated by an unjustified mapping will not occur.

3.4 Auto-encoder and Dimension Reduction

The feature vectors of response sets to questionnaires include an important extra property, which is why it is not only useful but also necessary in modern research using AI, especially in unsupervised learning: while the possible one-hot encoded response vectors for each question are orthogonal (and thus independent), the feature vectors constructed via concatenation of many responses are *not*

orthogonal. These concatenated feature vectors include two interdependencies: one, among the components for each feature vector of each respondent and two, interdependencies among the feature vectors from different respondents. Suitable AI algorithms detect these interdependencies. We reiterate: one-hot encoding a) does not fallaciously assign cardinal numbers to categorical variables via a linear mapping, b) ensures that the response vectors for each single question/statement are mutually independent (orthonormal), c) introduces no a-priori metric, d) *allows* for the detection of interdependencies among the components of the feature vectors, and e) *allows* for the detection of interdependencies among the feature vectors from the different respondents.

Here, we follow standard AI methodology, namely, the construction and use of neural networks to detect these two interdependencies. These neural networks, called auto-encoders, look for nonlinear interdependencies between the feature vectors (Murphy, 2012; Mohri et al., 2018; Strang, 2019). We use auto-encoders to map these very high-dimensional feature vectors onto points in a lower-dimensional space. Each 49-dimensional feature vector of an individual's response set is mapped as a point in a two-dimensional plane (Fig. 5).

The components of the individual's response scores in the dimension-reduced vector space *derive* a metric. This metric, therefore, is not imposed by questionable mappings beforehand, but detected by the neural network. The distances between points in the dimension-reduced vector space *can be* the basis of statistical analysis; various clustering algorithms, or non-parametric probability density functions are further options, as we show below. In many other fields dealing with categorical variables (such as medical injury states), the suite of one-hot encoding, feature vector construction, auto-encoder neural network and distances in dimension-reduced vector spaces with a derived metric have become commonplace.

3.5 Kernel Density Estimation

We analyze the non-parametric distribution of the points in this plane using KDE (kernel density estimation; Murphy, 2012; Hastie et al., 2017). We can (and do) use the machinery of probability density functions, segmentations based on likelihood, and Monte Carlo methods to determine probabilities. We construct a non-parametric *pdf* (probability density function) of the random variable u , estimated by using a kernel K_h (a Parzen window density estimator; Murphy 2012)

$$pdf(u) = \frac{1}{n} \sum_{k=1}^n K_h(u - u_k)$$

over the data points u_k , using the training/test paradigm of AI learning to minimize the bandwidth h . The very many possible kernels are not restricted to u being one-dimensional (in our application, u is two-dimensional); there exist several algorithms to minimize h ; we use Silverman's rule-of-thumb. The resultant *pdf* has peaks separated by troughs (regions where the occurrence of dimension-reduced response-vector points are unlikely). We construct contours that characterize these regions of high

likelihood (which we call segments) and identify the individuals within these segments. We find commonalities of response statistics that characterize these segments. By implication, these segments therefore characterize different CGN female categories. As we communicate in the Results section, we find three segments (and thus three female CGN personalities/categories) using this suite of algorithms. A fourth segment contains those individuals whose responses characterize them as ‘highly conforming’ females (that is to say ‘typical’; their responses were all “A”s).

4. Results

4.1 Age

The ML parametric distribution of the participants’ ages is a mixture distribution (a Gamma distribution plus a Cauchy distribution) with two modes (Fig. 3). The overlap between the *pdfs* of these two distributions is so large that we may not assume that the sample consists of two populations. Statistical descriptors are in Table 1.

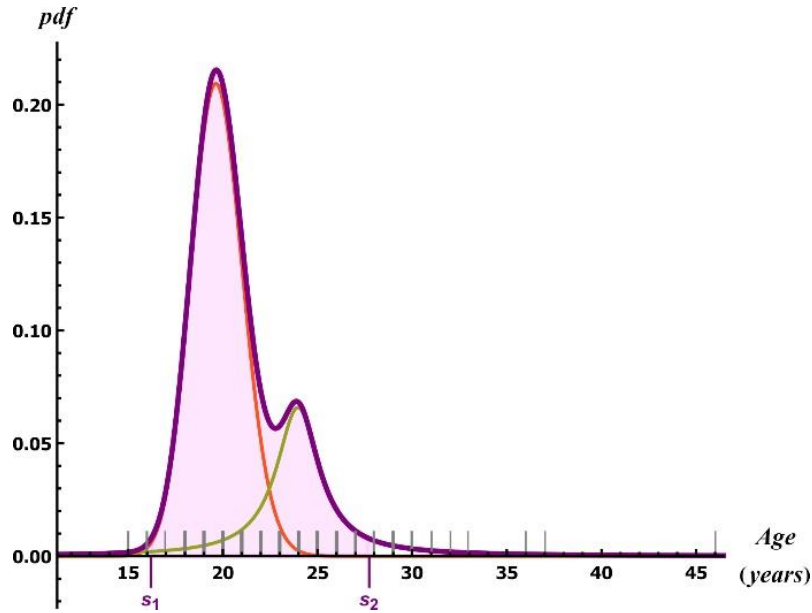


Figure 3 The *pdf* of the ML (maximum likelihood) distribution of the ages of the questionnaire respondents. The *pdf* is the superposition of two parametric distributions: A Gamma distribution (orange) and a Cauchy distribution (green). (Parameters are listed in Table 1). The gray vertical lines represent a rug plot of the 450 ages of the sample; the thickness indicates the multiplicity of the reported ages. We observe that the distribution is bimodal, but the overlap is so large that the confusion matrix cannot be considered close to diagonal.

4.2 Demographics

The KDE-derived likelihood surface for the dimension-reduced categorical variable registrations of the participants showed 72 ‘spikes’ and no clustering (Fig. 4), implying no associations. The lack of clustering shows that the participants are homogenous with regard to the four categorical variables listed in Table 3.

Category	Municipality Population (thousand)		Education Level		Belief		Religious Practice	
A	< 10	102	Primary	1	Atheist	117	Never	128
B	10–50	138	Practical	41	Christian	166	Rarely	103
C	50–100	41	High School or equivalent	233	Agnostic	36	Few times/year	69
D	> 100	68	Bachelor's	56	Buddhist	1	~Biweekly	18
E			Master's	2	Muslim	4	Weekly	26
F			Specialist beyond Master	13	Other	25	More than weekly	5
G			PhD or higher	3				

Table 3 The categorical variable encodings of the demographic parameters of the questionnaire respondents and the frequencies of occurrences.

4.3 Clustering

Based on the women's responses about their childhood, we discovered that the feature vectors cluster (Fig. 5). Remarkably, there exist *only* four childhood clusters; they have statistically identifiable characterizations. Three labels exist in the literature (“Tomboys”, Carr, 1998; “Ladylikes”, Ullman, 2014, and “Conformists”, Hornsey et al., 2015). We adopt these labels, but do not imply that the characterizations we succeeded in identifying completely match those described by the naming authors. We label the other identified cluster “Noncompetitors”. We have labeled each cluster based on the typical preference or avoidance of certain activities derived from the responses and made manifest in the associated heat maps (Fig. 6).

We used a low-likelihood contour outputted by the AI methods to identify the different clusters (Fig. 5). The volume enclosed by each cluster is the probability of cluster membership. The “Conformists” cluster (C_0) has the highest probability of membership (46.3%). The “Tomboys” cluster (C_1) the second highest (19.5%), while the other two, the “Noncompetitors” cluster (C_2) and the “Ladylikes” cluster (C_3), have almost the same membership probability (17.2% and 17.0%, respectively).

Only the “Conformist” cluster (C_0) shows ‘pure’ homogeneity (all responses are “A”s) and is shown as a disc in the contour plot (Fig. 5), because it is a ‘spike’; rendering it with contours would distort the scale of the *pdfs* of the other three clusters.

In the three clusters with extended contours, homogeneity within each cluster is not observed. Such a finding is characteristic of the power of unsupervised AI being applied to a data set of categorical variables. The *pdfs* have differentiable (smooth) contours, with many regions of locally high curvature, implying the absence of some possible linear scaling. We evidence therefore, that it is impossible to find one single numerical score that characterizes each CGN. The contours of each cluster (Fig. 5) lie

within a narrow band. Perhaps this leads to the intuition-driven speculation that there exists a linear score for CGN; our results show that this speculation about a one-dimensional manifold cannot be fulfilled (and, to boot, does not allow for the linearity of the metric of the natural numbers conventionally used).

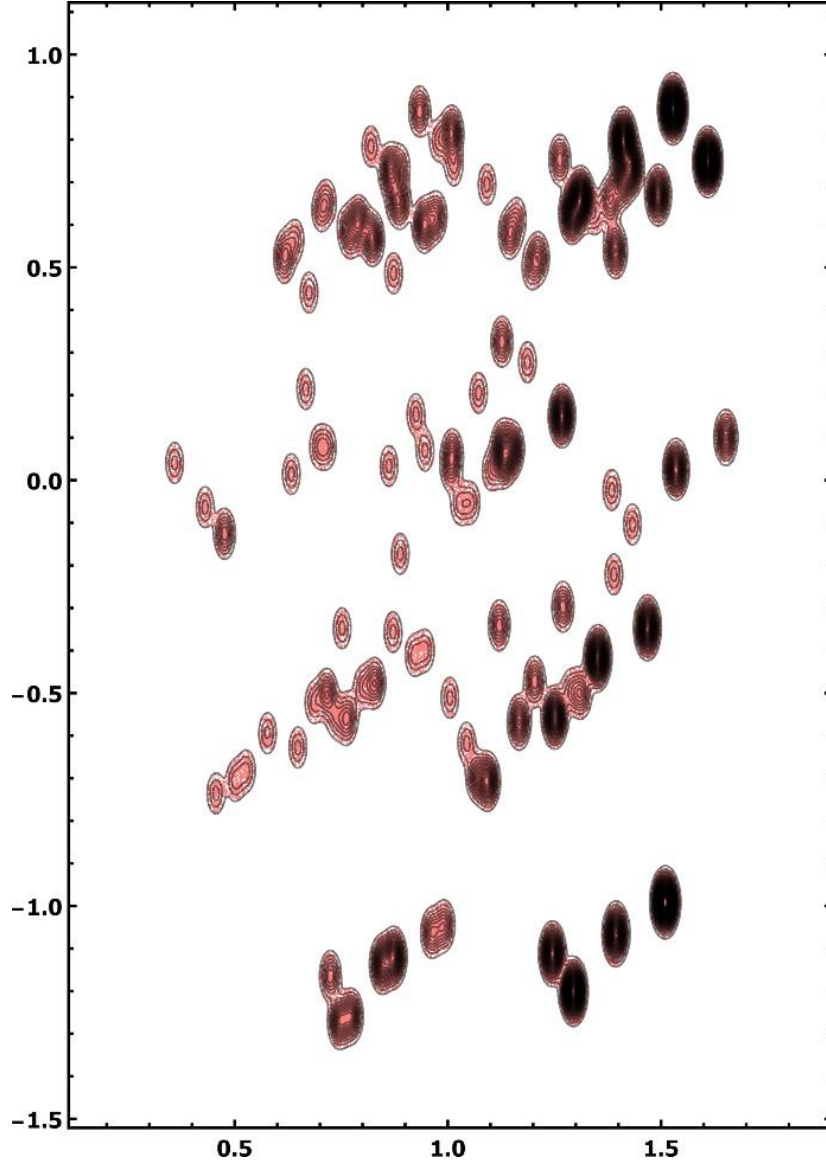


Figure 4 The contour plot of the dimension-reduced feature vectors of the responses to the categorical variables listed in Table 3. Contours (lines of constant likelihood) are in steps of $\frac{1}{50}\mathcal{L}_{\max}$ from cutoff = $\frac{1}{50}\mathcal{L}_{\max}$. Of the 75000 points randomly generated with the likelihood function, the 69318 (pink) points (92.4%) are the those with a likelihood above cutoff. We observe that there exists no clustering; very, very few of the ‘spikes’ have common contour lines. Thus, all 72 ‘spikes’ are de facto independent at 92.4% confidence level, implying a quasi-random association. We conclude, therefore, that the sample of respondents is homogenous with regard to the four categories listed in Fig. 3.

Member of the “Ladylikes” cluster (C_3), trend strongly towards gender conformity, as evidenced by the general absence of response “G” and the almost complete absence of response “F” (Fig. 6). Their

responses showed high homogeneity (remarkably few combinations of responses; 55 combinations of responses by the 71 respondents in this cluster).

Members of the “Noncompetitors” (C_2) cluster are more heterogeneous (as evidenced by the contours; Fig. 5) than those in the “Ladylikes” cluster (C_3), yet they tend, while marginally conforming, towards nonconformity, but not as strongly as members of the “Tomboys” cluster (C_1).

Figure 5

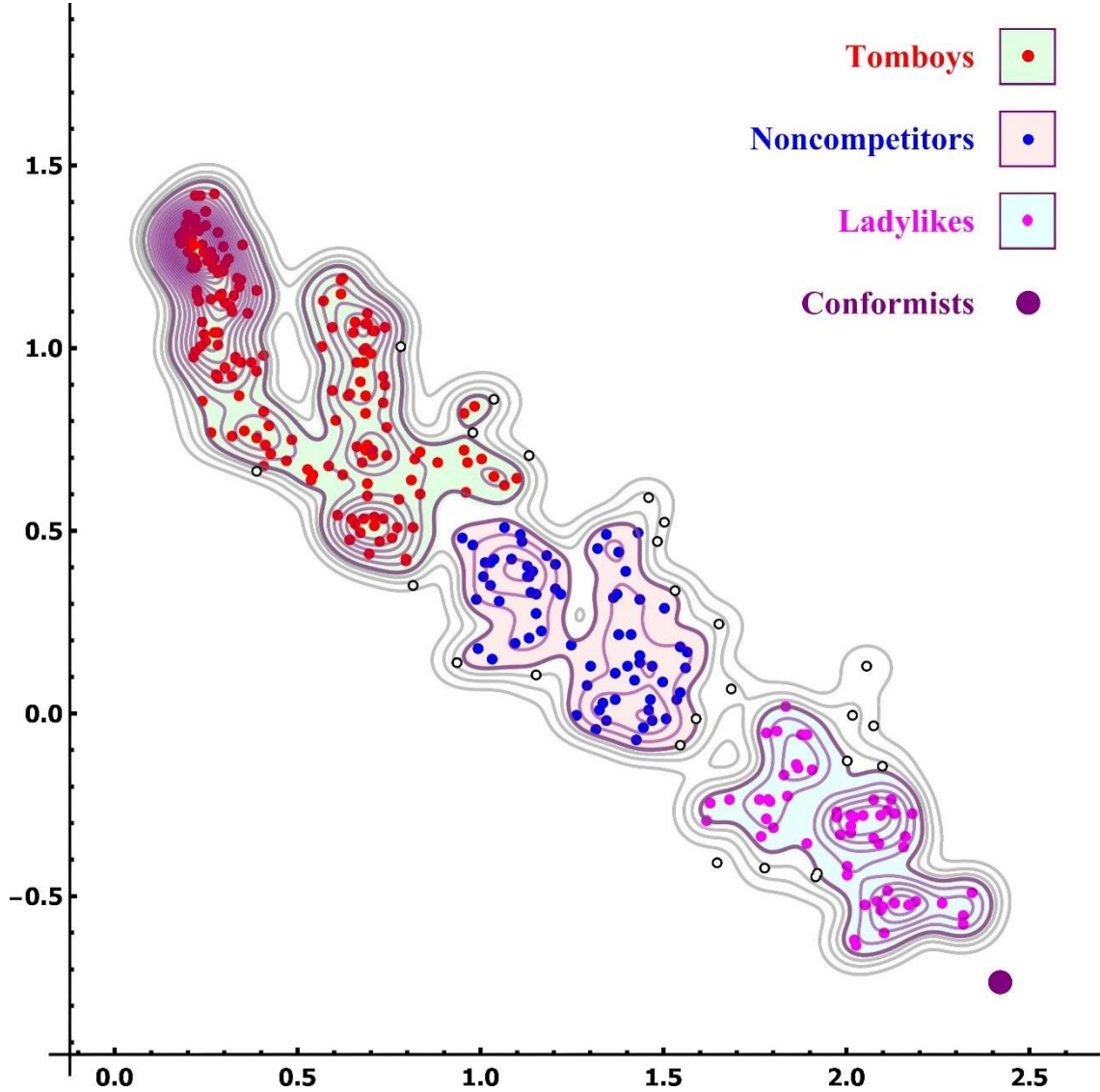


Figure 5 The result of using KDE (kernel density estimation) of the dimension-reduced feature vectors of the respondents. The contours (lines of equal likelihood) below threshold are thin gray and the contour of threshold likelihood is thick, dark gray. The *pdf* contours at threshold show the segmentation. Dimension-reduced feature vectors are points, which are color-coded according to cluster membership. Clusters are labeled and color-coded. The ‘spike’ (rendered as a deep purple disc) at coordinates (~ 2.4 , ~ -0.8) in the lower right identifies the “Conformists”. Points outside clusters are noise; they have extremely low likelihoods (and the respondents have no heat map with a pattern). The contours for segment “Tomboys” are very narrowly spaced and many, indicating that the likelihoods for this segment are particularly high; furthermore, the distribution of points is very inhomogeneous.

The “Tomboys” cluster (C_1) is the most heterogeneous (165 combination of responses by 167 participants) of all and their responses (with highest frequency of “G” and “F”) indicate that the participants belonging to this cluster are the least gender-conforming.

Responders within clusters C_1 , C_2 , and C_3 share a common degree of gender nonconformity but the type of attitudes (recorded by the questionnaire) that this degree expresses differ and occurs with different combinations of the response scores (Fig. 6). The situation presented by the outcomes of our analysis (and the discovery of four clusters) give reason to reject the possibility of distinguishing between the subjects using the CGN scores as numerical identifiers. We have noted that this (conventional) approach is doomed because respondents belonging to the same clusters (inferring the same degree of CGN) would be differentiated based on introducing a (unjustified, biased) metric (discussed in more detail in Appendix II).

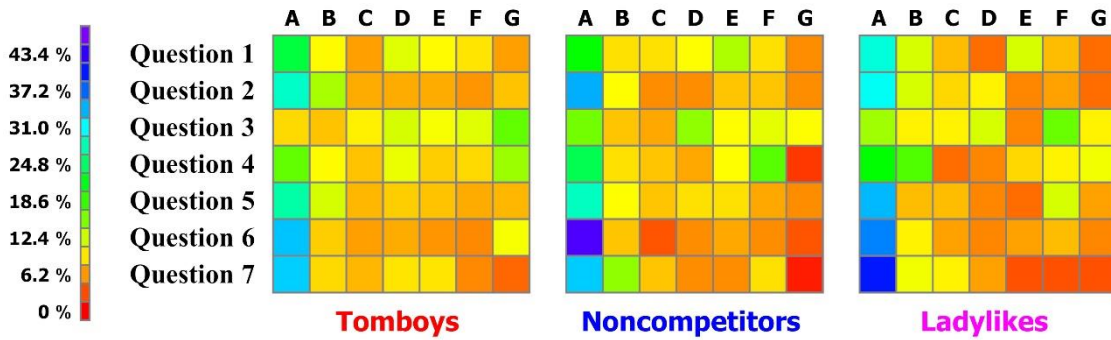


Figure 6 A ‘heat map’ showing the distribution percentages of response categories to the seven questions. Color codes are fractions of answers for each segment and each question separately. The segmentation achieved by using an auto-encoder resulted in the classifications labeled in Fig. 5. “Ladylikes” predominantly respond “A”, except for Questions 4 and 5; “Noncompetitors” predominantly respond “A” only to Question 6, but respond “A” to Questions 2 and 7, and rarely respond “G” to Questions 4 and 7. “Tomboys” have an almost uniform distribution of responses to all questions. Therefore, the heat maps show that: “Tomboys” have higher preference for dressing like a man and a preference for competition; “Noncompetitors” have an aversion to competition; and “Ladylike” a higher preference for typical female dressing and behaviors.

5. Discussion

Previous publications analyzed childhood gender nonconformity via scale entries along a number line (Bartová et al., 2015, 2020; Reiger et al. 2008, 2012; Skidmore et al., 2006); these registrations were considered to be the degree of conformity of each subject to roles and behaviors considered gender-typical. We use a modern, rigorous sequence of algorithms for analyzing the responses to the CGN scale. In this paper, we have demonstrated that, numerical registrations along a claimed number line cannot characterize the degree of conformity.

We are aware that our findings are novel, based as they are on a statistically rigorous analysis of categorical variables and because the response scores are not distributed on a univariate numerical scale. The novelty is not only ascribable to a proper analysis of categorical variables but also due to

advances in mathematical statistics and in artificial intelligence methods. Modern implementations (such as many-layered neural networks) have become tools for statistical methods (Murphy, 2012; Mohri et al., 2018).

Our novel, rigorous approach allowed us to reveal a discrete classification of respondents in our sample. Rephrased: we discover *categories* of CGN — four of them — evidenced as clusters in the contour plot. The spectrum of responses in each cluster indicates that CGN differs among the four clusters; CGN of respondents are homogeneous within each cluster.

The clustering we discovered is impossible to detect with (dubious) methods of statistical analysis in which a response total ‘score’ is used to calculate the gender conformity (e.g., Reiger et al. 2008, 2012; Skidmore et al., 2006). Clearly, the previous work should be critically appraised. For instance, we highly value the development of the queries in the questionnaire and the work related to diagnostic, therapeutic, and scientific use – and hope, on the other hand, that our work will become the statistical foundation for future studies. We are aware of the fact that only limited comparability with the previous work is possible due to shift in the analysis paradigm.

One consequence of the (local) inhomogeneity in each of the clusters “Noncompetitors”, “Ladylikes” and “Tomboys” (Fig. 5 and Fig. 6) leads us to reject the claim by Diamond (2005) of a discovered fluidity in sexual orientation of women. The analysis presented in that paper relies on mapping categorical responses onto cardinal (computable) integers. Our analysis shows that this fluidity is an artefact related to the analysis used in that paper. Our analysis shows the existence of clusters — relations with sexual orientation do not automatically follow. The inhomogeneity within the clusters would explain a fluidity phenomenon (which would be specific to cluster; in other words, members in each cluster may have a fluidity at variance with that in another cluster). The putative clusters of fluidity need to be tested in future topic-related work.

The issue of gender-typical behaviors and preferences is particularly manifest in females, because they are less socially penalized for certain behaviors such as wearing masculine attire (Broussard & Warner, 2019). Preferences must be, we find, heterogeneously distributed within the clusters (Fig. 6). Such heterogeneity is not (indeed, cannot be) discoverable when conventional, fallacious scaling is employed, whereas the auto-encoder method discovers it via unsupervised AI.

The presence of homogenous behavioral displays is easier to recognize, it is claimed, as a category with high inter-categorical difference (“cognitive economy”; Roach & Lloyd, 1978; Das-Smaal, 1990; Oakes, 1996). The construct of gender conformity as a distinction between male and female behaviors is manifest in females, we discover (see ‘spike’ in Fig. 5). Note that transitions from one cluster to the neighboring one need not be along an axis common to all clusters. Membership in clusters is defined via the spectrum (not: distribution) of CGN questionnaire queries; nearest-neighbor transition along some (currently unknown) axis from one cluster to another may involve a radically different spectrum of responses. Detailed analyses of these claimed effects necessitates further research using more

advanced research methods, such as supervised AI classification algorithms (gradient boosted trees, random forests, etc.).

The Gender Identity Disorder in Children as diagnoses by the DSM 5 includes criteria that resemble the behaviors tested in the CGN (Zucker, 2015), i.e., for females: strong preference for male playmates, interest in toys preferred by boys, and preference for other boys' clothes. These behaviors have therefore been considered atypical and, when co-occurring and in presence of strong distress, and have led to a diagnosis of a GIDC disorder.

The major problem of children considered being non-conforming with their 'typical' gender could stem from their relationship with parents and their rejection by peers (Swim et al., 2020; Rieger et al., 2012; Aspenlieder et al., 2009; Toomey et al., 2013), not with the behaviors *per se*. Assigning these 'atypical' activities as being abnormal and unhealthy in children have created a serious problem; more serious than the actual effect these behaviors have during a healthy development.

It is important to stress that previous publications infer that strong gender conforming behavior and attitude in women lead to a more problematic relationship with body self-image and self-objectification (Lippa, 2008; Aparicio-García and Nieto, 2019; Sigel and Calogero, 2019); the methods and clusters we present here may offer progress in discovering outcomes and developing insights into how the aforementioned problematic relationships are distributed.

Social rejection, as a consequence of non-conforming behavior, unavoidably leads to isolation, anxiety and depression (Roberts et al., 2013); these should be addressed as the problems, not the non-conforming behaviors themselves. Evidence comes from the cases in which the behavior does not apply to the individual as a gender conformity construct and cases in which the non-acceptance of gender conforming behavior is part of a rejection towards the gender construct itself (Carr, 1998). The rejection of the behavior itself is not necessarily well addressed as being the cause of the suffering. The behaviors are not to be considered correct in either case and attempts to correct them can lead to a wrong therapeutic approach. This acquires even more importance after observing that different clusters, due to varying weights of the responses, are observed and the existence of inhomogeneity is a typical characteristic of every cluster.

The statistical methodology used in the present research is novel, therefore the results are not straightforwardly comparable to those of previous publications. We suggest to implement the methodology used in the present study to: (a) analyze other characteristics related to CGN, (b) replicate the present study for participants from other nations and perhaps other cultures, and (c) include characteristics such as socio-sexuality. Collecting data related to childhood stress, adult self-acceptance, and information about psychological wellbeing of the respondents may contribute further insights needed for addressing gender non-conforming behaviors in children.

Kelloway (1998) has remarked that social scientists have a tendency to keep using a statistics analysis procedure because it seems to “work reliably”. They are therefore, so his observation, hesitant to apply methods more modern than the ones they feel comfortable with (Is the payoff for increased intellectual effort worth it?). Of course, such a state of affairs should not be considered proper science. For one, traditional, albeit established, statistics methods have limitations that have been overcome during the course of a social scientist’s career. Adhering to methods that have reached the stage of obsolescence incurs results that lead to flawed (or worse) conclusions. Part of the issue of irreproducibility of many field data interpretations in the social sciences can be traced to violations of assumptions due to applying obsolete methods. Secondly, some data sets, most notably those containing categorical variable scores, have been analyzed by statistical methods that are clearly wrong and have been known to be so for half a century (Bablock, 1960). Only recently have these methods been unequivocally superseded: by employing AI for statistical analyses. This paper is one example of how not only (1) can proper, rigorous, non-fallacious methods be applied to a data set with categorical variables, but also (2) new discoveries be made (discoveries that are not imaginable by researchers who are used to creating plausibility arguments that fit wrongly-adhered-to modeling paradigms): none of the traditional methods will discover clusters, let alone four of them — a noteworthy, copy-book case of serendipity. This serendipity may sound self-congratulatory to the research community, but it does benefit CGN females in their struggle for acquiring self-esteem.

6. Conclusion

We identified three clusters among the women (who were non-conforming as girls) responding to queries of the standard CGN questionnaire by using modern statistical (AI) methods. Analysis of responses to this questionnaire helps identify the inhomogeneities inherent in CGN of this population. Use of auto-encoders and KDE identifies cluster membership that a human (a clinician, say) would not be able to. We also discovered that members of each cluster had a different range of response spectra from those in other clusters. We find the CGN questionnaire to be sufficiently ideal; its measure-based construct has important implications in peoples’ everyday lives. We can identify three distinct clusters in each of which membership evidences gender-non-conform responses. The detailed statistical analysis of often-claimed confounding variables (age and four categorical ones) shows that we may rigorously show that the clustering of the CGN categories is not due to clustering of age, education, religiosity, and municipality size.

Acknowledgements

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Conflict of Interest The authors there are no conflicts.

Ethical Approval The Helsinki Convention was adhered to at all times: throughout the presentation of the questionnaire, collection of responses, and abiding by the wishes of those who did not agree with the terms and conditions (these were not allowed to proceed with the study). All data were anonymized. The current study is part of broader set of projects that were approved by Ethics Committee of Faculty of Science, Charles University (reg. no. 2018/08).

Informed Consent Informed consent was obtained by the respondent ticking an approval box. Only after the tick did the software package allow participation in the questionnaire.

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Appendix I

The Italian version of the CGNC questions (Version for females)

Non conformità di genere nell'infanzia (versione per le donne)

1. Da bambina i miei coetanei mi chiamavano maschiaccio.
2. A volte, quando ero bambina, avrei volute nascere maschio anziché femmina.
3. Quando ero bambina mi piaceva di più giocare con i maschi che con le femmine.
4. Spesso da bambina sentivo di avere più cose in comune con i maschi che con le femmine.
5. Da bambina di solito evitavo di usare abiti femminili (come gonne e vestiti).
6. Quando ero una bambina mi piacevano gli sport competitivi, come il calcio, il baseball e il basketball.
7. Ero una bambina mascolina.

Appendix II

Statistical errors when generating sums (indices) of responses

Many conventional (and, we claim and justify in this Appendix: erroneous) statistical analyses approaches begin by converting the categorical responses to cardinal (computable) integers along a linear one-dimensional scale. In a second step, these integers are summed, individual by individual, and then, in several other steps, analyzed by (questionable, non-informative) correlation calculations, estimating means and standard deviations, ANOVA, etc. Here, we show, using the data we collected, why computing the sums of responses is uninformative. By implication, using these sums invalidates the above list of computational techniques. For each respondent, the seven queries request one response from “A” to “G”. Using the linear mapping into the computable integers, each respondent is characterized by seven integers between “1” and “7”. Because there are seven queries, the sum of these mapped responses is between 7 (all “A”) and 49 (all “G”). One (fatal) flaw with this approach is due to the fact that there exist very many possible ways of achieving the same sum/index, if it is not at the extremes 7 and 49. Table App2 lists the number of possible response listings for a specified sum in this data set of seven queries and seven possible responses per query.

Table App2

Index (sum)	Number of possible summations	Index (sum)	Number of possible summations	Index (sum)	Number of possible summations
7	1	21	26769	35	26769
8	7	22	33390	36	20664
9	28	23	40166	37	15330
10	84	24	46655	38	10906
11	210	25	52374	39	7420
12	462	26	56854	40	4809
13	924	27	59710	41	2954
14	1709	28	60691	42	1709
15	2954	29	59710	43	924
16	4809	30	56854	44	462
17	7420	31	52374	45	210
18	10906	32	46655	46	84
19	15330	33	40166	47	28
20	20664	34	33390	48	7
				49	1

Table App2 The tabulation of the ambiguities of using sums/indices to characterize summative responses to questionnaires. Here we tabulate the ambiguities for seven queries and a 7-point Likert scale of responses. An example: there are 15330 different ways of generating a sum of 19.

Assuming that the construction of the sums/indices is legitimate, we observe that the sample size needed for reliable analysis must be upwards of 500 thousand (based on the “rule of thumb” that a coverage of about tenfold of the most frequent occurrences is needed)! To our knowledge, no study with such a large sample size has been published.

We demonstrate a further shortcoming of relying on indices by using our data set. For each cluster — the “Tomboys”, the “Noncompetitors”, and the “Ladylikes”, we have computed the indices as per conventional mapping. Fig. App2 shows the distribution of index frequencies in each cluster. Clearly, there is no separation of the data set into clusters (the distributions are not distinguishable).

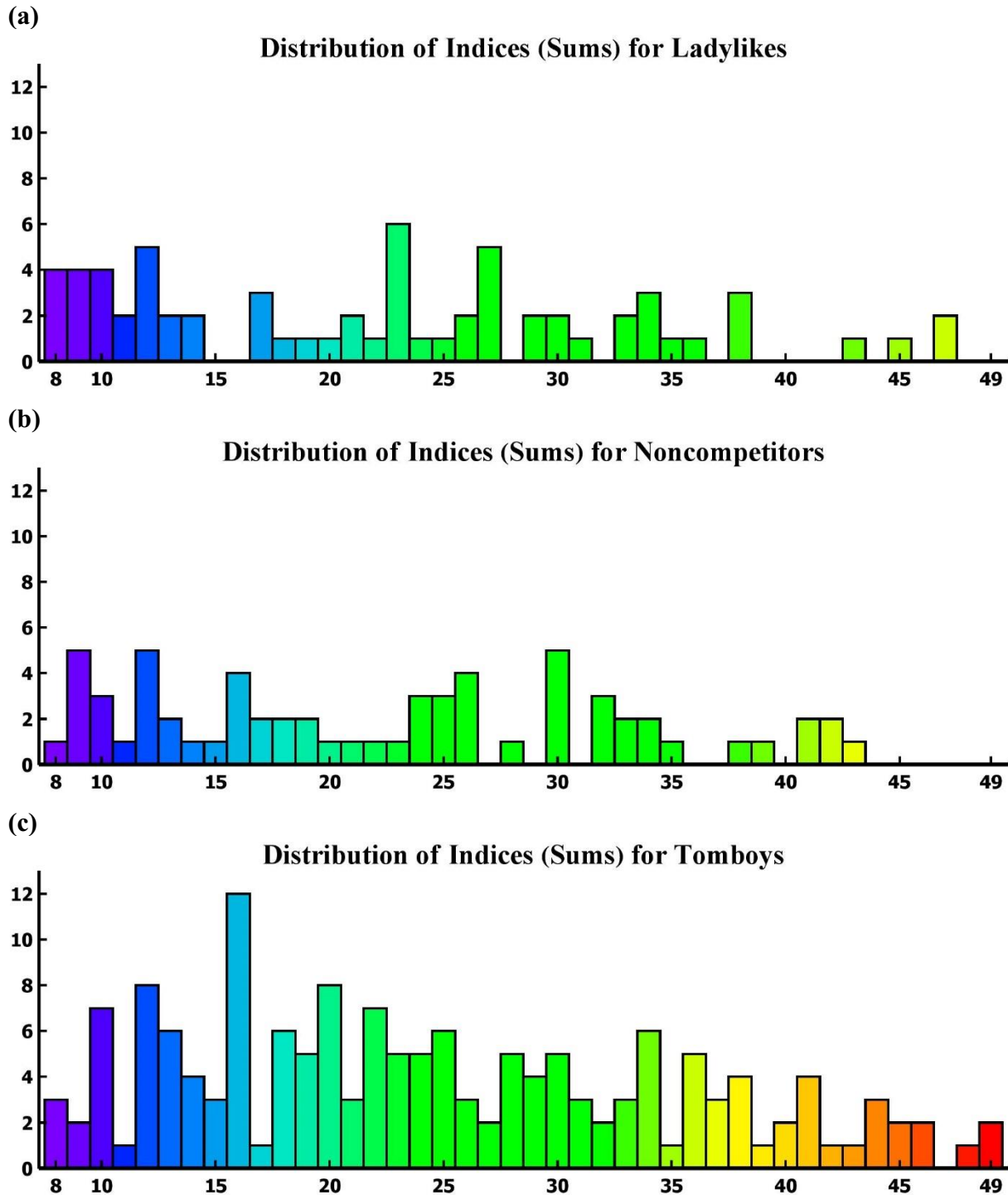


Figure App2 The distributions of the relative frequencies of the sums/indices obtained by summing the seven responses to the seven queries in this data set after converting to a linear scale of computable integers. Labeling is as in the text for the CGNC clusters: (a) “Ladylikes”, (b) “Noncompetitors”, (c) “Tomboys”. There are no distinguishing differences between the distributions. The fact that the highest sums occur only for the “Tomboys” should not be misleading: only 1% of the respondents in the segment “Tomboys have such a large sum. Note that the highest relative frequency for the “Tomboys” is for the index 16, comparable to the highest relative frequency for “Noncompetitors”. As can be seen from Table App2, the required sample size to ensure a sufficient coverage (which does not imply a statistically significant clustering, please note) the sample size would have to be close to or larger than one million.

4 Technology-driven Response Insights Contribute to Human Sexuality Research

4.1 WEIRD Questionnaire Participants

4.1.1 Sampling

The topic of sampling is problematic not only for those who work in sex-research but also for researchers in many other social science fields. The (oft-quoted) “queen of sciences” — physics — has developed theories that can control for variations in effects in many fields. Nonetheless, there are fields — even in physics and chemistry — that have to deal with large variances (such as stellar surfaces or thermal effects in semiconductors). In the majority of the ‘how-to’ books written for social science field researchers, we read about ideal sampling and how the samples should be collected. In human sexuality research, the majority of samples are collected from chosen populations, rather than, as in physics or chemistry, in carefully controlled laboratory conditions. This problem of ‘field-work’ research (Catania et al., 2015) when collecting the data, say, of the sexual life of indigenous Peruvians, of African-American youths, of urban men who have intercourse with other men, or of college-level students, necessitates the development of novel statistical tools. It has been estimated that 96% of research in the social sciences is conducted using western, educated, industrialized, rich, and democratically-minded (WEIRD) participants. Furthermore, more than half of these studies have been carried out in the United States (Rad et al., 2018).

The students are in close contact with others in their peer group; this is likely to produce a difficult-to-control-for influence on their observed social behavior and strategy (Binter et al., 2012). Furthermore, psychological problems and lower quality of life are prevalent amongst students (Henning et al., 2012). Inferences derived from such samples are fraught with shortcomings.

Another issue in sex research pertains to the topic of the existence of a self-selected sample (Bethlehem, 2010): individuals who participate in a study focused on sensitive topics such as sexuality tend to be more open-minded and experienced; individuals who choose not to participate in such a study tend to be more insecure or conservative (Copas et al., 2020; Wiederman, 1999). In such a case, we would only statistically analyze a narrowly yet well-defined, but not a general population.

As such, this narrow focus on participants could lead to less reliable inferences when applied to sexual behavior of the population at large. Also: even today a considerable fraction of the world’s population does not use the Internet and so has hardly been researched in quantitative studies during the last decade. Furthermore, participants of internet-administered studies may have other motivations — such as a financial reward for participation. Thus, the chances of discovering generalizable phenomena are higher when participating individuals are motivated by other notions; those different from interest in the topic or from signing up due to it being in a subject taught at university. The more salacious the topic, the more pronounced the risk of bias becomes.

In the Czech Republic, for example, I have been involved in efforts to collect representative samples (Boschetti et al., 2021). Weiss and Zvěřina succeeded using a representative sample for reporting annual changes in beliefs, behaviors and trends (Weiss & Zvěřina, 2001).

Thus, it should again be stressed that there is large methodological gap, if researchers are unable to collect data on individuals who together constitute a genuine demographically well-defined cross section of the population. Only then is the application of the descriptor ‘representative’ justified. Whether bean-counting or not, generalizability is only possible after the prerequisite ‘representative’ has been met.

4.2 Future: Globally Tracking Sexual Responses Online

4.2.1 Sampling

Methods needed to collect representative samples have become much easier in the past decade, since telephoning combined with paper-and-pencil questionnaire techniques need no longer be used. Online data collection is a wide-spread technique that allows for familiarity (the individuals are taking part in their familiar environment — usually their home) and privacy (no-one other than the participant knows what his/her response to a query is). Furthermore, there is neither a need for extensive financial support nor for re-checking response lists. Thus, improvement comes about by the change in the technique. The quality of the data due to the same problems of self-selection remains, although it is less problematic because the chances of self-selection are less.

Currently, and even more so in the near future, techniques employing cookie tracking and online behavior presence tracking is considerably more reliable since it is unobtrusive, prevents any distortion of the data, and supports longitudinal approaches, even when the individuals change devices (Morichetta et al., 2019). The issue of privacy and anonymity is much more pressing in sexuality research, because people may be tolerant of revealing some of their consumer habits, but very intolerant of others acquiring knowledge that transgresses the boundary of intimacy. Internet connection is close to being available globally (in fact, approximately 90% of population living in the developed world is now online) and the growth rate for internet access in the developing and in the least developed countries the growth rate is tripling since 2019

(<https://www.statista.com/statistics/209096/share-of-internet-users-in-the-total-world-population-since-2006/>).

Wearable sensors will soon be available to all members in a variety of populations; these allow the measurement, registration, collection and transmission of physiological measures at a distance, yet within the comfortable and familiar environs of the participant (Wang et al., 2021). So, data collection now extends from query responses to monitoring various activities. As pointed out in Section 2.2, AI techniques can find not only interrelatedness of stimuli, but also their interrelatedness with responses — all without requesting additional activities to support the researchers’ endeavors. Then studies with narrowly defined methodology can be pursued in a very large number of sets of individuals. The

notorious problem of small data sets, combined with each being analyzed by a different study design, will become a thing of the past. In fact, different study designs could, in principle, be applied to the same data sets, as the number of interrelated stimuli and the number of response query sets will be very large (Gormezano et al., 2022).

We are also living on the verge of the future when the Metaverse® will become virtually real. Authors are already suggesting that the whole phenomena of data acquisition combined with uncontestable knowledge of an individual's behavior in the Metaverse® will produce a further paradigm shift (Parsons, 2012).

4.3 Exemplary Exposition of AI Methods: English Version of a Czech Manuscript

In the following example, we describe research which applies AI to a *representative* sample of the Czech population. We looked for — and found clusters of pornography consumption and sexual behavior that cannot be detected using correlations, let alone indices, because more than of grouped exists within each cluster. The analysis of the data set demonstrates how my research team generated one-hot encoded vectors, dimension-reduced the concatenated feature vectors by using a neural network and then used the *K*-means algorithm to find clusters.

One outcome (“discovery”) is the presence of 8 clusters. The heat maps show the degree of similarity in the responses of the demographic subsets in each of the clusters.

AI (Artificial Intelligence) Detects Clustering of Czech Republic Inhabitants' Porno Consumption Habits and Associations with their Demographic Parameters

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Abstract:

Background: In societies with easy internet access, anonymous consumption of BDSM and non-BDSM porno videos has become widespread. It is neither clear what fraction of consumers in such a society consume how much, and how this relates to their personal attributes (education level, masturbation frequencies, and biological sex).

Aim: First, we are interested in associations between their personal and sexual attributes (BDSM and non-BDSM porn video consumption, and masturbation frequencies). Second, we investigate whether these segments associate with one demographic parameter, the population size of the locality in which they live.

Results: We find that the participants cluster into 7 segments; none are of only one sex, but several are overwhelmingly so. The spectrum of their sexual attributes is distinctly different in the segments. Education levels and relationship statuses are not good separators. Highly compulsive porno video consumption, together with high masturbation frequencies, characterize two segments, while restraining (very conservative) sexual attitudes are characteristic of two others. Demographically, members with conservative sexual attitudes are primarily female and live in small localities, as do males with highly impulsive sexual attitudes.

Conclusion: Modern, advanced statistical methods can identify segments with well-defined sexual attributes and associations with demography.

Keywords: Neural Networks DBSCAN algorithm, porno video consumption, masturbation frequency, demography parameters, compulsive sexual behavior

Introduction

The “purity movement”, in which Ellice Hopkins was a central figure, pointed towards a future trend (Hopkins, 1899), namely that men, by far more visually stimulated than women, would become mesmerized consumers (occasionally even compulsive ones) of internet pornography. Not without claimed costs, however; sexual development arguably predetermines sexual preferences and sexual behaviors that run the risk of lingering on into adulthood. Ten percent of respondents of one UK sample even claimed to be addicted to pornography consumption (Logue et al., 2018).

There exists a large overlap between the preferences for anticipated sexual fantasy and actual pornography watched, especially for men (Chivers & Bailey, 2005; Chivers et al., 2010; Binter et al., 2013; Krejčová et al., 2018). Two aspects seem to be explanatory: (a) sensation seeking and sexual drive (Galther & Sellborn, 2003; van Lankveld et al., 2015), and (b) availability of a sexual partner to have the sexual experiences with (Binter et al., 2012).

Arguably, there are three aspects relating to the availability of a partner. One, larger cities are more likely to be inhabited by individuals with higher education levels (since the universities are predominantly present there); two, a larger population ensures a higher availability of suitable partners (Binter et al., 2012); three, more individuals with minority preferences (such as BDSM-positive individuals) are also likely to be found in larger cities (Richters et al., 2008; Wismeijer & van Assen, 2013). For the third, possible reasons are anonymity, a larger partner market, more clubs and localities dedicated to fringe sexuality.

Pornography is viewed for various reasons, including novelty seeking. Those who are in a partnership over an extended time period are more likely to fantasize about sexual partners other than their current one. Those who have cheated on their previous partners and those who previously had more sexual partners are more likely to act out their thoughts in their current relationships (Hicks & Leitenberg, 2001). Conversely, some studies (i. e., Birnbaum et al., 2019) show that those partnered individuals who fantasize about their partners are likely to exhibit more behaviors related to partnership satisfaction. Therefore, pornography and relationship status are related.

The primary reason to watch online pornography is to become sexually aroused; moreover, curiosity satisfied by pornographic scenes and displays of gratification techniques also inspire (Sabina et al., 2008). Data for the Czech Republic evidences a difference between those who are in a relationship and those who are single (Smutny & Sulc, 2018). Singles are more likely (17.1% vs 12.5%) to watch pornography to satisfy their secret desires; inspiration for their sex life is lower, however, by 13.2% (21% of singles report such motivation). Both groups are motivated by experienced satisfaction (partnered: 59.9%; singles: 66.7%).

It is not uncommon for some to claim that there are only negative impacts of pornography. Not true; there are positive effects as well — a compensatory effect has been demonstrated in Japan, Denmark,

Finland, Croatia, United States of America, and Czech Republic (Diamond et al., 2011). It has been observed that the increased availability of pornographic materials is negatively associated with sex-related crimes in a country.

Noteworthy: the availability of pornography seems to be a liberating factor, especially for women; they, in previous times, were less likely to watch such offerings. Now they are consuming pornography. Choices and consumption, apparently, help them define more precisely what their sexual needs are, contextualize these needs and preferences, and more easily accept their sexuality (McKeown et al., 2018).

In a previous Czech sample — the most relevant one to compare with the one presented here — it was observed that approximately one third (29.5 %) of men consumed pornography very rarely (3.4%). More than half the women consumed pornographic materials a few times a month, while more than half of men consumes pornography 2 to 5 times a week. Less than one percent of women consume pornography at least daily; in contrast, 11% of men consume the pornographic materials several times a day and 14.4% at least once a day (Smutny & Sulc, 2018).

A Short History of Visual Pornography: Pornographic depiction has been documented: (a) in peripatetic Greece, (b) during the Roman Empire (surviving pornographic renditions are to be seen not only in a Pompeii brothel, but also in frescos in villas largely destroyed by the eruption of Vesuvius in AD 79 and now on display in the Archeological Museum in Naples), (c) in Chinese (for example Zhou Fang, 8th Century) and in Japanese (*shunga*) woodcuts, (d) in the Indian Kamasutra (Sinha, 1988), as well as (e) in the well-known sculptures on Indian temple facades (for example, Kandariya Mahadeva Temple, 11th Century).

We compare the accessibility of pornographic images in Renaissance Italy (16th Century) with those in the *Biedermeier* Period (primarily after 1815) in the Habsburg Empire, as they exemplify the decrease of exclusivity, the increase in availability, and, presumably, increase in consumption.

While Raphael (1483–1520) was painting his world-famous frescos in the *Stampe* in the Vatican, one of his assistants, Romano (1499–1546) (who was to become a very famous painter in his own right) painted a sequence of lascivious copulation positions on the walls. Of these, Marcantonio Raimondi (1482–1534) made copper etchings and distributed them in Rome. The Pope was enraged and threw Raimondo into prison. Notwithstanding, these depictions were then reproduced again and distributed in book form, accompanied by extremely explicit pornographic sonnets written by Pietro Aretino (1492–1556). These *I Modi* (best translated as *The Intercourse Positions*, which included depictions and descriptions of anal intercourse — sodomy was not always criminalized in the upper strata of society during the Italian Renaissance, nor had it been, by the way, in peripatetic Greece) were repeatedly hidden, destroyed when found, and so forth. In 1928, Walter Toscanini (son of the famous conductor) discovered an early 16th-Century specimen, with woodcuts instead of the copper etchings, which has since been sold to another private collector. 62 years later, reproductions have been

published (Lawner, 1984). In the context of the subject matter of this paper, it is important to note that the etchings and woodcuts circulated only among the wealthy and powerful in Rome and Venice and were avidly consumed.

During the Congress of Vienna (1815), erotic (and pornographic) art was consumed and distributed in a clandestine fashion (and certainly enjoyed). Notorious became a series of 40 aquarelles depicting copulation scenes that had been falsely attributed to Peter Fendi (1796–1842). In contrast to the *I Modi* of the Renaissance, these were much more easily accessible for viewing, purchase and trading, also by affluent commoners. Remarkably, the protagonists in the copulation scenes were middle-class Viennese dressed in *Biedermeier* fashion (albeit only partially, due to the pornographic depictions) — a considerable contrast to the attire of the contemporary nobility.

In Europe and in North America, post-Enlightenment (from mid-19th Century onwards) pornography became more and more ubiquitous and a mass-consumed product. With the invention of photography and — even more so — the movie, presentation of visual pornography allowed access to ever larger fractions of the population — primarily because of the inherent techniques of mass production and mass distribution of filmed materials. (The first enterprise that exclusively produced erotic and pornographic movies was *Saturn-Film*, Vienna, from 1907–1911.)

In this day and age (2021), the inundation with pornographic movies, accompanied by their ease of anonymous distribution, has resulted in seemingly indiscriminate and almost unlimited consumption.

We show in this paper, however, that the consumption is not as indiscriminate as is commonly believed.

BDSM Behavior and Consumption of Visuals: BDSM is both a genre and a lifestyle. We need to distinguish between BDSM activities that are purely sexual with those that include sexuality but are actually a complex of social interactions (Foucault, 1990). An early depiction of sexual whipping is the *Tomba della Fustigazione* (*The Tomb of the Whipping*), an Etruscan tomb (about 490 BC) depicting individuals who experience (sexual) pleasure from and while being flogged and spanked by a hand and a whip (Steingraber, 2006). A large gap in evidence follows. One surviving rendition is *A Satyr Flogging a Nymph Bound to the Branches of a Tree*, an engraving by Antonio Carracci (1557–1602). Marquis de Sade (Donatien Alphonse François), wrote *120 days of Sodom* and *Justine, or the Misfortunes of Virtue* (both considered gems of BDSM literature), which he wrote while imprisoned. Most of the content is arguably purely fictional, but from court proceedings and legal charges we do know about factual descriptions of his preferences (Gray, 1998). Richard Freiherr von Krafft-Ebing was the first to call the descriptions of such behaviors as sadism and masochism in his work *Psychopathia Sexualis* (1886). Masochism is named after Leopold von Sacher-Masoch, an Austrian nobleman. Sacher-Masoch's writings, as well as his sexual life, dealt with intentionally received pain, concomitant with punishment and degradation. His *Venus in Furs* (1870) includes passages of devotion, sexual violence, psychological mistreatment and fetishism. The modern clinical

understanding of both sadism and masochism are considered non-consensual and differ from Sader-Masoch's. Consensual sadomasochism is, on the other hand, recently considered a variant of sexual preference without negative implications (Federoff, 2008).

The modern consensual BDSM visual style and appearance can be traced to one sole photographer who created the presentations we associate with such materials in the 1940s and 1950s; it was John Alexander Scott Cutts (pseudonym John Willie; Pine, 2013).

Currently, BDSM porno videos show sexual behavior during which (usually consensual) power exchange takes place. Some practices are focused on physical sensations, some on mind sets and some on mental states (these include punishment and role-play). Pain induction may or may not be an element; any more than obedience and subordination. Special costumes are sometimes used to generate further immersion (Binter et al., 2021).

The Age of New Technologies: One of the most life-changing technological advancements, the Internet, has resulted in enormous databases of pornographic materials. Hardly any pornographic topic is missing in their offerings. One in five Internet searches are pornography oriented; one in four respondents have pornographic materials stored on their mobile devices; one third of World Wide Web content is pornographic (Smutny & Sulc, 2018). Approximately 70% of the consumers use a notebook to watch pornography, and at least one third watches it on a smartphone. 90% of both sexes always watch something new, while less than 25% of men and 10% of women (re)watch already viewed materials. The majority of non-consumers had one or two sexual partners; almost $\frac{1}{5}$ of had more than ten — demonstrating that novelty-seeking is one of the motivating factors. Here we would like to point out that there may be five types of relations of the pornography use and real life preferences: (a) the more novelty is searched in pornographic materials, the more real life experiences are preferred to be novel (both, pornography consumption and socio-sexuality are high), and (b) willingly compensatory mechanism may take place (while real life experiences are willingly avoided, high pornography consumption is an acceptable alternative). Furthermore (c) there are limiting factors of the real-life experiences the pornography consumption is therefore an alternative which is not preferred but available. When sexual drive is not as high as in previous examples (we intentionally avoid words regular or average) option (d) when the sexual drive is satisfied by sexual activity with a partner or porn consumption (presumably depending on the partner availability but without compulsive element), lastly (e) pornography is not consumed and due to lack of high sexual drive, neither frequency of sexual intercourse is high.

Men, being more visual, are more likely to watch pornography videos of almost all types and themes (including, but not limited to, fetish, group sex, female-female sexual interaction). However, for two types of porno videos women outscored men: (a) in male-dominant depictions of BDSM pornography and (b) in sexual foreplay. No sex differences were found for depiction of 'usual' (sometimes called 'regular' or 'conventional') sexual activities (Krejčová et al., 2018).

A representative sample of the Czech population shows that, for both sexes, the onset of masturbation is usually at age 13 and increases in frequency by the age of 15 (Weiss & Zvěřina, 2001). The masturbation frequency has been hypothesized to negatively impact sex-life satisfaction (Brody & Costa, 2009); in the context of pornography consumption, there is an ongoing discussion about its impact on sexual behavior (Dines, 2010; Gyamfi & Zalata, 2018, Boschetti et al., 2021; Průšová et al., 2021).

In a longitudinal study of sexual behavior in the Czech Republic (Zvěřina, 2009), it was found that men masturbate more often than women (men 7.1/month, women 5.8/month, in 2009). In 1993, 84% of men confirmed regular masturbation, 83% in 1998, 89% in 2003, and 90% in 2008. 50% of women confirmed masturbation in 1993, 58% in 1998, 61% in 2003, and 65% in 2008. The steady increase is statistically indistinguishable between the sexes. 76% of men consider masturbation to be a natural phenomenon; so do 62% of women. 20% of men consider masturbation to be a bad — albeit harmless — habit, as do 29% of women. 4% of men and 9% of women consider masturbation to be harmful.

The above descriptors infer the existence of classes of porn consumers. Vaillancourt-Morel (2017), for example, identified three: (a) recreational users (approximately 75%), (b) compulsive users (13%), and (c) non-compulsive, non-recreational users (12%). The (a) users have reported that inspiration is their main motivation and their sexual life was not negatively affected by porn consumption. Women were the predominant members of this (a) group and spent approximately half an hour a week watching pornography. 10.2% of a university sample and 7.8% of a community sample were found to be compulsive users; these were primarily young heterosexual males exhibiting the clinical symptoms of Compulsive Sexual Behavior Disorder (Castro-Calvo et al., 2020).

Aim and Methods of the Study: This paper deals with the varied (but not indiscriminate) degree of pornography consumption of our adopted dichotomy (BDSM versus non-BDSM porno videos) and how it relates to further parameters: (a) demographic categories (population sizes of villages/towns/cities in which the respondents live), (b) personal attributes (relationship status, education level, biological sex), and (c) masturbation frequency.

Our method of analysis, using artificial intelligence (AI) methods and unsupervised clustering algorithms will contrast our findings with the above published study outcomes.

Materials and Methods

Materials: 902 individuals from the Czech Republic took part in an online survey concerning aspects/characteristics of their sexual attitudes and pornography-related activities, as well as the village/town/city categories in which they lived (Table 3). Of these, 881 individuals completed the questionnaire.

The age distributions of the participants were matched to the demography of the Czech Republic (Table 1).

Segment	Number of members	Age Range (years)	Mean (years)	Median (years)	Mode (years)
#1	184	18–50	33.8	33.0	29
#2	45	18–47	28.4	27.0	19
#3	134	18–49	32.9	32.5	28
#4	187	18–50	32.9	33.0	32
#5	73	18–49	30.7	29.0	26
#6	52	18–50	32.6	33.5	24
#7	206	18–50	30.3	29.0	29

Table 1 The age distribution estimators and the numbers of members in each of the seven segments. The age range is very close to equal for all segments.

Queries were: (a) biological sex, (b) education level, (c) relationship status, (d) frequency of non-BDSM video consumption, (e) frequency BDSM video consumption, and (f) frequency of masturbation. The responses were categorical variables ranging from A–B (for (a)) to A–I (for (d), (e), and (f)). The encodings of the categorical responses are listed in Table 2.

Attribute	Encoding	Encoding Property
Biological Sex	A	Female
	B	Male
Education Level	A	Elementary Schooling
	B	Vocational School Level
	C	University Entrance Level
	D	University Degree
Relationship Status	A	Single
	B	Partnered
	C	Married
	D	Divorced
	E	Widowed
Porno Video Consumption (non-BDSM)	A	Never
	B	Rarely
	C	Once in 2 or 3 months
	D	About once a month
Porno Video Consumption (BDSM)	E	Once in two weeks
	F	Once a week
Masturbation Frequency	G	Multiple times a week
	H	Almost every day
	I	At least once a day

Table 2 The response options for each of the queries in the questionnaire.

Methods: All responses are categorical random variables, some of them ordinal. These may not be mapped into cardinal integers (Blalock, 1960). Rather, we employ one-hot encoding (Murphy, 2012) to extract a feature vector for all responses of each individual. The construction of the 38-dimensional feature vector (known as ‘one-hot-encoding’) will be described below. The data set thus is a 38×881 matrix.

Population Category	Population (thousands)
A	<1
B	1–5
C	5–20
D	20–100
E	100–1000
F	>1000

Table 3 The population sizes of the municipalities (villages, towns, cities) in which the respondents to the questionnaire lived.

An example of one-hot encoding: for the query “relationship status”, there are five possible responses (Table 1). The feature vector for the response for this query is thus 5-dimensional. Response “A” is encoded as (1 0 0 0 0), response “B” is encoded as (0 1 0 0 0), response “C” is encoded as (0 0 1 0 0) — and so on. We observe that these feature vectors are (a) orthogonal — their scalar product is 0 —, and therefore each individual’s response is independent of another individual’s response, and (b) the norm of each feature vector is 1 — the feature vectors are all normalized —, so no metric is introduced by one-hot encoding of the response. Each individual has, however, responded (in this study) to every one of 6 queries. For example, let us assume that three responses to the first three queries are “B” (of two options), “D” (of four options), and “C” (of five options). The feature vectors for these query responses are $3 \times (0 \ 1)$, $1 \times (0 \ 0 \ 0 \ 1)$, and $1 \times (0 \ 0 \ 1 \ 0 \ 0)$. The feature vector of all five responses, obtained via concatenation, is thus 15-dimensional: (0 1 0 1 0 1 0 0 0 1 0 0 1 0 0). Notice that the feature vector is no longer normalized (its norm is $\sqrt{5}$) and there are internal dependencies among the components. Because, for the questionnaire (Table 1) of this study, there are 6 responses, the (concatenated) feature vector for each individual’s responses is 38-dimensional ($2 + 4 + 5 + 3 \times 9 = 38$), and has norm $\sqrt{6}$; there must exist (very many) interdependencies. No 38-dimensional feature vector in the sample need be orthogonal to any other 38-dimensional feature vector.

In order to make use of these interdependencies, we use a neural network with seven layers — an auto-encoder (Mohri et al., 2018; Strang, 2019). The input is the 38-dimensional feature vector, and the output is a 38-dimensional feature vector. The middle layer has, however, 3 nodes. The algorithm

finds the weightings of the connections between nodes so that the output equals the input (based on a convergence criterion). The 3 nodes of the central layer therefore generate a 3-dimensional vector that has removed the interdependencies between the 38 components of the input feature vector. We can map these 3-dimensional vectors (called the “dimension-reduced feature vectors”) in 3-dimensional space (Fig. 1).

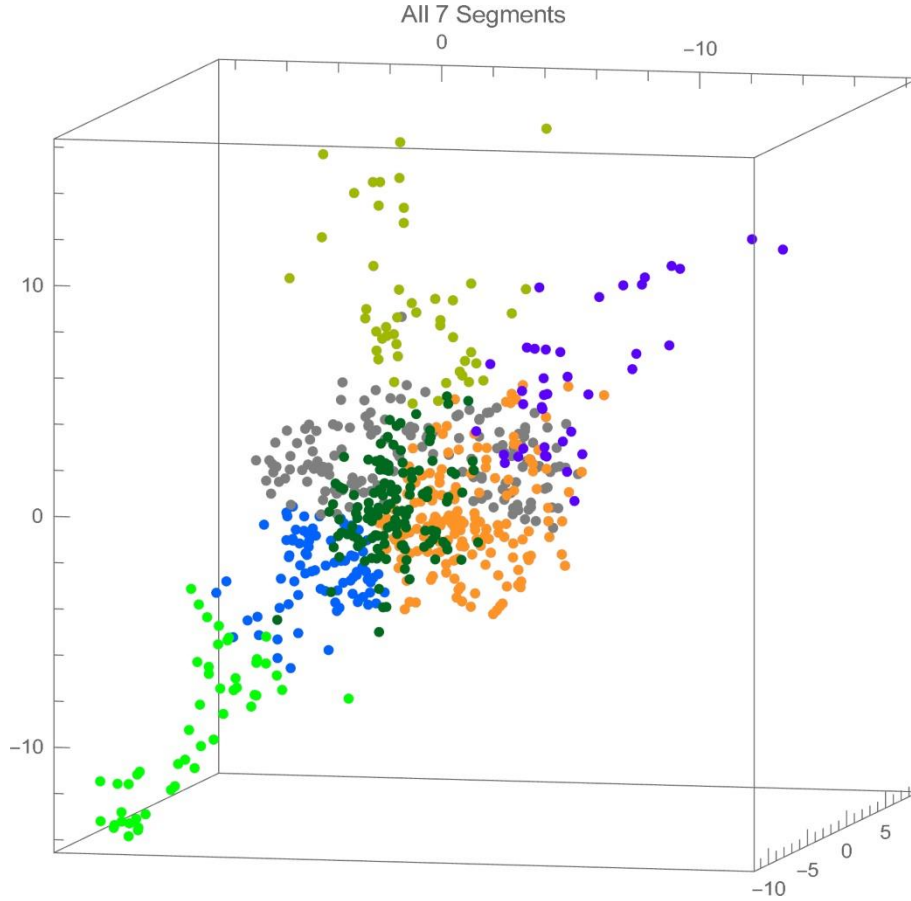


Figure 1 The distribution of the dimension-reduced feature vectors of the 881 individuals in the sample analyzed in this paper. Some individuals have identical reduced feature vectors, so there are 667 points in this graph. The colors identify the points belonging to one of the 7 different clusters/segments obtained by *K*-means clustering.

The points in 3-dimensions generated by the dimension-reduced feature vectors are not uniformly distributed (Fig. 1). We attempt to find a clustering of these points. Of the many clustering algorithms (we experimented with 7 different ones), we found that the *K*-means clustering algorithm generated a reliable clustering: seven clusters were generated (color-coded in Fig. 1). In this manuscript, we call the obtained clusters segments.

We can “backtrack” the outputted coordinates within each cluster to determine the components of the inputted 38-dimensional feature vectors, and, consequently, the respective query responses. We use this method and present the summative statistics as heat maps in Fig. 2.

We are interested in how attributes of the members of the segments (their sex, their education level, and so on) associate with the population category of where they live (at the time when they participated in the questionnaire).

As a first step, we check for uniformity of the contingency table (population category versus segment number) with a χ^2 -test. As we elaborate in greater detail below, the test outcome is far from informative.

We therefore employ a much more informative investigation tool: Correspondence Analysis (CA; Greenacre, 2007; Beh & Lombardo, 2014). This tool is based on a Singular Value Decomposition (SVD; Leon, 1998; Strang, 2019) of the scaled contingency matrix. Further details in the Results section.

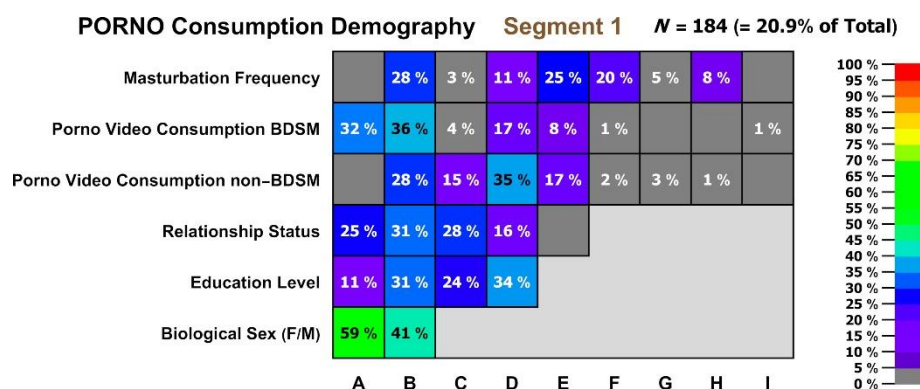
Results and Discussion

Results:

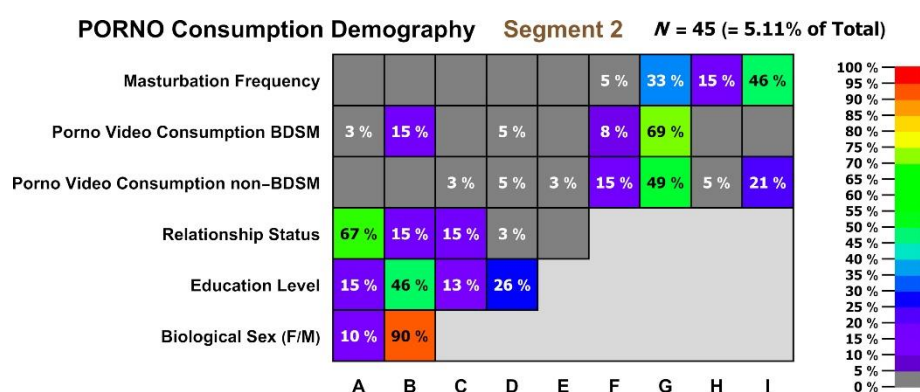
Clustering: The *K*-means clustering algorithm outputted 7 clusters, with a varying number of members in each cluster. Table 2 lists the number of members in each cluster and Fig. 1 shows the spatial distribution of the dimension reduced feature vectors of the clusters.

For each labeled segment (each cluster), we tally the responses for each query and generate a heat map that describes the tallied responses (Fig. 2).

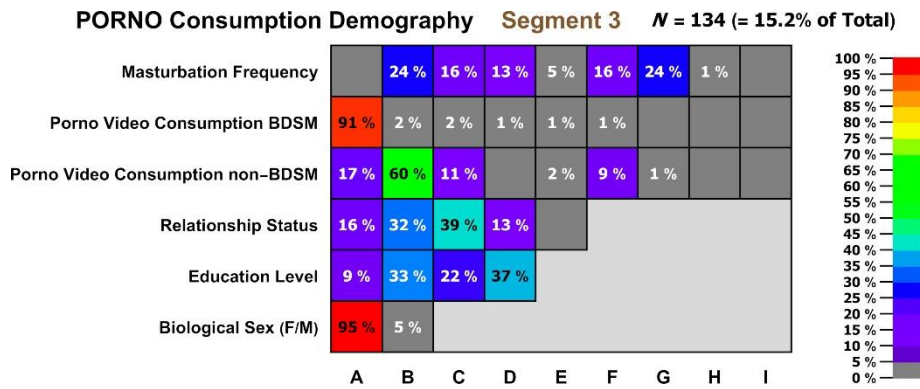
(a)



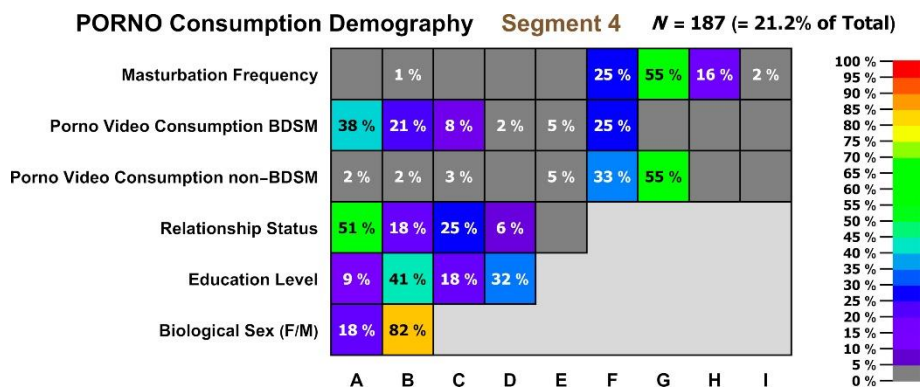
(b)



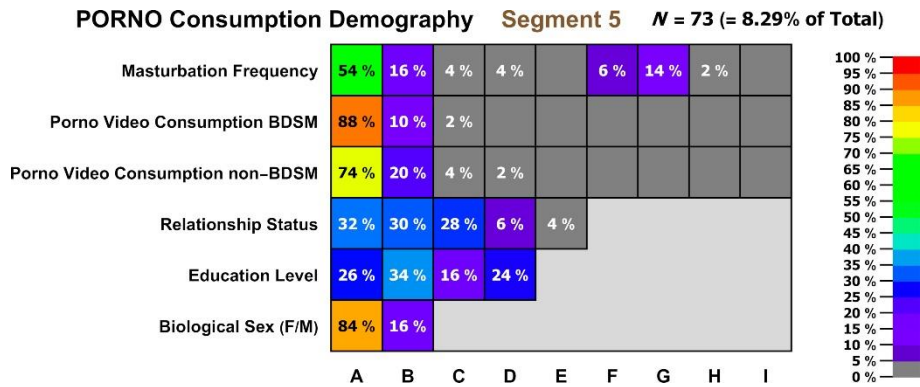
(c)



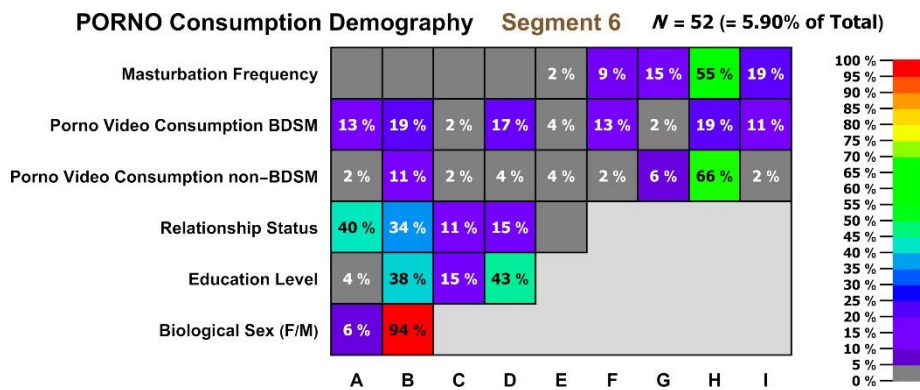
(d)



(e)



(f)



(g)

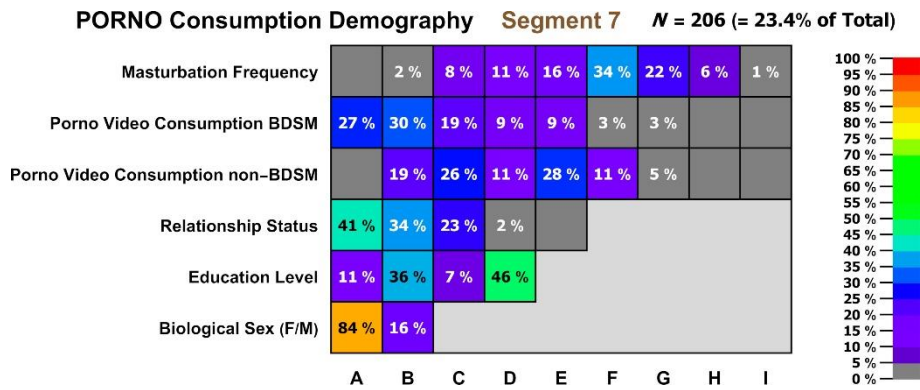


Figure 2 The heat maps of the relative frequencies of the attributes of the individuals in each of the seven segments detected by the K -means clustering algorithm of the dimension-reduced distributions of the 881 individuals (Fig. 1).

Segment Descriptions: We proceed to describe the characteristics of members in each cluster, derived from the heat maps.

Segment #1 (“The Conventional Ones”) (Fig. 2a): Although ‘only’ roughly $\frac{1}{5}$ of the sample, these members are best described as the ones with no unusual sexual attitudes in a libertarian society. Females and males are almost equally distributed; roughly $\frac{1}{3}$ have vocational education and roughly $\frac{1}{3}$ have a university degree. Roughly $\frac{1}{3}$ are married and few are divorced. Non-BDSM porno video consumption is largely between ‘hardly ever’ and at most fortnightly. BDSM porno video consumption is between ‘never’ ($\sim \frac{1}{3}$) and ‘hardly ever’ ($\sim \frac{1}{3}$). Masturbation frequencies occur between ‘hardly ever’ ($\sim \frac{1}{4}$) and once or twice a month ($\sim \frac{1}{2}$).

Segment #2 (“The sexually desiring males with low education”) (Fig. 2b): The members of this segment are $\sim \frac{1}{20}$ of the sample; they are best described as predominantly male with very high sexual consumption (evidently mostly non-interactive; $\sim \frac{2}{3}$ are unpartnered). Roughly $\frac{1}{2}$ have vocational education and roughly $\frac{1}{4}$ have a university degree. Both non-BDSM and BDSM porno video consumption is more than once a week (more than daily for $\sim \frac{1}{5}$ of the members). Masturbation frequencies are very high, from de facto daily to several times a day.

Segment #3 (“The females with very low sexual activity”) (Fig. 2c): The members of this segment are $\sim \frac{1}{7}$ of the sample; these (de facto) female members are best described as those with very little sexual consumption, having rarely watched a non-BDSM video and never watched a BDSM video. They are predominantly partnered ($\sim \frac{2}{3}$); rarely widowed ($\sim \frac{1}{8}$). Roughly $\frac{1}{3}$ have a vocational education and more than $\frac{1}{3}$ have a university degree. Masturbation frequencies are split: $\sim \frac{1}{2}$ rarely masturbate, while $\sim \frac{1}{3}$ masturbate a few times per week.

Segment #4 (“The males with very, very high sexual activity”) (Fig. 2d): The members of this segment are $\sim \frac{1}{5}$ of the sample; these (de facto male) members are best described as those with very high consumption of non-BDSM videos but who never or hardly ever watched a BDSM video. They are predominantly unpartnered ($\sim \frac{1}{2}$); some are married ($\sim \frac{1}{4}$). Roughly $\frac{1}{2}$ have vocational education and $\frac{1}{3}$ have a university degree. Masturbation frequencies are very high: more than $\frac{2}{3}$ masturbate weekly or more than once weekly.

Segment #5 (“The females with hardly any sexual activity”) (Fig. 2e): The members of this segment are $\sim \frac{1}{8}$ of the sample; these (de facto female) members are best described as those with no consumption of either BDSM or non-BDSM videos and who never masturbate (with a small exception of $\sim \frac{1}{5}$). They are either unpartnered ($\sim \frac{1}{3}$), in a relationship ($\sim \frac{1}{3}$), or are married ($\sim \frac{1}{4}$). Roughly $\frac{1}{3}$ have vocational education and $\frac{1}{4}$ have a university degree.

Segment #6 (“The unpartnered males with extremely high sexual activity”) (Fig. 2f): The (few) members of this segment are $\sim \frac{1}{17}$ of the sample; these (de facto male) members are best described as the those with a very high consumption of non-BDSM videos ($\frac{2}{3}$ daily) and an extremely high masturbation frequency (more than $\frac{1}{2}$ masturbate daily and $\sim \frac{1}{5}$ more than once daily). Surprisingly, their BDSM video consumption frequency is mixed; it is almost uniformly spread across the whole range. They are predominantly unpartnered ($\sim \frac{1}{2}$) or in a relationship ($\sim \frac{1}{3}$) but rarely married. Many (almost $\frac{1}{2}$) have a university degree.

Segment #7 (“The rarely partnered females with high masturbation frequencies”) (Fig. 2g): The members of this segment are $\sim \frac{1}{4}$ of the sample; these (de facto) female members are best described as the those females with a high fraction of university degree (almost $\frac{1}{2}$), predominantly without a relationship ($\frac{1}{2}$) or partnered — but not married ($\frac{1}{3}$) — and a high masturbation frequency ($\frac{1}{2}$ from fortnightly to daily; others even more).

Commonalities within all segments: We note that (biological) sex is unbalanced in all of the segments (but close to being balanced in Segment #1). We also note that extreme responses (namely, response categories beyond “G”) to non-BDSM and BDSM porno video consumption, as well as masturbation frequencies, are sparsely represented.

Overall, we can observe certain identifiable characteristics of individuals in each segment. These characterizations are often derisively characterized as “stereotypical”. Remarkably, irrespective of their being labelled as such, they indeed are identifiable characterizations. For example, females in

Segment #2, #3, and #5 live in villages and small towns (see below). Their sexual attitudes are very inhibited ('conservative'). The warning is: take note of the fraction of the sample population.

We know that the members in the different segments are characterized by different sexual attitudes, be it the frequency of their consumption of non-BDSM or BDSM porno videos and/or their frequency of (self-reported) masturbation. Fig. 3 shows that their distribution of observed frequencies appears non-uniform (in every segment), because the number of members in the different segments differ among one another.

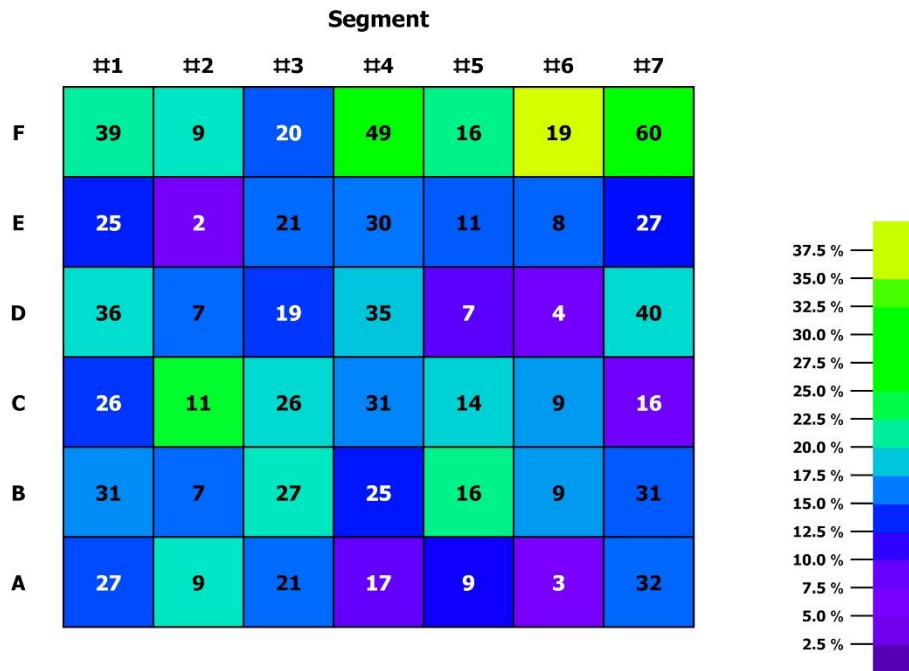


Figure 3 The demographic distribution of the members of the segments (the contingency table). The demographic categorical variables (columns) are the labels of village/town/city size in which the members live (Table 3). The segments are listed horizontally. The numbers in each square are the number of members of a segment living in the population category. The color coding of each square is the fraction of the members in a *segment* living in the respective population category.

Contingencies between segment characterizations and demography: Fig. 3 shows the contingency table for the relationship between population category and segment label. A test for uniformity of this contingency table is, of course, a χ^2 -test (Baguley, 2012). However, this test only specifies the probability of observing an inhomogeneous distribution; it does not reject the null hypothesis of the homogeneity of the distribution. In fact, assuming that a low probability of the χ^2 -test outcome rejects the null hypothesis is known as the “Prosecutor’s Fallacy” (Spiegelhalter, 2019). Krzywinski & Altman (2017) write: “Unfortunately, the P value is often misinterpreted as the probability that the null hypothesis (H_0) is true. This mistake is called the ‘Prosecutor’s Fallacy’. [...] Thus, a small P value (for example, $P = 0.05$) merely tells us that an improbable event has occurred in the context of this assumption.” Apart from being hardly informative, there exist two further shortcomings of the χ^2 -test: (a) the outcome of the test (the significance) does not inform the investigator of how the inhomogeneity (if present) results in the observed distribution, and (b) what fraction of the distribution

(uniform or otherwise) is due to noise. These shortcomings are overcome by applying Correspondence Analysis (CA; Greenacre, 2007; Beh & Lombardo, 2014). We apply both the χ^2 -test and CA to determine the demographics of the segments and, by implication, any possible associations (not: correlations — the response levels are categorical) between characteristic sexuality attributes (via segment labels) and population categories (sizes of the residences of the participants).

For the χ^2 -test: we obtain a significance of 0.596. We repeat: this value simply states how likely or unlikely it is to observe this distribution of demographic categories, without allowing a conclusion about the validity of the null hypothesis. A value of 0.596 thus indicates that this result is not unusual if one assumes the null hypothesis of uniform distribution — nothing more (Altman & Krzywinski, 2017).

Index No.	Singular Value λ_{index}	(Singular Value) ² λ_{index}^2	Fraction (%)	Cumulative Fraction (%)
1	0.160	0.0256	47.3	47.3
2	0.129	0.0165	30.5	77.8
3	0.0790	0.00625	11.5	89.4
4	0.0746	0.00556	10.3	99.6
5	0.0139	0.000192	0.4	100.0
6	0	0	0.0	100.0

Table 4 Program output of the SVD (singular value decomposition; Leon, 1998) of the contingency matrix (Fig. 3) after scaling (Beh & Lombardo, 2014).

We apply a SVD to the (scaled) contingency table and obtain the list of singular values, their squares and their contributions to the squared Frobenius norm (Table 4); the scree plot of the squares of the singular values (Fig. 4) indicate that three singular values extract the non-noise fraction (89.4%) of the

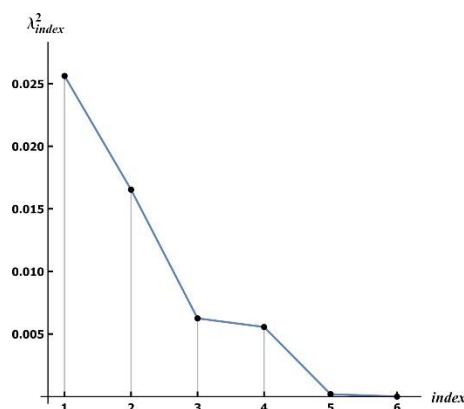


Figure 4 The scree plot of the squares of the singular values of the SVD of the rescaled contingency table. The sum of the squares of first three singular values contribute 89.4% to square of the Frobenius norm of the scaled contingency table (Table 4).

squared Frobenius norm (Leon, 1998). The listed squared singular values of the (normalized) contingency table indicate that there is an observed association between segments (columns) and

population categories (rows) and these associations can be visualized in a graph (Fig. 5). In contrast to the χ^2 -test, which only informs us whether the entries are uniformly (or close to uniformly) distributed, CA informs us that there do in fact exist associations between rows and columns of the contingency matrix — by extension, associations between size of residence and sexual attitude segment membership.

Fig. 5 shows these associations. They were determined by applying the DBSCAN clustering algorithm (Ester et al., 1996) to the (3-dimensional) coordinates resulting from SVD. We can observe the associations of the segments with the population sizes of the respondents' residences. Segment #1 associates most strongly with D, Segment #4 associates most strongly with E, and Segment #6 associates most strongly with F (cities with more than 1 million inhabitants). We note that Segment #7 associates with none of the population categories; consequently, sexual attitudes exhibited by members of Segment #7 are uniformly distributed across all population categories. Segments #2, #3, and #5 associate most strongly with population categories A, B, and C (i.e., villages and small towns with up to 20 thousand inhabitants).

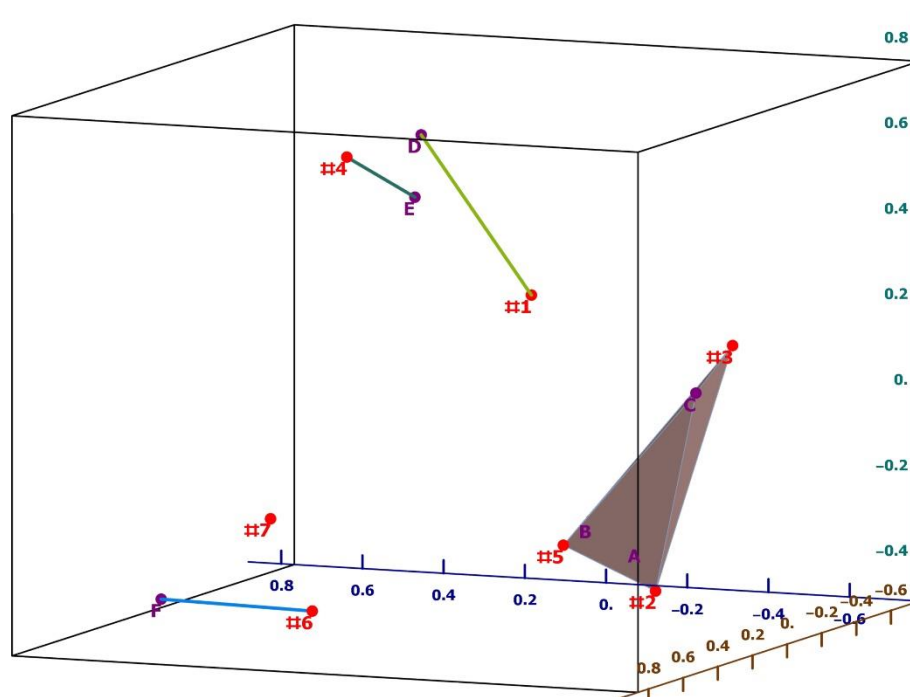


Figure 5 The results of a Correspondence Analysis of the detected association between the segments and the population categories (sizes of villages/towns/cities; Table 3). The red symbols are the segment labels; the purple capital letters are the population categories.

We note that three segments (#2, #3, and #5) have 252 members (29% of the sample), but that the sexual attitudes in these segments differ considerably. For this reason, the members in the different segments may not be considered uniform in their sexual attitudes, despite living in villages and small towns. Remarkably, segment #2 contains predominantly male members who are sexually very, very active, both with regards to porno video consumption and masturbation frequency. Segments #3 and #5 contain predominantly women who live in these villages and very small towns. These women — in

contrast to the males who also live in these villages and small towns — have remarkably subdued (‘conservative’) sexual attitudes. Stereotypically phrased, the women seem to adhere to a lifestyle which seems to enforce refraining from sexual desires, sexual inquisitiveness and sexual release activity. The males seem to be sexually frustrated and seek release in contrary behavior.

Discussion: In our study we have used a suite of novel methods based on Artificial Intelligence and unsupervised clustering algorithms. They revealed that different clusters characterizing individuals based on their sociodemographic characteristics, two kinds of pornography consumption, and sexual self-gratification frequencies. Our outcomes are comparable to findings in other, mostly Czech, studies. It should be pointed out that Czech society is considered very open-minded and tolerant (in politically liberal terminology) in issues sexual (Widmer et al., 1998). However, in contrast to previous findings, we discover that there are sizable fractions of the Czech society that cannot be characterized in this way.

For this study, a large fraction of the sample was recruited so as to be representative of the Czech population aged 18–50 years. As Table 1 shows, this is indeed the case. No sample has only participants less than 45 years of age. Fig. 4 also shows that the distribution of participants across the population categories is quite uniform (the χ^2 -test also shows this). Therefore, any non-uniformity of age (and, for that matter, education, etc.) is due to the peculiar sexual attributes within each segment.

Education levels: the education level “C” (completed secondary schooling) is, in every segment, represented with a low percentage. This low percentage is unavoidable, because, in ‘advanced societies’ (i.e. those with a well-structured tertiary education system and an adequate economic base), students of secondary schools habitually proceed to colleges, universities, etc. Only due to the coincidental timing of questionnaire participation with the transition from secondary school to institutions of tertiary education will the low fraction of category “C” be noticed. In any case, inspection of segments illustrated in Fig. 2 show that no characterization differences between the segments are ascribable to the low fraction of this group of participants.

Issues concerning stereotyping: Characterization and description of attributes of members in the different segments has been called ‘stereotyping’ by (typically politically focused) critics. Nonetheless, the statistical methods presented here document that such stereotypical descriptions are not only apt, but also well supported by our findings. We find, indeed, that certain ‘types’ of males and females are most likely to be found in villages and small towns, and other ‘types’ in large cities. This begs the question as to whether the population categories infer sociological descriptors, such as ‘libertarian’, ‘conservative’, ‘non-progressive’, and so on. We note that (a) such sociological categories seem to exist and are made manifest in the sexual attitude variations between segments; and (b) sociological attitudes can be detected by the porno video consumption and differing masturbation frequencies in the different segments. These clusters are statistically independent units (and refute

claims about the expression of certain traits being normally distributed in the population; del Giudice, 2009), an observation that should be helpful for guidance of future therapeutic and research work.

We find that our statistical methodology is very powerful in detecting two aspects of sexuality-related porno consumption and self-reported masturbation frequencies. Because we have analyzed a large sample (881 participants) that has a very close to representative distribution throughout the Czech Republic, we anticipate possible similarities in such attribute distributions, concomitant with demographic categories in other nations with comparable infrastructure, well-structured tertiary education system, and advanced (more high-tech than manufacturing) economies.

In order to detect possible clustering of the registrations in CA, we used the DBSCAN clustering algorithm (Ester et al., 1996), because it is an unsupervised clustering algorithm, meaning that the number of clusters is not externally controlled. The associations between population categories and segments relies on DBSCAN's performance advantages.

Non-self-evident patterns: It may seem frustrating to the reader of this manuscript that patterns in the heat maps are not self-evident (Fig. 2): the separations are often (weakly) transient. This is, however, a consequence that *all* the registered categories are interdependent. When searching for patterns, we humans have a tendency to look at one or two categories in isolation. Outputs of neural network algorithms expressly do not cater to this, because (the unobserved) interactions are also present as confuters in the heat maps.

Overlap of the sexes: We first address specific findings that relate to previous published ones. First, we find that the segments are never composed of individuals of solely one sex. Other published findings show a large overlap between sexual preferences even though the benefits for a member of one biological sex need not be evidently present in the other (Binter et al., 2013). There may be a large difference between the sexes (Del Giudice, 2009) but that does not infer zero membership of the other sex in a segment. In our detected segments, 4 out of 7 have at least 15% of the other biological sex.

Segment #1 contains 20.9% of all participants, (41% male). Members have a positive attitude towards sex and enjoy pornography, but more as an inspiration (Smutny & Sulc, 2018) than as primary means of satisfaction; they can be considered non-problematic users (Logue, 2018). The largest segment, (Segment #7, with 23.4% of all participants), consists mainly of females (84%) who are rather experimental and (sexually) open-minded, and share the characteristics of non-problematic porn use with the Segment #1. Individuals in this segment, we note, have a high consumption of BDSM pornography.

For two segments (#2 and #6) we observe the compulsive use of pornographic materials, as has also been observed in other studies (Gaither & Sellborn, 2003; Vaillancourt-Morel, 2017; Logue, 2018). Members of Segment #6 are largely unpartnered men who prefer non-BDSM pornography. They are located in Prague (the only city in the Czech Republic with more than 1 million inhabitants) and are

highly educated. Therefore, the unavailability of partners cannot explain their sexual attributes. For members in Segment #2, on the other hand, the porn consumption and high masturbation frequency can be ascribed to a compensatory mechanism due to the unavailability of a consensual partner (Binter, 2013; Smutny & Sulc, 2018). These — predominantly male — members have low education level and live in towns and smaller cities; their position on the partner market is low (Edlund & Sagarin, 2014). Their high BDSM video consumption suggests a compensation mechanism and (presumably) masturbation while watching such movies putatively serves as a fulfillment of their sexual drive (Smutny & Sulc, 2018). These two segments, in which the masturbation frequency is maximal (daily or even more frequently), constitute approximately 11% (5.11 for #2 and 5.90 for #7) of the participants — in agreement with Smutny & Sulc (2018). Many other studies dealing with problematically high pornography consumption also find fractions of approximately 10% (Castro-Calvo et al., 2020). One suggested mechanism could be the repeated gratification caused by a ‘supernormal stimulus’. Such a ‘supernormal stimulus’ (Průšová et al., 2021) is based on tuning one’s perception system so as to maximize gain (Buchholz et al., 2021) when presented with a variety of stimuli, one of which is perceived as “better than real” (such as an oversized egg made of plaster is preferred by birds over their own eggs; Tinbergen, 1953) — a preference that is occasionally maladaptive. It should be especially frustrating for these men to share community space with women from Segments #3 and #5!

Segments #3 and #5 have two commonalities; one is residency in small towns (resulting in a decreased chance of meeting partners), and the other extremely low pornography viewing frequency. The AI algorithms detected a difference, however: members of Segment #5 have a low sexual drive when estimated via masturbation frequency, while members in Segment #3 have a varied propensity to masturbation (also including high frequencies thereof). Remarkably, Segment #3 includes the highest proportion of divorced individuals and lowest of singles. Segment #3, we suspect, contains the members that have a low sexual activity for social reasons. Perhaps some of these individuals may be transiting between partnerships. A different suite of possibilities is: these people (a) have low socio-sexuality (Penke & Asendorpf, 2008), (b) may have had few sexual partners since their sexual maturation, and (c) are a priori sexually inhibited.

Conclusions and Recommendations

The use of a neural network for analysis overcomes several statistical challenges. One is the ‘curse of dimensionality’. The neural network reduced the dimensions from 38 to 3, discarding noise (by reducing entropy) without discarding any information (namely, the interdependencies — including nonlinear ones — between the components of the original 38-dimensional feature vector). The use of clustering algorithms can detect commonalities between segments of the population: what sexuality attributes (masturbation frequency, porno movie/video consumption, and partnership relationship — which itself is also a sexuality indicator!) they possess at the time they completed the questionnaire. In

the Discussion section, we provided indicators that the common features of the respondents are *more* than indicators of plausibility; we provided rigorous arguments why the commonalities of the members in each segment do indeed demonstrate that a stratification of the sexuality attributes in the Czech population can be detected by using artificial intelligence.

Neither the sexual attributes nor the participants' demographics are uniformly distributed. Of utmost (medical and psychological) concern are members in segments that exhibit overly compulsive sexual behavior, such as masturbation (accompanied by porn video consumption) far beyond normal. In fact, 'normal' consumption can be detected by the AI methods we implement herein. Arguably, 'normal' can be defined using AI. Those members with overly compulsive behavior are in need of help.

Sexologist and therapeutic specialists involved with attempting to help these people can gain helpful insight as to how such compulsive behavior is interrelated with frequencies of masturbation, and with BDSM and non-BDSM porno video consumption. Members of the opposite extreme, those with very suppressed sexual activity and hardly any consumption, may also be in need of therapeutic intervention. Evidence for this need is rare; society, it seems, does not consider these people to be in need of a more fulfilling sexual gratification.

Furthermore, we find that the observed stratification of sexuality has a demographic aspect. Certain types of sexual attitudes are found only in villages and small towns, whereas in large cities all sexual attitudes are present, albeit in varying distributions. This is, to our knowledge, the first study that provides such data-based associations.

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Conflicts of Interest The authors declare no conflicts of interest.

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5 Conclusion: Are Paradigm Shifts Achievable in Human Sexuality Research?

Currently, the status of research into human sexuality is mainly driven by traditional psychological methodology. Now research has reached a point where this traditional mode has become more and more wanting, — because, among other issues, a majority of elementary topics remains uncovered. It is by no means clear that psychological explanations (be they founded in some semblance of a theory or not) do justice to the biological manifestations of human sexuality. Arguably, the biology drives the psyche, and not the psyche drives the biological response. This reverse of cause-and-effect is due to our observations of notable changes in the world around us. It is filled not only with humans, but with their technology, specifically, in the context of this thesis, audiovisual presentations, wearable sensors mapping the state of physiological state of a wearer at any given moment, and virtual realities that also include sexuality driven ones, such as pornography. Enhancements of the electronic hardware drive analytical approaches. Analysis now is driven by the hardware department, not by attempted refinements in quasi-humanistic perceptions of humanity. Arguably, far more complex methods of analysis are required; seemingly never-ending discussions about what to include and what to discard in questionnaires do not offer adequate (insightful) progress. Not unexpectedly, magnitudes of data sets that include metrics have exploded, necessitating advanced statistical analyses that are far beyond comparisons of means and correctly applied ANOVA. The manifestation of sexuality in the world is more and more affected by the entertainment industry, and, whenever there is a new technology, it is immediately adopted and engulfed by sex-related topics. Even populations that were not drawn in in the past now participate. Superficially, it is arguable that most of these advancements are predictable and do not necessitate a paradigm shift. The virtual stimuli creation itself also does not constitute paradigm shift — so this argument claims — since a gradual and accepted increase in the ability (and availability!) of technology and the concomitant modifications of predictions were known since 1960s.

Now, however, when we can achieve a certain level of believable alternative-world (or otherworldly?) creations, these will allow us (and force us) to fool ourselves not only sensually. This novel Umwelt (in the Uexküllian sense) will soon become a fascinating environment because the boundaries of the real-world will then perceptually no longer exist and it will fuse with the virtual and augmented reality so as to constitute a Brave New World, hopefully without the insinuated irony. Presently, we find ourselves trapped — while the

Uexküllian Umwelt gains momentum. It is not yet cheap enough nor of high enough quality to be an all-purpose playing field for the budget- and time-constrained research environment. And we should not forget the lack of ethical boundaries and safety-fuses. This Brave New World will generate not only new sexuality, but also a new paradigm of how to think about it. Of course, the biological determinants will not disappear, but how we theorize about them will require a radically different approach as to how hypotheses are formulated (if at all) and whether there exist hypotheses that can be tested. In the future, we argue, the Umwelt will force us formulate new theories. I note that theories can be tested without formulating testable hypotheses.

There are many parallels of how this happened in other realms of science, not only the oversimplified and popularized Kuhnian paradigm shift from the Ptolemaic to the Copernican universe. When Bunsen discovered the existence of spectra, chemists embarked on identifying the presence or absence of elements in any environment they could observe, even at very low concentrations of the elements to be observed. The surprise came when spectra were discovered that did not allow for the identification of an element. The unidentified spectrum was discovered by Fraunhofer and chemists, physicists and astronomers were required to postulate the existence of a further element: Helium. Likewise, a careful measurement of the fraction of Nitrogen in the atmosphere forced Ramsey to postulate the existence of a whole new group of elements in the Periodic Table of the Elements: these are the Noble Elements. (Ramsay called them “Noble Gases”, because the technology needed to liquefy these elements was not available in his time.) The paradigm shift is obvious: a tool devised to enhance the understanding of the chemists’ world now forced chemists to think differently about this world — an altogether different world; namely one in which elements existed that were inaccessible to their laboratories. The merging of the world holistically perceived (in a neoplatonic sense) and attempted to be understood by traditional, psychology-driven sexuality researchers with the virtual world of computer games and online pornography transforms how to theorize about human sexuality, accompanied by radically novel methods of data evaluations. The analogy of the paradigm shift in chemistry from reaction chemistry to spectral chemistry resulted, ironically, in chemists realizing that there exist elements that don’t react. The discovery of expressions of human sexuality in the world of online pornography and other phenomena in the world of virtual reality necessitates a paradigm shift from hypothesizing in greater detail about human sexuality to a radically different aspect of human sexuality. In both cases, however, these paradigm shifts neither discard the world of chemical reactions nor the world of sexuality that is the basis of reproductive success. So —

to be specific about sexuality — constructivist musings that human sexuality has nothing to do with reproduction and enhancing fitness in the biological sense is analogous to the misperception of chemists no longer being interested in chemical reactions. The (radical) paradigm shift in chemistry that led to the incorporation of quantum mechanics is the same as the (radical) shift in the research about human sexuality that necessitates the use of wearables and application of neural networks. I argue for the following in this thesis: our perception of human sexuality is insufficient: we need to base human sexuality research much more in biological contexts (sensory perception is, after all, a biologically understood phenomenon).

Where we can see (and also expect) the paradigm shift is in the analytical approach. The current system of research focusses on the very exact description of all the details about the hypothesis creation, data collection, data handling, hypothesis description and comparisons of putative outcomes. In many cases pre-registration, uploading to servers in form of “pre”-publication, as adopted from physics, is a useful pre-condition for high-ranking publication. Any deviation from this path to academic respectability threatens the career of the researcher. Alas, it ensures the perpetuation of fallacious and antiquated (woefully inadequate!) analytical methods of data analysis: supporting hypothesis that describe noise and not true signals, falling victim to the curse of dimensionality, handling ordinal data as scales, and computing indices. It seems ironic that the advent of the paradigm shift to studying human sexuality as an expression of a biological substrate is accompanied by a paradigm shift to statistical analyses away from point Laplace paradigm defined estimators to Bayesian statistics involving likelihood functions and towards the machinery of neural networks and clustering algorithms. There are many particularly well established researchers who have been creating a barrier to prevent the unleashing of the novel approaches described in this thesis. These barriers we have experienced personally multiple times in the form of responses to conference presentations and in severely incompetent reviewer comments about submitted manuscript to prestigious journals. We have received feedback on our work in human sexuality that is closer to sect-like behavior (to quote one reviewer: “I do not understand it therefore I do not believe it; do it the way I do it.” And, to quote another one: “I do not believe your statistics and so I recommend rejection of your submission.”) than to the oft-claimed mantra that peer review ensures quality. Angry avoidance of paradigm-shift related discussions and behind-the-back criticisms by some researchers maintains the belief in continuums of personality measures and the usefulness of correlation.

After one hundred and twenty years of approaches based on point estimators and 60 years of use of NHST, despite the knowledge of its fallaciousness, there is space for improvement and, more specifically, adoption of advanced reliable, rigorous methods. Many of the analytical approaches that were, in the past, limited by the computation prowess. The world was analyzed by the slide rule (and Nobel Prizes won by using it); it was, in some way, the best tool available until the 1970s when the personal desk-top calculator was invented; in those days, the methods of evaluation had to be simple enough to be handled. Computational prowess, powerful algorithms, and massive data sets do not infer that the hypotheses-testing approach should be continued. Confidence in established methods is no guarantee of their validity. Limitations in prowess, fallacious algorithms and small data sets are rapidly disappearing, and the majority of data-driven sciences (astronomy, particle physics, economics, genetics) is already relying on appropriate analyses. It is time for research into human sexuality to do likewise.

Advanced technology has entered our home gadgets, our pockets and our sexuality. Irrespective of what the dangers, risks and benefits are there are, developments in other fields will trigger applications that will be used in sexual entertainment and will necessarily force human sexuality researchers to focus on these. Online pornography was not available at all until 1990s and reasonably fast audiovisual porn sites with high resolution appeared in the early 2000s. Now, VR webpages are readily available, as well as many additional computer devices and pleasure enhancers. In the near future, human sexuality research will have to come to terms with these interdisciplinary phenomena. Advancements in some many fields: stimuli presentation, objective measurement availability, big data availability, and analytical tools can fall into the lap of researchers whenever they actively seek it. Two examples: cookie tracking allows for incredible data acquisition and the seemingly innocuous smart-watch has sensors that approach the quality of medical grade devices, and can be employed for very many physiological measurements.

Imagine a world in which the sexual behavior with real biological partners is combined with the stimuli from augmented or virtual reality; your physiological activity is continuously tracked, and your sexual arousal is enhanced via scenario adjustments that employ brain-computer interfaces. The latter not only acquires high-accuracy data, but its continuous analysis also keeps you safe. That may be the world in few years from now. Sex-researchers, get ready.

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Exploring the Pathways of Adaptation an Avatar 3D Animation Procedures and Virtual Reality Arenas in Research of Human Courtship Behaviour and Sexual Reactivity in Psychological Research

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Abstract

There are many reasons for utilising 3D animation and virtual reality in sexuality research. Apart from providing a mean with which to (re)experience certain situations there are four main advantages: a) bespoke animated stimuli can be created and customized, which is especially important when researching paraphilia and sexual preferences; b) stimulus production is less expensive and easier to produce compared to real world stimuli; c) virtual reality allows us to capture data such as physiological reasons to stimuli, that we would not be able to otherwise (without resorting to self-report measures which are especially problematic in this research domain); d) ethical, legal, and health and safety issues are less complex since neither physical nor psychological harm is caused to animated characters allowing for the safe presentation of stimuli involving vulnerable targets. The animation sub-group has been exploring so far several production quality levels and various animation procedures in a number of available software. The aim is to develop static as well as dynamic, interactive sexual stimuli for sexual diagnostic and therapeutic purposes. We are aware of number of ethical issues related to the use of virtual reality in proposed research are analysed in this chapter.

Key Words: 3D animation, sexual response, virtual reality, paraphilia, psychophysiology, partner choice.

The processing power of computers has been growing exponentially, propelling the emergence of a whole new set of tools for displaying and experiencing digital data. Text-based interfaces were gradually replaced by moving images before computers finally grew able to handle large sets of 3D coordinates, enabling the first interactive experiences taking place in virtual space.

More recently, advances in technology that harness the increasing power of computer hardware has made great strides toward making virtual reality (VR) environments feel as believable as possible.

Although VR has traditionally been considered an enabling technology for videogames, given its versatility and increasing sophistication, it comes perhaps as

no surprise that VR methodology is quickly gaining a foothold in areas outside entertainment.

Military, education and healthcare are but a few examples of fields where VR technology experiences a significant growth. The ability to visualize and re-enact practically any real world scenario from within a lab or a training facility has proven to be exceedingly useful whilst being safer, less costly and far more flexible than more traditional experimental or training methods. Moreover research areas such as psychiatry are frequently utilizing VR as a diagnostic tool allowing scientists to produce accurate diagnosis by utilizing it in combination with other methods such as MRI scans, psychophysiological measures, self-reported data, observational inputs (by third person).¹

In 2015, National Institute of Mental Health has been established as a new centre of research and leading institution in Czech Republic for psychiatric treatment as well as psychological and diagnostic research. The institute comprises more than thirty research groups with various specialisation. We are an interdisciplinary research group of Evolutionary Sexology and Psychopathology, that is interested in several research topics ranging from investigating factors relating to sexual orientations, sexual activity preferences (e.g., sado-masochism), and sexual pathology, and behavioural aspects of sexual relations such as non-verbal behaviour, power and dominance. Currently, we are working to develop techniques in 3D animation and virtual reality that can be applied in our studies. Our projects demand us to recreate various social interactions that cannot be manifested in reality, in VR, to later serve as stimuli in an experimental study. This goal introduced us to a number of technical challenges stemming from the fact that we needed to accurately recreate human (non-verbal) behaviour, including gesticulations and facial expressions, with a high degree of reality.

Because manual creation of such animations requires a considerable time investment and the qualitative outcome of the process can vary, therefore we currently explore the idea of developing stimuli using motion sensors which allow us to record the given social interactions performed by real actors and then translate the recordings into animations. We believe that systems such as motion sensing device² in combination with relevant motion capture software packages, e.g. Faceshift or iPiSoft, may represent a viable framework allowing us to record various social interactions for their later accurate recreation in virtual reality. It is also considerably less expensive and more time efficient. Once generated, animations can be mapped over any 3D figure representing a virtual human, thus allowing for the speedy generation of different versions of any potential stimuli.

The potential benefits of recording human animations using motion sensors are further amplified when considering that such recordings can be translated in more robust 3D packages, such as Maxon Cinema 4D or Autodesk MotionBuilder, for further adjustments since these provide the user with ready-to-use motions and

possibilities of blending existing ones with those developed by using motion capture.

Generating realistic virtual human characters is another significant challenge for our research. However the time generally required to create and manually texture sufficiently detailed 3D models prompted us to investigate alternative approaches. Solutions such as DAZ Studio or MakeHuman were found to offer a comparatively time efficient framework allowing us to procedurally transform basic humanoid models into desirable characters with relative ease.

Virtual characters can be brought to life through animations captured with a motion sensor and can finally be used to populate interactive virtual environments using the Unity 3D game engine. Our evaluation and estimation - comparison of costs, time efficiency, easy and intuitive operating, possibility to transfer data to other software, error rate, and hardware setting - suggests that such a pipeline might provide us with the most viable results.

Bellow we present an example of two research designs (dealing with timely topics in the field of sexology), where the possible application was discussed for years but the technology was not in reach and/or the software was not on today's level of accuracy and graphics to serve well to the research aims.

2. Current Applications

2.1. Application 1: The Study of Ontogeny of Nonverbal Courtship Behaviour in Women

One of the most important choices made by an individual is the selection of a sexual partner.³ Previous studies have described a system of non-verbal communication labelled 'courtship' that facilitates successful access to individuals of the opposite sex.⁴ A number of studies⁵ were focused on courtship behaviour especially in adults but there is minimal knowledge about development of non-verbal behaviour in childhood and young adulthood. The research is focused on ontogeny of female courtship behaviour during the lifespan which is a topic that has not been investigated in detail yet, but has important implications for treatment of various paraphilic disorders. Particularly, it is unknown in what age category the courtship behaviour appears, how it is modified during the lifespan and if there are inhibitory mechanisms that allow men to detect and sexually react exclusively on nonverbal courtship displays of women in reproductive age. Therefore, in this research, we focus on a) detection and animation of pure non-verbal behavioural displays in females of various age categories, and b) on perception of courtship in different age groups by male raters.

Therefore we decided to use motion capture followed by 3D animation to capture the nonverbal behaviour of six age categories of girls and women (age categories chosen to cover important periods of psychosocial development in females⁶). The intention is to combine movements obtained from motion capturing

sensors with avatars of physical features corresponding to various age (in experimental setting) to test the reactions on pure nonverbal irrespective of variability in physical traits of target stimuli.

In the first step, the actors-volunteers representing each age category will be asked to present non-verbal behaviour displays of courtship during which movements are tracked by motion sensing sensors. The instruction are as follows: ‘Imagine an attractive man and act in a way you would gain the attention of a potential “partner”’. The sub-adult volunteers⁷ will be asked to interact with an unknown but sympathetic adult person of the opposite sex in a friendly manner.⁸

Then, we intend to create the stimuli rated by men of more age groups under the experimental conditions as follows:

1. Sub-adult avatar animated with courtship non-verbal displays of a female of the same age category,
2. Sub-adult avatar animated with courtship non-verbal displays of an adult female,
3. Adult-looking avatar animated with courtship non-verbal displays of sub-adult female,
4. Adult-looking avatar animated courtship non-verbal displays of an adult female.

If adult males rate adult female avatars animated with courtship non-verbal displays of sub-adult females as comparably attractive to adult avatars animated with non-verbal displays of adult female we would reveal that courtship is learned through imitation of post-pubertal models (parents, etc.). If the adult avatar animated with behaviour of a sub-adult female is rated as less attractive than the adult avatar animated with adult behaviour, it supports the theory favouring the explanation that courtship develops from age specific general social behaviour.

2.2. Application 2: The Study of Sexual Variation: Prevalence across Population, Physiological and Neural Correlates During Experimental Exposure to Erotic Stimuli

In the next project, we plan on using the VR for development of stimuli that would allow us to determine whether an individual has paraphilic sexual preferences - with a specific focus on Paedophilia. Particularly, we test the theory that the etiology of paedophilia is linked to inappropriate content of sexual motivational system.⁹ Namely, there should be the appetite of non-verbal behavioural displays presented by children in affiliative situation that are false detected/misinterpreted as courtship behaviour and have a potential to start-up

sexual reaction, whilst in normal population (heterosexual males attracted to adult women in reproductive age) these displays inhibit sexual reaction as well as negative proceptivity - rejective or startled reaction. In the project, the target subjects will be presented in VR by animated avatars with appropriate nonverbal displays¹⁰ while the psychophysiological reaction of male subjects is measured (PPG,¹¹ GSR,¹² ECG¹³).

To create the behavioural displays patterns of stimuli, we will ask female actors to act out positively - flirtatiously (friendly for children) towards a potential sexual partner (an unknown but sympathetic adult for children), in second situation negatively and will display rejection towards a partner (hostile for children). The dyadic interaction between two actors will occur but only target stimuli will be captured. The final sequence (avatar with nonverbal behavioural displays) will then be presented from first person perspective (point of view of person interacting with target stimuli) to evoke the feeling of interaction (from point of view of the interacting partner - unique to our study). This will allow for the creation of virtual versions of the video stimuli using 3D avatars as target objects that have several advantages:

1. Avatars of average faces and bodies can replace the actors,
2. Physical traits of objects can be manipulated (we will create set of paedophilic target stimuli in paraphilia-related preferred age groups (based on current scientific research), possessing the typical physical features of the child in the appropriate age group and having age-typical friendly non-verbal behaviour displays),
3. Avatars can replace actors in phase of receptivity/copulation,
4. Avatars can be presented in 3D reality using oculus rift, evoking the feeling of real interaction.

To our knowledge, only one research team worldwide has already successfully employed avatars corresponding to different developmental stages in study of paraphilia.¹⁴ For this study we will obtain three samples - volunteers with no paedophilic preference, volunteers with paedophilic preference but without history of child abuse (from paedophilic community we closely cooperate with) and patients with paedophilic disorder with history of child abuse who will voluntarily undergo the procedure. As part of the procedure we will measure physiological reactions such as penile tumescence, simultaneously with galvanic skin response, electro cardio graphy, and fMRI¹⁵ data will be collected during the procedure to explore reactions in different participating groups.

3. Ethical Constrains

We are aware of numerous ethical controversies connected with the proposed research topics - especially because the study involves children-actors as participants and stimuli. We already went through large amount of consultations of stimuli content with forensic experts and judge advocates in field of sexology. We do have a permission of ethical committee¹⁶ to run the study and it is supported by representatives of mental hospitals in field of sexology we closely cooperate with since there is urgent need for development of standardized set of stimuli for more accurate testing of paraphilic preferences.

In first study, we believe fewer controversies will occur since the aim of the study is generally non-conflicting with Czech law.

For study 2 child-actor- based avatars will not be presented in the erotic pose, the main focus is on child - typical nonverbal displays in avatars. Also we guarantee strict anonymization of data, in all parts of study and special attention will be focused on blindness of researches to individuals diagnoses, volunteer participation of all individuals, training of researchers/clinicians in techniques of communication on sexual topics/debriefing, intimacy assurance during testing and security arrangement during testing and after testing - skilled psychologist and psychiatric doctor will be present in all times and the supervising MD will be available for case of complications of any kind. Participants will be debriefed with non-interesting neutral film for purpose of lowering excitation of the participant lasting 30 minutes and will be contacted in time periods of 12 hours, 36 hours and one week after participation. No person will be forced to participate and everyone is allowed to end the procedure at any time. To avoid risk of unexpected complications during commuting, patients (and volunteers) will be transported to Institute on our expenses.

Notes

¹ Matthew Price and Page Anderson, 'The Role of Presence in Virtual Reality Exposure Therapy', *Journal of Anxiety Disorders* 21.5 (2007): 742-751.

² In our case Kinect 2 - body, and Intel RealSense - facial expressions.

³ Monica M. Moore, 'Nonverbal Courtship Patterns in Women: Context and Consequences', *Ethology and Sociobiology* 6.4 (1985): 237-247.

⁴ Ibid, 237-247.

Karl Grammer, 'Strangers meet: Laughter and Nonverbal Signs of Interest in Opposite-Sex Encounters', *Journal of Nonverbal Behavior* 14.4 (1990): 209-236.

⁵ Moore, 'Nonverbal Courtship Patterns in Women', 237-247.

Grammer, 'Strangers meet', 209-236.

⁶ Erik Erikson, 'Eight Ages of Man', in *Childhood: Critical Concepts in Sociology*, (2005): 313.

⁷ Age categories under 15; parents will obtain the detailed script of the scene before they underwrite the informed content about the participation of their child in the project

⁸ Just introducing themselves in a way to gain the attention of the adult.

⁹ Kurt Freund and Ray Blanchard, 'Phallometric Diagnosis of Pedophilia', *Journal of Consulting and Clinical Psychology* 57.1 (1989): 100.

¹⁰ Adult man and woman, children of both sexes aged 6-7 years.

¹¹ Penile plethysmography (PPG): measurement of penile responses to stimuli that vary on the dimensions of interest. It is considered to be a specific measure of sexual arousal. For simultaneous measurement of PPG and fMRI we will use MR compatible custom-built penile plethysmography recording system HEINRICH SOM-04.

¹² Galvanic skin response (GSR): measuring electrical conductance of the skin using electrodes placed on a patient's body. Increase of sweat glands is considered to be signal of emotional excitement. We will use standard GSR equipment of Biopac systems.

¹³ Electrocardiography (ECG): recording the electrical activity of the heart over a period of time using electrodes placed on a patient's body. Increase of electrical activity is considered to be signal of emotional excitement. We will use standard ECG equipment of Biopac systems.

¹⁴ Renaud Patrice, Trottier Dominique, Rouleau Joanne-Lucine, Goyette Mathieu, Saumur Chantal, Boukhalfi Tarik and Stéphane Bouchard, 'Using Immersive Virtual Reality and Anatomically Correct Computer-Generated Characters in the Forensic Assessment of Deviant Sexual Preferences', *Virtual Reality*, 18.1 (2014): 37-47.

¹⁵ Functional Magnetic Resonance Imaging (fMRI) is well-suited method for studying local and network brain functional correlates of psychological processes. fMRI uses Blood-Oxygen Level Dependent (BOLD) contrast, reflecting amount of oxygenated blood in an area, as an evidence of neural activity Measurements will be conducted using 3T Siemens device.

¹⁶ On National Institute of Mental Health, Klecany, Czech Republic.

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Use of Virtual Reality and Human-Computer Interface for Diagnostic and Treatment Purposes in Human Sexuality Research

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Abstract. Virtual reality technology allows designing of immersive virtual environment that might be used for diagnostics and treatment of persons with minor sexual preference that is ego-dystonic or is perceived as dangerous to society. We do operate with the theoretical framework that is based on sexual motivational system, which we reintroduce. The eye tracking, electroencephalography and galvanic skin response in combination with phalopletysmography – the change of penile tumescence in male users are data to be collected to distinguish between sexual arousal and stress. The bio-cybernetic loop will consist of combination of positive and negative feedback loop to diverge the scenario. The biofeedback training should allow us to shape the preference by employing biofeedback training of suppression of the arousal to previously created scenario. This procedure might allow better diagnostics and treatment. Although we have in mind individualization of scenario creates problems in comparison during diagnostic phase, and is more important in case of future therapy. The resulting adaptable GNU software will be available to partner and other interested research centers.

Keywords: Virtual reality · Bio-cybernetic loop · Biofeedback · Sexual paraphilia · Diagnostics

1 Introduction

For decades, we may trace the growing interest in design of a direct human-computer connection amongst professionals, enthusiasts, and even public. Until constructing first bio-cybernetic loop (also human-computer interface) [1], the human-computer relationship may be best described as monologic – the initiation has always been on the side of human and all input are highly asymmetric. The standard control of the computer is implementing the keyboards, mouse, joysticks or various types of touchpads, and more recently touchscreens. The volume of information that one person would gather on/from computer is much higher than the computer could gather about the person who is in control. A dialogue, two-way information sharing, would be much more advantageous since there is very specific population that is mostly disqualified from using standard ways of controlling electronic devices i.e. users with disabilities.

There are several approaches to enable their engagement in computer control. The first and currently easily accessible interface is a voice-control that allows a user to execute the additional activity while using their hands for primary activity simultaneously. So, in this case we can talk about the monologue even literally. Electroencephalograph (EEG) has also been implemented to allow paraplegic users to control their electronic devices.

EEG was originally, in HCI context, applied to diagnose specific brain activity and distinguish between several mindsets such as engagement in the task or extreme workload. That is why NASA has adopted this technique to diagnose pilots' ability to cope with specific situations that can occur during aerospace operations for example [2]. The examples listed in this contribution do relate to the unidirectional information flow from human to computer. These examples can also state control measures during psychological testing to obtain data about the subject's attention where adaptation is not undergoing analysis based on the EEG data [3]. These approaches are characterized by the fact that does not need real time feedback and might be analyzed retrospectively but are generally applicable to non-patient population.

With a priority to focus more on the dialogic options, we might set an extension of the above mentioned examples to change the environment based on the information obtained through psychophysiological measures [4]. Users of such loop are often healthy users and one of the intended implementation is in area of entertainment. We are informed about ongoing research on other applications of bio-cybernetic loop in psychology related research.

While there are unquestionable benefits raising from adoption of such approach, we may trace related risks. The gameplay relation must be executed in a real-time or close-to-real-time mode of analyses and adjustment. The user and gaming-like application need to set up a sort of co-evolution while using such a platform, especially in the initial phases. In other words, the butterfly effect of player-game interaction will occur [5]. That avoids comparative measuring of players' gameplay performance due to differences in gaming environment design as each players' gameplay establishes an individualized environment for each player. The same problem we can spot when using bio-cybernetic loop for scientific use, namely diagnostics. In our research, we attempt to challenge this premise.

Currently, we do proceed with a research on (above-listed options) at the Laboratory of Evolutionary Sexology and Psychopathology associated with National Institute of Mental Health in the Czech Republic.

2 Current Research

Our recent research activity has been including as one of the team priorities a focus on utilization of immersive virtual reality technology and animated avatars design. We may list a number of benefits when implementing virtual reality technology in sexuality research such as: (a) bespoke animated stimuli can be created and customized, that is especially important when researching paraphilia (unusual sexual preference) and sexual preferences; (b) stimulus production is less expensive and easier to produce when compared to real world stimuli; (c) virtual reality allows our researchers to record

data such as physiological reasons to stimuli, data that would be normally not available to capture before (without resorting to self-report measures that are especially problematic in this research domain); (d) ethical, legal, and health and safety issues are less complex since neither physical nor psychological harm is being caused to animated characters, which allows for the safe presentation of stimuli involving vulnerable targets [6].

This research intends to combine the various approaches and design a diagnostic tool and training environment for users with various difficulties such as social, developmental and, since it is our primary interest, sexual preference disorders that will allow us to more accurately diagnose, and possibly treat these users.

The final product interface/software with adaptive environment control should be available to wide public since all patents we would produce would be of GNU General Public License and can be adapted for various implementations. Namely, we would like to employ the bio-cybernetic loop for diagnostic purposes of people with unusual (in scientific literature also called minor) sexual preferences such as pedophilia or sexual aggression. For each case, the loop will be applied in a specific way as described further.

2.1 Theoretical Framework of Paraphilia

First, we should explain theoretical approach to paraphilia that is being employed for better understanding of the loop design and paradigm of changes. Currently, the research in its entirety to be primarily focused on men since their sexual reactivity is object and activity specific as opposed to women, who seem to exhibit much less stable sexual preference and reactivity. Also male paraphilics are much more common, therefore scientific literature on female paraphilia is rather scarce, and male offenders are more dangerous to society than female ones. Moreover, there is relatively high concordance between self-report measures of male sexual arousal and measures obtained by using psychophysiological measures. As for preference of object (usually a person, but not necessarily) and activity we feel need to give decryption of terms used further in text. Preference for sexual partner of adult age is called teleiophilia and in the article it will be used as opposite to pedophilia which can be described as predominant preference for sexual partners that are underage, in research usually defined as being between 4 and 12 years of age (even though we are aware that the complete opposite is gerontophilia – predominant preference for partners of elderly age).

Also we will use description of two types of sexual behavior towards partner differing based on consent. The usual preference during which the partner is cooperative and willing will be called consenting. People with this preference do have conventional sexual preference and usually are healthy controls¹. The second type, coercive, where aggression and pressure is present and the sexual intercourse is initiated even when the sexual partner is non-consenting. This distinguishes such preference from consensual sado-masochistic preference where is also present certain degree

¹ Non-patient population used to show contrast between specific participants and “normal” population.

of violence but both partners are consenting, and the interaction can be interrupted at any moment. To be able to diagnose and treat patients with unusual preference we need to understand etiology of such preference.

One of the influential theories having its origin in research conducted in the Czech Republic attempts to explain various unusual sexual preference as an expression of a common “underlying disorder” is the theory of disruption of Sexual Motivation System derived from the model of “courtship disorders” by Freund [7] and the “theory of vandalized lovemaps” by Money [8]. SMS posits premise that sexuality can be seen as hierarchically ordered and an interconnected system of particular sexual motivation levels that refer to a sequence of courting behaviors found in female mammals including humans and corresponding male reactions. According to the SMS approach, pre-intercourse cognitions of a female sexual object and its sexual interest precede the start of male sexual reaction and successful sexual act. Particular parts of male SMS system are:

- Attractivity (attention to a sexual stimulus with specific physical traits, e.g., adult female)
- Proceptivity (appetence for signals of female attraction to a male and attempts to seduce),
- Receptivity (appetence for signs of female readiness to copulate and of cooperating copulative behavior) [9].

Importantly, SMS theory suggests that the hierarchy of behaviors and their specific cognitive patterns occur sequentially. That is, the fulfilment of lower motivation levels must be achieved for the next step in motivation to be employed (e.g., attractivity must be complete before proceptivity is employed). If the motivational levels occur out of sequence, or some are omitted, the system inhibits sexual arousal (e.g. proceptivity of a female without previous attraction to her). The first two phases are key phases to understand unusual sexual preferences. In the first one, attractivity, the object (most likely person of preferred age and sex) plays major role. Male heterosexual teleiophilic would be attracted to adult female, male homosexual teleiophilic would be attracted to adult men. Male heterosexual pedophile would be attracted to underage girl and male homosexual pedophile would be attracted to underage boy. In the second, proceptive, phase it would decide whether the courtship would be consenting or coercive (based on positive or negative signals coming from the sexual object chosen in phase of attractivity).

2.2 Environment

The research that includes the bio-cybernetic loop design has an objective to design environment that will enable for testing of sexual preferences, or rather distinguishing between various (above described) pre-defined preferences. This type of testing method is especially helpful when combined with immersive virtual reality environment and implementations of near-photorealistic designed avatars. The implementation of virtual reality environment will offer to design (technically speaking) infinite amount of realistic appearing avatars with a goal to increase the fit of preference of each person tested. This is especially advantageous in case of studying preference of sexual

aggressors and pedophiles since in both cases they seem to “have a type”. In other words, the person does prefer certain characteristics such as specific age, sex, color of hair and eyes, etc. The first part of the procedure is aimed to determine the preferred type of interacting avatar.

The environment itself will be created in one of the commercially available game engines. We are still in testing phase of the study and based on the outcome, Unity² or Unreal³ game engine will be used to meet criteria such as immersion, photorealism, and loop design functioning. Preferably, there will be no animated objects or other avatars in any of the scenarios. We expect that the environment does not need to be complex since the attention should be focused solely on the interacting avatar itself. In case of out of the door scenario, the city environment will be used with unified color and light conditions will be controlled since eye-tracking and pupillometry used during this phase are light-condition sensitive procedures. Indoor scenario will always take place in same looking room, with low complexity for the above mentioned reasons. All scenarios will be presented from first person perspective.

The avatars will be interacting in the same manner, the same (on scientific literature [10] based, consenting and coercive) behavior – the movement will be the same (except for underage avatars, as described lower in the text). For this purpose, prototypic types of appearance respecting avatars will be pre-made. The expected amount is 10 avatars of each sex and age group to capture the variability of population. In the first set, only Caucasian race will be present since racial diversity of Czech population is very low. There will be four age groups present in the stimuli sets: (a) 4–6, (b) 10–12, (c) 14–16, and (d) 20–25 years of age. The age groups are based on previous scientific literature and Tanners development stages. In total, there will be $10 (\text{appearance}) \times 2 (\text{sex}) \times 4 (\text{age}) = 80$ different types of avatars. Each avatar will also be presented in consenting and coercive proceptive behavior (80×2 different types of stimuli). Also sexual activities represented for each avatar type will be presented but in this case, only genital interaction (of neutral age) respecting the sex of the preferred avatar will be presented (2, penile-vaginal or penile-anal intercourse) for ethical reasons. The total amount of stimuli prepared for this study will be then 162.

Four time-loops with same amount of behavioral displays of each type (consenting and coercive) will be created to create illusion of ongoing interaction for case of prolonged exposure in training with a possibility of terminating the loop and starting a new one, with fluent change. In case of biofeedback, we expect that there can be two possible ways of visualization. One is to present the person with bars representing degree of arousal and stress. The other, perhaps more useful in later stages of training, is processing of saddle color changes in the environment, such as color filter engagement, respecting certain amount of stress and arousal. Or only specific object color change can be applied (e.g., vase on a table will change color on a scale from blue to red, clock will change time based on arousal (minute hand) and stress (hour hand) to allow biofeedback training with smaller amount of disruption of the situation, which we find novelty. The whole project is under development and actual outcome may differ.

² <https://www.unrealengine.com/what-is-unreal-engine-4>.

³ <https://unity3d.com/>.

2.3 Procedure

The participant will be comfortably seated in room with all the equipment ready, researcher will attach all the sensors. Participant will be asked to attach the head-mounted-monitor (if compatible, eye-tracking is available, if not, monitor and eye-tracker will be used). Neutral movie with controlled light environment will be presented to obtain basal levels of psychophysiological measures.

First, the participant will be virtually walking on a street (speed will be adjusted) and on each side of the street there will be an avatar of certain type. Since visual attention and sexual preference are in concordance in men, as was shown in past research, the type of avatar that will be given attention will be automatically further developed in scenario. During this part, EEG data will also be collected to distinguish the preference. We expect that avatars will be presented wearing clothes, but possibly they will be presented naked in case of adult ones and in swimming suit for case of children. The decision logic will be tested but by now we expect that the hierarchy of choice will follow these lines: sex (male vs. female), age (10–12 years old vs. adult avatars) – in case of preference of underage avatar, all three underage categories will be tested against each other. Number of trials will be chosen based on pilot study and specific physiological reaction, expectedly EEG data will be used, accompanying the eye-tracking procedure. Once age and sex are selected, other properties will be tested as well.

As an alternative to this procedure there is one suggested by Patrice Renaud and his colleagues, using magnetic resonance [11]. In this scenario, the age of pre-chosen sex is dynamically changing and based on psychophysiological reactions during certain period of presentation, highlighting the age of avatar can be used as decision-making procedure. Such design is especially helpful in treatment in future phases.

Nevertheless, once the looks are decided, the scenario will shift to interior spaces where the avatar will be presented in the non-interactive manner to fulfill the phase of attractivity. Length of presentation will be also adjusted based on pilot study and individual reactivity. As next, both, coercive and consenting proceptivity will be presented in randomized order directly followed by receptivity (sexual act). During all phases, psychophysiological measures will be collected to distinguish between the above mentioned sexual preferences. As control condition, non-preferred avatar will be presented in the same scenarios and data from both conditions will be compared. The same will follow, but this time the appearance will be kept, but proceptivity will differ. In case of clear negative reaction (change of EEG pattern, change of galvanic skin response are expected variables) towards the stimuli, the scenario will be changed. During the calibration phase, self-report data will be also collected. This will allow us to create profile of preferences that the person has for future testing.

Such scenarios will be, in case of patients, saved for case of bio-feedback training during which the person will learn how to cope with their sexual preference.

Since one of the intended implementation of the loop is treatment and behavior adjustment, the biofeedback training will be employed. Based on previous diagnostic session, the scenarios will be created respecting the appearance and activity that the tested person exhibited. In case of participants with sexual preference that, for legal or personal reasons, needs modification, alternative scenario, respecting target preference, will be constituted. In the next part we will use original scenario – the one based on

participant's preference, and target scenario – the one that is respecting legal, or personal (in some cases) boundaries.

In phase of biofeedback training, during scenario presentation, the tested participant will be exposed to visual representation of his mental state, especially sexual arousal and stress (generally negative reaction). The aim of the procedure is to enhance participant's ability to suppress their sexual arousal in inappropriate scenario, but also to maintain control over their negative and stressful reaction during periods of suppression. In ideal world, we would hope to enhance ability to consciously increase arousal in the appropriate scenario.

Since the theory of SMS is based on hierarchical model where each phase is followed by hierarchically higher motivation (attractivity => proceptivity => receptivity), we can let the participant stay in specific phase for all the time needed to achieve the goal and change the scenario based on outcome of the previous phase.

2.4 Sample of Participants

Since we want to use the diagnostic tool to distinguish between males with usual (homosexual teleiophilia is considered usual sexual preference) and unusual sexual preferences based on the age they prefer (child or adult), sex they prefer (male or female) and type of proceptivity (positive and negative). For this reason we decided to ask patients with the matching sexual preferences (pedophilic preference, sexual aggressors, approx. 15 of each preference, 30 in total) and healthy controls (male heterosexuals and homosexuals of matching age, with no history of sexuality related problems, approx. 40) to participate in the study. All participants will go through procedure of sexual diagnostics before participation and rules for ethics of psychological research will be strictly obeyed. Advantage of use of these target groups is also that each target group reacts by positive reaction and sexual arousal to presentation of stimuli that match their preference but has rather negative reaction towards all other categories of stimuli.

2.5 Measurements

In the past research, many potential problems of measurement have been identified. The primary problem is that representation of mental state by changes in psychophysiological measures does not have to be linear. For more, the psychophysiological change can relate to more than one state. And vice versa, one state can be demonstrated in more than one psychophysiological measure change.

In the existing scientific literature, it has been recommended to use more than one measurement to represent the mental state of a person. As suitable for such loop construction several psychophysiological measures were suggested. Among these, eye tracking⁴ and pupilometry⁵, galvanic skin response⁶, electrocardiography⁷, data about

⁴ Area of visual attention related data are collected to estimate area of interest.

⁵ Measuring the size of pupil to estimate mental states.

⁶ Measured to estimate level and type of excitation.

⁷ Data about heart rate change will be collected to distinguish between emotional states.

respiratory rate⁸. Newly, we would like to add penile-plethysmography⁹ on the list of measures used to construct bio-cybernetic loop, since it is one of measurements with relatively high accuracy and is well studied in scientific literature [12]. Also electroencephalography is possibility that will be considered since scientific literature shows that specific emotional states can be represented by changes in electrical activity of the brain and specific response is demonstrated when their preference matching type of stimuli is presented. The advantage is that since different part of human body are used to collect data, more measurements can be collected simultaneously resulting in possibility of using variety of combinations to define mental state more accurately. All of the above mentioned measures have also been used in research of human sexuality individually or in combination, and we believe we will create functional loop based on these measurements. Process of testing is described lower in text.

2.6 Equipment

For this study we dispose with dedicated experimental room at National Institute of Mental Health of Czech Republic. The bio-cybernetic loop will consist of: personal computer (HP Envy gaming series 2015 desktop seems to meet the our requirements so far) – head mounted display (e.g., Oculus Rift, FOVE or 4 k phone display) – human – device for psychophysiological data collection – computer. We will employ BioPac MP¹⁰ as the device for psychophysiological data acquisition allowing the collection of more physiological measures simultaneously, when special modules, present in the lab to be added to the device. All of the above mentioned psychophysiological measures can be measured using one single device. The device also can be used for signal amplification and redirection of the data to computer to close the loop.

Specialized software is to be used to collect data about the user, as an interface, and set thresholds on individual variables allowing storing individual profiles of tested participants in memory. The software will also be used for visual representation of mental state, or single variable(s), on the screen for the bio-feedback training in later phases that are not described in this article. Also, we will use a device for self-report data acquisition preferably of a lever construction with possibility of visual representation of choice on the screen to allow employ the head-mounted monitor on. Virtual reality environment is currently developed and tested in Unity 5 game engine, while Unreal 4 having as a possible alternative. All devices and software are being tested with the goal to identify and optimize the virtual environment production pipeline (capacity, compatibility, efficiency, and ease of use).

2.7 Testing Process and Development of the Loop

Testing of the loop will follow 6 phases suggested by Fairclough [13]:

⁸ Collected since it is related to emotional states and for more is under voluntary control.

⁹ Data about penile blood flow are collected to estimate sexual excitement.

¹⁰ Device for psychophysiological measurement data acquisition.

1. **Conceptual Model (s)** – Model of psychological states during specific situations was put together based on scientific literature to conceptualize specific user behaviors. In our case we made bipolar labels of possible reaction on stimulus. As mentioned above, we expect rather sexual positive reaction on preference matching stimuli and rather sexual negative reaction on all other categories of stimuli.
2. **Psychophysiological Interference** – At this stage we have elected and chose psychophysiological measures to represent each mental state. Namely, we focused on eye tracking data, EEG, and PPG measures for which scientific literature is very clear and we will test all other variables in combination to find best possible solution. All participants will go through all possible testing scenarios collecting data from psychophysiological measures as well as self-reports. Also there will be phase during which they will have possibility of voluntary decision in times where the future loop would make scenario shift.
3. **A Quantified Model of User State** – We will develop the way in which the user state or behavior is represented within the bio-cybernetic loop. The minimum requirement of the quantified model will be that the user is represented with sufficient fidelity to enable the process of adaptation within the loop. In other words, the target states that drive the adaptive logic of the loop will be clearly defined during this part.
4. **A Real-Time Model of User State** – Based on previous generic formulation defining “data space” the model to trigger adaptation in real time. The model will be populated with criteria and classes that define regions of user state representation. Also individual user customization of thresholds possibility will be brought out in this stage.
5. **Design of Adaptive Interface** – The way that the loop makes adaptations will be tested during this testing phase. Main concern would be whether the change is efficient and noticed or not by the participant, and the change is in concordance with researcher’s expectations and matches preference of each tested target group. Testing will also focus on concordance with self-perceived adequacy of the change and states before and after change will be compared to see whether the change does not create confusion or immediate notable change in participant’s state showing that the change can be rather disturbing.
6. **Evaluation** – During this stage all benefits of creation of bio-cybernetic loop will be considered and analyzed, and the result will be compared with possibility of direct testing or use of other method to reach the goal of research.

The loop will be designed as a combination of positive and negative control loop, so called “toggling loop”. Negative control loop has been proven to be more stable and seem to be advantageous in cases in which psychological comfort and wellbeing during testing is preferred. In all instances of testing and biofeedback phases there will be “safe” (neutral) scenario for case of procedure induced stress where participant would be redirected if needed. The positive control loop is applied in case of scenario diverting (for each sexual preference based on change of psychophysiological changes during presentation of the stimuli) but will have control in negative control loop to ensure the stability and control for time variable.

2.8 Ethical Aspects of the Proposed Study

There are a number of ethical issues associated with the design and use of physiological computing systems. This technology is designed to tap private psychophysiological events and use these data as the operational fulcrum for a dynamic HCI. The topic is even more tormenting since the primary use of this loop is sexual diagnostics which is very sensitive topic in general, for more it is related to sexual acts that are in conflict with law (pedophilia and sexual aggression).

All personnel directly participating on this research are skilled researchers of human sexuality with years of training, trained psychologist and a medical doctor will be present for case of need of intervention. After the whole session, there will be time for debriefing that will take approx. 20 min and will consist of watching neutral video about traveling (to induce calm emotional state), and short consultation with a skilled psychologist. The debriefing will be prolonged in case of complication. Permission of institutional review board will be obtained before the whole study will be conducted and all participants will be informed about sexual nature of the experiment and will be clearly informed that they can terminate their participation at any time. We also guarantee strict anonymization of the data as well as blindness of researchers to individual sexual preferences during testing phase. Underage avatars will not be present in the erotic pose; the main focus is on child typical nonverbal displays in avatars. Consultations of stimuli content with forensic experts and judge advocates in field of sexology is clear.

3 Conclusion

We would like to emphasize the option to design an environment that is based on user's preference and allows for more accurate diagnostics than currently available methodology due to possibility of authoring the stimuli to fit user's preference in appearance and behavior. This should allow us to distinguish between sexual aggressors, pedophiles and healthy controls. We do consider two mental states, sexual arousal and stress (negative reaction), that will allow us to distinguish between preference for such stimuli or aversion towards it in male users. As a theoretical framework for minor sexual preferences, we have decided to apply a theory of sexual motivational system that can be seen as hierarchically ordered and an interconnected system of particular sexual motivation levels that refer to a sequence of courting behaviors. In phase of attractivity, the looks and appearance will be selected, in second stage, proceptivity, the consent related behavior will be decided. The advantage is that persons with chosen minor preferences are known to be highly reactive towards preferred stimuli and do not react (by arousal) to other types of stimuli, the opposite is valid for healthy controls who are rather repulsed and vice versa. To distinguish between the two mental states, we will collect data about eye gaze, brain activation, and galvanic resistance of skin in combination with the change of penile tumescence. There will be total of 162 stimuli needed to be created to fulfill the criteria of testing. We hope that once the user is

correctly diagnosed with sexuality related disorder and the therapy is needed, the biofeedback training will allow them to suppress their arousal in inappropriate situations and hopefully to shape it toward more socially and personally acceptable preferences. We are aware of numerous ethical issues related to such procedure but only skilled and experienced professionals will participate on the whole procedure.

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Fyzická atraktivita a sexuální přitažlivost obličeje a těla: vývoj stimulů pro měření sexuální reaktivity, výsledky první fáze studie

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Klíčová slova: *atraktivita, sexuální přitažlivost, sexuální odpověď, mužská sexualita, stimuly*

Při měření pohlavní sexuální vzrušivosti se často využívají erotické stimuly v podobě například fotografií, videí či 3D avatarů. Neexistuje však standardizace těchto stimulů, které by umožňovaly maximální možnou odpověď měřeného jedince.

V sexuologickém výzkumu jsou často využívána měření sexuální odpovědi, která nám poskytují cenná data o sexuálních preferencích měřených osob. Ovšem jednou z potíží při takovém výzkumu je fakt, že stimuly, které jsou užívány k navození sexuální odpovědi, dosud nebyly dostatečně standardizovány. U žen je shoda udávané a měřené preference nízká. Ovšem tento výsledek může být pouhým artefaktem dosavadních metod měření. Ženy jsou ovšem schopné velmi dobře ohodnotit vzhled a přitažlivost jiných žen, což je pravděpodobně způsobeno tím, že vzhled je jednou z primárních forem kompetice mezi ženami (Fisher, 2004). Jednou z charakteristik mužského vzrušení je, že svého vzrušení jsou si muži, na rozdíl od žen, vědomi a jejich fyziologická reaktivita je ve shodě s jejich udávanou preferencí. Toto platí pro pohlaví, věk, a také vzhled ženy, kterou preferují (Rosenthal et al, 2011, Chivers a kol., 2007).

Znaky, které jsou považovány za atraktivní, jsou také často spojovány s vysokou genetickou, respektive fenotypickou kvalitou a vývojovou stabilitou (Thornhill, R., a Møller, 1997). Bylo opakovaně prokázáno, že hormonální hladiny, v případě žen zejména estrogenu, pozitivně souvisí s atraktivitou (Thornhill a Grammer, 1999). Zvýšené hladiny estrogenu ovšem působí negativně na imunitní systém, což znamená, že pouze v případě, že je žena dostatečně odolná, vyvinou se u ní pohlavně typické znaky ve větší míře (Thornhill a Grammer, 1999). Vyšší hladina estrogenu, a tedy i znaků na jeho hladině závislých, také souvisí s vyšším reprodukčním úspěchem (Thornhill a Gangestad, 1996). Reaktivita na takové stimuly je také obvykle nejvyšší (Chivers a kol., 2007).

Muži, a ženy, při hodnocení atraktivity partnerky zohledňují více, než jeden prvek (oblast), naopak obvykle celkovou atraktivitu tvoří kombinace jednotlivých samostatně hodnotitelných oblastí. Tyto oblasti (například obličejová atraktivita, atraktivita těla, hlasu, Fraccaro a kol., 2010, Møller a Pomiankowski, 1993; Thornhill a Grammer, 1999) jsou obvykle studovány odděleně. Ovšem tzv. *teorie mnohočetných signálů* (*multiple message theory*; Wells a kol., 2009) poukazuje na fakt, že každá část je sice hodnocena zvlášť, nicméně následně je celkový dojem porovnáván a tvoří celkovou vnímanou atraktivitu daného jedince.

Ovšem v odlišných kontextech je kladen důraz na jiné znaky. V kontextu vytváření stimulů pro měření sexuální odpovědi jsme se proto rozhodli nechat účastníky výzkumu hodnotit stimuly na škále *fyzické atraktivity* i škále *sexuální přitažlivosti*. Věříme, že užití této nové, konkrétnější, škály nám umožní lépe pochopit tento konkrétní aspekt atraktivity.

Dále jsme se zaměřili na dvě oblasti, které jsou při vývoji stimulů pro sexuální vzrušivost, s ohledem na vzhled zobrazované osoby, velmi důležité: obličej a tělo. Obličej je zcela unikátní evoluční inzertní plochou. Člověk je adaptován na to, aby obličej vnímal jako Gestaltický tvar, tedy holisticky. Oproti tomu tělo i celá postava jsou vnímány jako běžný objekt (Szatmári a Lábadi, 2015).

Obličej je považován za atraktivní, pokud je symetrický (Braun a kol., 2001), pohlavně typický – tedy v případě žen má malou bradu, tmavé dlouhé řasy, malý nos, velké oči, plné rty a jasně patrné lící kosti (Perrett et al., 1998).

Tělo je považováno za atraktivní, pokud je symetrické (Thornhill & Grammer, 1999). Dále pak, pokud má žena střední Body Mass Index (BMI; Tovée a Cornelissen, 2001; Fan a kol., 2004). Oba extrémy, tedy jak nedostatek, tak nadbytek tukové složky je považován za neatraktivní a současně existuje vyšší riziko neplodnosti (Rich-Edwards a kol., 2002). Dalším užívaným indexem je poměr pasu a boků (WHR [Waist-hip-ratio]; Singh a Young, 1995; Tassinari a Hansen, 1998; Schmalz, 2006) u kterého je považován za nejvíce atraktivní poměr 0,7. Vzhledem k rozsahu příspěvku nejsou diskutovány další vlivy jako textura kůže, výška či konkrétní struktury jako např. ňadra.

Celkově jsou však za atraktivní považovány ženy mladistvého vzhledu, které se blíží prototypickému ženskému vzhledu se spíše nižším množstvím tělesného tuku (Buss, 1989, Thornhill a Grammer, 1999), s jednosměrnou odchylkou směrem k vyššímu poměru tukové tkáně u populací s nedostatkem zdrojů – se snižujícím množstvím zdrojů roste preference pro vyšší tukovou zásobu.

Vztah atraktivity obličeje a těla byl v minulosti zkoumán nedostatečně a výzkumníci, kteří se tímto tématem zabývali, obvykle významně manipulovali vzhledem participantů zakrytím částí obličeje, sjednocením oblečení, či prezentovali pouze stimuly nahé, případně prezentovali pouze 10 stimulů (Thornhill a Grammer, 1999, Currie a Little, 2009). V provedené studii bylo participantům prezentováno 90 žen oblečených v běžném oblečení dle vlastního výběru. Vzhled ženy nebyl nijak upravován a žádné části těla ani obličeje nebyly zakryty.

Cíly studie bylo tedy zjistit, zda se hodnocení na škále „fyzické atraktivity“ a „sexuální přitažlivosti“ bude lišit a dále pak určení míry významnosti obličeje a těla pro celkové hodnocení na obou škálách.

Metody:

Studie se zúčastnilo 101 dobrovolníků (51 mužů a 50 žen ve věku 18 až 40 let, průměrný věk žen = 29.86 ± 3.04 , průměrný věk mužů = 21.78 ± 2.27). Většinu účastníků tvořili studenti humanitních oborů, kteří byli kontaktováni osobně v atriu budovy Karlovy Univerzity Jinonice (U kříže 8, Praha 5, 158 00). Kritériem pro vstup byl věk mezi 18 a 40 lety, bez vad zraku, s případnou korekcí brýlemi či čočkami. Kritériem pro vyloučení bylo závažné fyzické či psychické onemocnění. Žádný účastník nebyl ze studie vyloučen.

Participantů byli poučeni o účelu studie, ujištění, že studie je anonymní a svou účast mohou kdykoli bez udání přerušit. Věk participantů byl kontrolován výzkumníkem při vstupu do testovací místnosti a po poučení o studii byli participantů požádáni o podepsání informovaného souhlasu. Veškeré hodnocení a odpovědi participantů byly označeny pouze přiděleným číselným kódem. Sběr dat probíhal v počítačové učebně, kde byli usazeni tak, aby si navzájem neviděli do monitoru. Všechny stimuly byly prezentovány na 14'' monitorech s totožným rozlišením i nastavením zobrazení. Za svou účast byli odměněni finanční částkou 50 Kč, hodnocení celkově trvalo asi 25 minut. Projekt byl schválen etickou komisí PřF UK č. 2017/04. S daty bylo nakládáno dle zákona 101/2000 Sb. a data jsou přístupná výhradně výzkumníkům podílejícím se na studii.

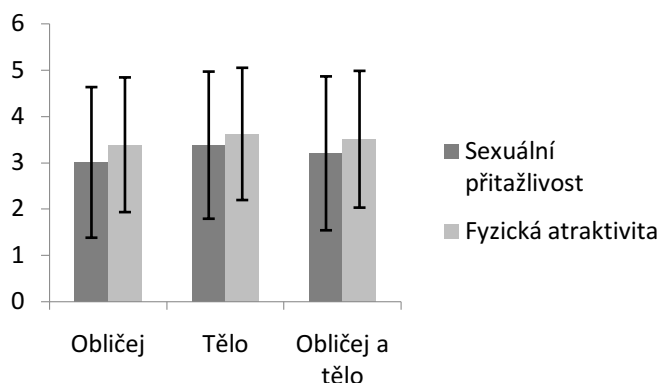
Účastníkům bylo prezentováno 90 stimulů tří typů: a) žena oblečená v běžném oblečení s viditelným obličejem, b) žena oblečená v běžném oblečení s rozmazaným obličejem, c) detail obličeje. Kvalita všech stimulů byla 1041 x 1561 pixelů a fotografie byly ve stejné kompozici a velikosti. Stimuly byly získány z webových stránek, které dovolují stahování obrázků k nekomerčnímu využití a pochází z databáze dívek, které se účastnily castingu do pornografických filmů, což je podstatné pro další části studie. Ke sběru dat byl použit software E-prime 2.0 (Schneider, Eschman a Zuccolotto, 2002). Před započítím studie každý účastník vyplnil dotazník zaměřený na socio-demografické charakteristiky a sexuální chování. Každý hodnotitel hodnotil stimul na dvou desetistupňových škálách, jejichž definice byla participantům prezentována na začátku studie:

- A) Fyzická atraktivita, kterou lze chápat jako míru, do jaké zobrazená osoba (žena) reprezentuje představu o ideálním fyzickém vzhledu.
- B) Sexuální přitažlivost, kterou lze chápat jako míru přitažlivosti, kterou k zobrazené osobě (ženě) cítí bez ohledu na fyzický vzhled. Zobrazená osoba může mít nějaký konkrétní znak či vlastnost, která ji činí (sexuálně) přitažlivou.

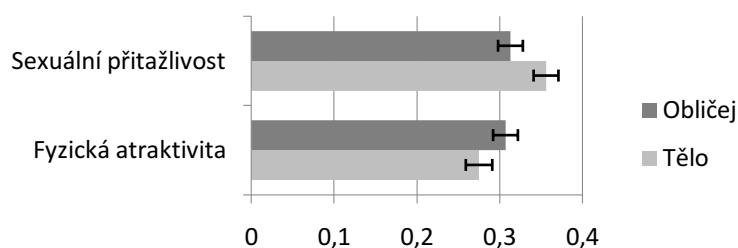
Výsledky

Vícenásobná lineární regrese ukázala, že škály jsou na sobě nezávislé. Tedy hodnocení na jedné škále významně nepřispívá vysvětlení hodnocení na škále druhé. Dále byl prokázán významnější vliv těla na hodnocení celkové sexuální přitažlivosti a naopak významnější vliv obličeje na hodnocení celkové fyzické atraktivity.

Graf 1: Průměrné hodnocení *sexuální přitažlivosti* a *fyzické atraktivity* se standardními odchylkami pro obličej, tělo a obličej + tělo



Graf 2: Odhad fixních efektů odvozených z nezávislých modelů *sexuální přitažlivosti* a *fyzické atraktivity* se zobrazenými chybovými úsečkami



Diskuse

Za použití stimulů zobrazujících obličej, tělo a celou postavu i s obličejem devadesáti žen oblečených v běžných šatech dle vlastního výběru jsme testovali vliv obličeje a těla na hodnocení celkové sexuální přitažlivosti a fyzické atraktivity. Hodnotiteli byli muži i ženy. Ovšem pohlaví, sexuální orientace ani jiné socio-demografické údaje neměli na hodnocení žádný vliv. To je v souladu s naším očekáváním, neboť minulé studie ukazují významnou shodu mezi hodnotiteli, v rámci pohlaví i mezi pohlavími bez ohledu na socio-demografické proměnné a tedy robustnost konceptu atraktivity (Buss, 1989, Elliot a kol., 2013).

V psychologickém, respektive sexuologickém výzkumu je často užíváno zastřešujících pojmů, což ovšem může být nevýhodou, pokud má výzkum zcela konkrétní účel. V minulosti

bylo přesnější vymezení zkoumané škály přínosem. Například použití doplňující škály *módnosti* (*fashionability*) výzkumníci vysvětlili, proč jsou ženy hodnoceny jako stejně atraktivní, když nosí červenou a černou barvu. Oblékání červené barvy přitahuje pozornost díky své výraznosti a spojením s ovulačním obdobím ženy (Guéguen, 2012, Haselton et al., 2006). Vyšší hodnocení černé barvy vysvětluje její módnost (Pazda a kol., 2012).

Škála *sexuální přitažlivosti* se v naší studii ukázala být také nezávislou podsložkou *fyzické atraktivity*. To je podstatné pro budoucí výzkum, kdy očekáváme využití v přesnějším zacílení otázek ve výzkumech, které se týkají právě sexuální přitažlivosti, potažmo sexuální odpovědi.

Dalším podstatným zjištěním je, že vzhled obličeje je pro hodnocení celkové fyzické atraktivity podstatnější, než vzhled těla. To může být dáno tím, že obličej je stabilnějším znakem, než vzhled těla (Herman a kol., 2009). Toto zjištění je v souladu s předchozími studiemi na podobné téma (např. Rhodes a kol., 2005; Currie a Little, 2009).

Naopak vzhled těla je podstatnější pro celkové hodnocení na škále sexuální přitažlivosti. To je významné zejména s ohledem na fakt, že ženy byly oblečené do oblečení dle vlastního výběru. V minulosti byl vliv těla na hodnocení diskutován zejména v případě, že jejich motivace byla sexuální, oproti hledání dlouhodobého vztahu (Currie a Little, 2009; Confer, Perilloux a Buss, 2010).

Hodnocení obličejové atraktivity a atraktivity těla však spolu pozitivně korelovala a obě tyto složky tak predikovaly celkovou atraktivitu. Tato zjištění podporují *teorii mnohočetných signálů* (Wells a kol., 2009, Candolin 2003), která říká, že jednotlivé prvky či znaky jsou posuzovány odděleně a poskytují nám o jedinci odlišené informace, avšak hodnoceny jsou poté podle celkového dojmu, holisticky. Tento přístup byl použit například při studii obličeje, těla a hlasu (Saxton a kol. (2009).

Tyto znalosti nám pomohou v dalších částech studie, kde se chceme zaměřit především na neverbální chování ženy, které, jak bylo ukázáno (Moore, 2010), hraje při interakci s protějškem důležitou roli. Dle znalosti *teorie mnohočetných signálů* (Wells a kol., 2009) a výsledků ze současné studie očekáváme, že chování bude rovněž důležitou složkou při posuzování fyzické atraktivity a sexuální přitažlivosti ženy. Zároveň bude pozornost zaměřena na konkrétní prvky chování, které mají na hodnocení největší vliv a v zájmu dalších studií je tak vytvořit etogram, který by posloužil pro vytvoření stimulů pro maximální sexuální odpověď.

Závěr

Naše studie prokázala, že obě škály, byť spolu souvisí, jsou na sobě nezávislé. To je podstatné pro budoucí studie, které by se měli soustředit na další faktory, jako je pohyb – neverbální chování – či záměrná manipulace vzhledu – tedy oblékání a líčení. Dále jsme zjistili, že pro hodnocení fyzické atraktivity a sexuální přitažlivosti je kladen důraz na jiné části těla. V případě celkové fyzické atraktivity je největším vlivem atraktivita obličeje. Naopak pro hodnocení sexuální přitažlivosti je tělo významnější. Při tvorbě stimulů, jejichž účelem je vybudit sexuální odpověď by tedy měl zejména kladen důraz na vzhled těla.

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Porovnání statické fyzické atraktivity a atraktivity neverbálního chování u žen, výsledky druhé části studie

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Klíčová slova: *atraktivita, sexuální přitažlivost, sexuální odpověď, mužská sexualita, stimuly*

Ve výzkumech sexuálního vzrušení se nejčastěji využívají erotické stimuly v podobě fotografií, videí či 3D avatarů (Chivers a Bailey, 2005; Freund, 1963; McConaghy, 1999; Heiman, 1977; Graham, Janssen a Sanders, 2000). Stimuly využívané pro měření sexuální odpovědi ale nejsou doposud dostatečně standardizované a dosavadní výsledky výzkumů navíc ukazují, že velmi důležitým prvkem, který ovlivňuje mužskou sexuální reakci, je vzhled ženy, která se ve stimulech objevuje. Sexuální odezva mužů, kteří se identifikují jako heterosexuální, se totiž ukazuje jako nejvyšší právě v případě, pokud jsou jim prezentovány stimuly, na který jsou zobrazeny ženy, které odpovídají jejich vzhledovým preferencím (Freund, 1963; Chivers a Bailey, 2005; Both, Everaerd a Laan, 2003; Chivers a kol., 2004).

Nejen vzhled, ale také chování ženy může mít významný dopad na sexuální odpověď muže. To je zejména patrné při interakci s protějškem, kdy vnímání a posuzování partnera/ky může významně ovlivnit situační kontext (Beach, 1976; Perper a Fox, 1980). Během dvoření je to totiž převážně žena, která vysílá určité neverbální signály, které mohou predikovat nejen průběh, ale i výsledek dvoření. Proto může nejen vzhled, ale i neverbální chování v prezentovaných erotických stimulech hrát klíčovou roli (Kolářský a Madlafousek, 1983; Binter a kol., 2016, Říha a kol., 2016, Klapilová a kol., 2016).

Samotné neverbální prvky, které se objevují během dvoření, bývají výzkumníky pojímány buď jako specifické právě pro namlouvání (Moore, 1985) nebo jsou kategorizovány jako prvky objevující se v běžném neverbálním projevu, ovšem v daném (dvořicím) kontextu jsou považovány za významné. Grammer se svými kolegy (2000) tvrdí, že neverbální signály se neliší od neverbálního chování v běžném životě nebo které děláme nevědomky. Rozdíl je pouze ve frekvenci a délce těchto signálů a pro jejich správnou interpretaci je tedy nutné znát

situační kontext. Za důležité pozitivní prvky jsou považovány zejména signály kontaktní, tedy takové, které poutají pozornost, jako je časté střídání přímých pohledů, uhýbání pohledem, úsměvy (Grammer, 1990) a dále tzv. palming, tedy viditelné prezentování dlaní (Kendon, 2004). Naproti tomu Moore (1985) tvrdí, že při dvoření se objevují konkrétní a specifické signály, které můžeme kategorizovat jako negativní nebo pozitivní. Například pokud žena pohazuje hlavou, odvrací pohled směrem dolů, hraje si s vlasy či inzeruje odhalenou kůži na krku, značí to její otevřenost a dostupnost. Naopak pokud žena zájem nejeví, odvrací se od protějšku, mění pozici těla na pozici uzavřenou či si například hraje s nehty.

Tab. 1. Příklady pozitivních a negativních signálů při dvoření

Pozitivní signály	Negativní signály
Střídavé přímé pohledy	Příliš dlouhé přímé pohledy
Střídavé pohledy stranou	Příliš dlouhé pohledy stranou
Palming	Pozornost směřována např. na své ruce
Hraní si s vlasy	Vyhrnutí rukávů
Pohození s hlavou	Rozhlížení se kolem
Prezentace krku	Neklidné nohy
Otevřená pozice rukou a nohou	Uzavřená pozice rukou a nohou
Vypínání hrudi	Odvracení se
Úsměv	Celková ztráta zájmu

Cíle studie:

- Prvním cílem výzkumu bylo zjistit, jakou měrou neverbální chování a fyzická atraktivita přispívá k vyšší sexuální přitažlivosti prezentovaného stimulu.
- Druhým cílem výzkumu bylo zjistit, zda je neverbální chování, pokud takové existuje, specifické pro danou situaci či jde o obecné projevy, které mají v daném kontextu význam.

Metody:

Podmínkou účasti byl věk participanta mezi 18 a 40 lety a zkušenost s erotickými materiály v minulosti. Studie se zúčastnilo 50 dobrovolníků (mužů ve věku 18 až 25 let, průměrný věk mužů = $21,78 \pm 2.27$). Většinu účastníků tvořili studenti humanitních oborů, kteří byli kontaktováni buď osobně v atriu budovy Karlovy Univerzity Jinonice nebo osloveni skrze vyvěšené letáčky. Žádný účastník nebyl ze studie vyloučen.

Sběr dat probíhal v počítačové učebně, kde byli participantů usazeni tak, aby si navzájem neviděli do monitoru. Celé hodnocení probíhalo anonymně, skrze platformu Qualtrics. Všechny stimuly byly prezentovány na 14'' monitorech s totožným rozlišením i nastavením zobrazení. Hodnocení trvalo celkově cca 60 minut a za svou účast byli participantů odměněni finanční částkou 100 Kč.

Stimuly byly tvořeny videi českých žen, které se zúčastnily castingů do pornografických snímků. Na základě hodnocení celkové fyzické atraktivity (obličeje a oblečeného těla) nezávislými hodnotiteli bylo za použití dat z pilotní studie z 90 žen vybráno 5 nejvíce atraktivních žen, 5 nejméně atraktivních žen a 5 žen se střední mírou hodnocené atraktivity. Toto hodnocení probíhalo v první části studie. Video prezentované hodnotitelům bylo rozděleno a sestřiháno na 3 části: a) 20 sekundové video rozhovoru s oblečenou ženou, b) přibližně 45 sekundové video nahé ženy provádějící erotické pohyby, c) 60 sekundové video ze samotného sexuálního styku. Videi vykazovala variabilitu zejména v případě videi B a C, jelikož některá videa B obsahovala i záběry svlékající se ženy a některá videa C obsahovala i záběry orálního sexu. Videi byla nakódována dle předem připraveného etogramu. Tento etogram obsahoval jednak neverbální chování popsané v předešlých studiích (Moore, 1985; Grammer, 1990; Grammer, 2000) zabývajících se především neverbálním chováním při poutání pozornosti protějšku (žena poutá pozornost) a jednak neverbální chování zjištěné explorativní analýzou videi. U veškerých prvků v etogramu byl zaznamenán počet a délka.

Tab. 2. Seznam neverbálních prvků testovaných v naší studii

Pro video A	Pro video B	Pro video C
Neverbální prvek	Neverbální prvek	Neverbální prvek
Úsměv	Přímý pohled	Přímý pohled
Stydlivý úsměv	Pohled na muže	Pohled na muže
Přímý pohled	Pohled na sebe	Pohled na sebe
Pohled stranou	Pohled stranou	Pohled stranou
Přikývnutí	Zavřené oči	Zavřené oči
Kroucení hlavou	Úsměv	Úsměv
Palming	Stydlivý úsměv	Ruce se dotýkají ňader
Gestikulace kontextuální	Kousání do rtů	Ruce se dotýkají rozkroku
Sezení zpřímá	Ruce se dotýkají ňader	Masturbace
Opírání se	Ruce se dotýkají břicha	Detail obličeje
Uzavřená pozice nohou	Ruce se dotýkají nohou	Detail ňader
Otevřená pozice nohou	Ruce se dotýkají rozkroku	Detail zátylku
Neutrální pozice	Ruce se dotýkají boku	Detail pozadí
Uzavřená pozice rukou	Ruce se dotýkají stehů	Explicitní záběr na rozkrok
Otevřená pozice rukou	Masturbace	Orální sex

Neutrální pozice rukou	Detail obličeje	Sex
	Detail ňader	Poloha zezadu
	Explicitní záběr na rozkrok	Misionářská poloha

Účastníkům bylo prezentováno 8 typů stimulů: a) fotografie obličeje, b) fotografie oblečeného těla s rozostřeným obličejem, c) fotografie oblečeného těla včetně viditelného obličeje, d) fotografie celého nahého těla s rozostřeným obličejem, e) fotografie celého nahého těla včetně viditelného obličeje, f) video rozhovoru (video A), g) video nahé pózující ženy (video B), h) video sexuálního styku (video C). K hodnocení stimulů respondenty byl použit software E-prime 2.0 (Schneider, Eschman a Zuccolotto, 2002). Každý participant hodnotil stimul na dvou sedmibodových škálách (1 = velmi fyzicky atraktivní/ sexuálně přitažlivá, 7 = velmi fyzicky neatraktivní/sexuálně nepřitažlivá), jejichž definice byla participantům prezentována na začátku studie:

- a) Fyzická atraktivita, kterou lze chápat jako míru, do jaké zobrazená osoba (žena) reprezentuje představu o ideálním fyzickém vzhledu.
- b) Sexuální přitažlivost, kterou lze chápat jako míru přitažlivosti, kterou k zobrazené osobě (ženě) cítí bez ohledu na fyzický vzhled. Zobrazená osoba může mít nějaký konkrétní znak či vlastnost, která ji činí (sexuálně) přitažlivou.

Statistické zpracování dat

Vzhledem k explorativnímu charakteru studie byly zvoleny statistické postupy, které jsou v explorativních studiích užívány k odhalení vztahů mezi proměnnými, v našem případě vnímanou sexuální přitažlivostí a neverbálními prvky. Všechny statistické postupy byly zpracovány za použití zobecněných lineárních modelů (GLM), které jsou užívány v případě explorační dat a je z nich možné vyčíst přispění jednotlivých nezávislých proměnných na jednu proměnnou závislou. Vzhledem k povaze výzkumu a významu přisuzovanému jednotlivým prvkům jsme zvolili tzv. backwards elimination metodu (postupné odstraňování proměnných s nejmenším dopadem na vysvětlovanou proměnnou) a reportujeme vždy první model, který byl signifikantní.

První fáze explorace

Do modelu vstupovala jako závislá proměnná hodnocení sexuální přitažlivosti dívky. Jako fixní faktor do analýzy vstupovala kategorie atraktivity dívky (kategorie byla určena na základě fyzické atraktivity oblečené dívky v případě videa A a nahé v případě videa B a C).

Výsledné modely ukázaly, že v případě všech videí měla vliv pouze kategorie atraktivity.

Video A (interview):

V případě hodnocení prvního videa byl celkový model signifikantní ($F_{9, 5} = 12,489$, $p = 0,006$) a jediným prediktorem byla kategorie atraktivity ($F_{1, 5} = 15,127$, $p = 0,008$), žádný neverbální prvek neměl vliv na subjektivní hodnocení sexuální přitažlivosti zobrazené dívky.

Video B (erotické pózování):

V případě hodnocení druhého videa byl celkový model signifikantní ($F_{10, 4} = 10,326$, $p = 0,019$) a jediným prediktorem byla kategorie atraktivity ($F_{1, 4} = 15,149$, $p = 0,014$), žádný neverbální prvek neměl vliv na subjektivní hodnocení sexuální přitažlivosti zobrazené dívky.

Video C (sexuální styk):

V případě hodnocení třetího videa byl celkový model signifikantní ($F_{10, 4} = 14,331$, $p = 0,010$) a jediným prediktorem byla kategorie atraktivity ($F_{1, 4} = 19,973$, $p = 0,008$), žádný neverbální prvek neměl vliv na subjektivní hodnocení sexuální přitažlivosti zobrazené dívky.

Druhá fáze explorace:

Vzhledem k explorační povaze analýz jsme z modelů v druhé fázi explorace vyřadili fixní faktor a zařadili škálové hodnocení atraktivity obličeje a těla jako kovariáty.

Video A (interview):

V případě hodnocení prvního videa byl celkový model signifikantní ($F_{11, 3} = 108,323$, $p = 0,001$). Prediktory vyššího hodnocení na škále sexuální přitažlivosti byl přímý pohled ($F_{1, 3} = 21,475$, $p = 0,019$), palming ($F_{1, 3} = 19,409$, $p = 0,022$) a hodnocení fyzické atraktivity obličeje žen ($F_{1, 3} = 48,082$, $p = 0,006$). Přímé pohledy a palming (viditelná prezentace dlaní) jsou v tomto případě vyjádřeny počtem/frekvencí a nikoliv délkou.

Video B (erotické pózování):

V případě hodnocení druhého videa byl celkový model signifikantní ($F_{10, 4} = 16,846$, $p = 0,008$). Prediktorem vyššího hodnocení na škále sexuální přitažlivosti bylo hodnocení fyzické atraktivity nahého těla žen ($F_{1, 4} = 22,263$, $p = 0,009$).

Video C (sexuální styk):

V případě hodnocení třetího videa byl celkový model signifikantní ($F_{10, 4} = 47,012, p = 0,001$). Prediktorem vyššího hodnocení na škále sexuální přitažlivosti bylo hodnocení fyzické atraktivity nahého těla žen ($F_{1, 4} = 13,568, p = 0,021$).

Diskuse

Ve všech případech první explorační studie, se ukázal být nejdůležitějším prediktorem subjektivně hodnocené sexuální přitažlivosti hodnocená atraktivita, respektive kategorie z něj odvozená. Žádné neverbální chování nemělo na výsledné hodnocení vliv. To je v přímém rozporu s očekáváním založeným na předešlých zjištěních výzkumníků, kteří kladli důraz právě na neverbální chování. Naše zjištění naopak přikládá největší význam právě fyzickému vzhledu dané dívky a podtrhuje význam atraktivity v případě krátkodobého sexuálního výběru. Podobný výsledek se dá očekávat pro případ reaktivity na stimuly, jak bylo ukázáno v minulých studiích (Chivers a Bailey, 2005; Both, Everaerd a Laan, 2003; Chivers a kol., 2004).

Pokud do modelu nevstupovala kategorie atraktivity, ale dalšími proměnnými bylo společně s neverbálními prvky i hodnocení fyzické atraktivity obličeje a těla, bylo zjištěno, že nejvíce signifikantní vliv na vnímání sexuální přitažlivosti má fyzická atraktivita obličeje či těla. V případě nesexuálních videí (A) to byl pouze obličej, v případě sexuálních videí (B a C) šlo o nahé tělo. Důležitost obličeje ve videu A může být ovlivněna podobou stimulu. Oblečená žena v této části sedí na pohovce a vnímání tvaru těla tak může být zkresleno.

Naopak nahé tělo ovlivňovalo hodnocení v případě sexuálních videí. Dá se předpokládat, že tělo poskytuje o jedinci zásadní informaci. V předešlých studiích (např. Currie a Little, 2009) bylo uvedeno, že tělo odráží momentální zdravotní stav jedince, jelikož se zdá, že je méně stabilní než tvář a poskytuje nám tak informace o jedinci při aktuálním posuzování (Herman a kol., 2009).

Co se týče konkrétních prvků neverbálního chování, které měly vliv na pozitivní hodnocení videa A, tedy palmingu (prezentování dlaní komunikačnímu partnerovi) a krátkých přímých pohledů, jedná se o prvky kontaktní. Tedy takové, jež naznačují přímý zájem o komunikaci. Taktiku přímých pohledů a uhýbání pohledem využívají často ženy při aktu dvoření (Givens, 1978; Moore, 1985; Grammer, 1990) a zdá se, že muži jsou na ně velice citliví. Je tedy možné, že pokud muž shledával v našem výzkumu ženu atraktivní a přitažlivou, vnímal její pohledy jako flirtovní a tedy se sexuálním podtextem, ačkoliv tento podtext zřejmě přítomný nebyl, protože video A bylo nesexuálního charakteru (rozhovor s jinou ženou). Neočekávalo se tedy žádné flirtovní chování. Respondentům však tato skutečnost nebyla oznámena a na

samotném videu nebyla žena, která vedla rozhovor, vidět a kamera zabírala pouze ženu-aktérku. Výsledky předchozích výzkumů naznačují, že muži jsou v rozpoznání a popsání neverbálního chování mnohem méně přesní v porovnání se ženami (Perper a Fox, 1980) a rovněž jsou méně schopni rozpoznat zájem či nezájem protějšku (Shotland a Craig, 1988). Muži tak mohou vnímat určité neverbální chování jako okamžitý sexuální podnět i když jím není (Ostler, 2003). Tomuto tvrzení nasvědčují i výsledky recentního výzkumu Zsoka (2017). Podle něj, pokud muž jeví zájem o protějšek, vždy je prvotním popudem touha po sexuální interakci s jedincem opačného pohlaví. Je tedy možné, že ačkoliv neverbální chování ženy žádný sexuální podtext neobsahovalo, muži ho přesto takto mohou vnímat. Je vhodné adresovat, že tyto prvky měly vliv na hodnocení pouze v případě nesexuální interakce, nikoli v jejím průběhu. Dále pak, že šlo o prvky běžného repertoáru přátelských gest a nikoli projevů typických pouze pro dvoření.

Je třeba upozornit na skutečnost, že nešlo o interaktivní studii, a tedy participant byl pouhým recipientem, který nemohl ovlivnit dění. To je velmi významné s ohledem na fakt, že tento výsledek není nutně v rozporu s teoriemi Moneyho a Freunda (oba 1986), kteří své teorie zaměřují na neverbální chování, stejně jako pozdější autoři (Moore, 1985; Renninger, Wade a Grammer, 2004).

Vzhledem k vysoké shodě hodnocení subjektivního vzrušení mužů a jejich následné sexuální reaktivitě náš výsledek přináší významný poznatek pro studie zaměřené na testování sexuální reaktivity mužů, kde se očekává rychlá odpověď na stimul. V takovém případě je atraktivita natolik důležitá, že neverbální chování nemá významný dopad na hodnocení v případě, že jde o výhradně erotický snímek, bez ohledu na to, zda žena je ve videu sama či v interakci s partnerem. V případě, že jde o prezentaci, která zahrnuje sexuální i nesexuální vyobrazení stimulu, mohou mít přátelské projevy potenciál zvýšit sexuální reaktivitu na stimul.

Shrnutí

Fyzická atraktivita hraje v případě hodnocení stimulů nejvýznamnější roli. Co se týče návrhu stimulů ve výzkumech zabývajících se mužskou pohlavní vzrušivostí, bylo by důležité zaměřit se zejména na vzhled aktérky ve videu a to konkrétně na vzhled těla v případě sexuálních stimulů.

Prvky chování, které se v naší studii ukázaly být významné, jsou prvky běžného chování, které však v jistém kontextu získávají podstatný význam. Tyto prvky jsou projevem otevřenosti a zájmu o komunikaci. Je tedy důležitý kontext, ve kterém jsou běžné prvky užity.

Je velmi důležité si uvědomit, že laboratorní testování nezahrnuje prvek interakce tolik podstatný pro flirtování, ke kterému se mnoho předchozích studií neverbálního chování vztahuje. Naopak je účastník studie v roli pouhého pozorovatele, který nemá možnost vyvolat reakci stimulu. Některé dosud známé technologie a výzkumné designy takovou interakci však již dnes dovolují a právě takové by měly být dále rozvíjeny. Těmto krokům se plánujeme v blízké budoucnosti věnovat.

Etické otázky

Veškeré fotografie i videa jsou volně přístupná na internetových stránkách umožňující jejich prohlédnutí a stažení. O aktérkách ve videu nejsou poskytnuty žádné osobní údaje a respondent nemůže aktérku dohledat. Veškerá videa byla promítána bez zvuku. Tento projekt byl rovněž schválen etickou komisí PřF UK č. 2017/04. S daty bylo nakládáno dle zákona 101/2000 Sb. a data jsou přístupná výhradně výzkumníkům podílejícím se na studii.

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A Warning: Potential Damages Induced by Playing XR Games

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Abstract. This article focuses on psychological safety while playing XR (VR + AR) games, and the development of safe-guards ('fuses') to avoid possible negative impacts incurred during virtual experiences. VR and AR have moved from hi-tech development laboratories and design studios into the homes of otherwise conventional users. XR technology has been repeatedly proven to be beneficial for supportive treatment of phobia, PTSD (post-traumatic stress disorder), training of complex behaviors in harsh environments, and education related applications.

Gaming applications are in high demand and financially successful, but are insufficiently supervised by professionals with regard to user safety. Immersion and quality of the technology has increased markedly, resulting in the emergence of arenas that look and feel increasingly realistic, and hence can trigger and impact human affectual states, notably fear and sexual pleasure, more easily. The tendency to create super-stimuli is in the minds of the creators with little (we argue: insufficient) regard to deleterious side effects.

Motion sickness has been considered a negative side-effect of VR gaming, but the possible damage to emotional and psychological well-being of users has been overlooked. Other media platforms, such as movies, have documented the impact on the human psyche of pre-disposed individuals, especially when their psychological state is affected by psychoactive substances. We argue the necessity of programming psycho-physiological response-based 'fuses' that limit possible negative impacts on individuals with pre-existing or pre-generated conditions.

We do not criticize XR development trends or claim that XR is dangerous outright, and we suspect that various benefits could far outweigh the risks. The warning call we publish here should help establish safety measures while not diminishing the enjoyment during XR gaming.

Keywords: Virtual Reality, Augmented Reality, VR gaming, gamer safety and gamer wellbeing, PTSD, psychoactive substances, neural networks, decision trees, kernel density estimation.

1 Introduction

1.1 Overview

Welcome to a near future that is actually upon us already. Virtual reality (VR) and augmented reality (AR; oftentimes, VR and AR together are labeled XR) games keep developing at a breath-taking pace. Their quality has improved tremendously, while currently available state-of-the-art and next generation hardware promises almost flawless implementation. These mass-produced gaming arenas offer such a high degree of immersion that oftentimes during the gaming session it is (intentionally!) well-nigh impossible to distinguish between what is real and what is virtual. In addition to these developments, the cost of hard- and software for gaming keeps decreasing, making consoles increasingly widely available.

Since triggering sensations in humans is easy to achieve in certain psychological domains, developers have become spectacularly imaginative in mastering scenarios that force the delivery of the very last possible drop (as it were) of adrenaline so as to trigger experiences of sexual arousal, fear, panic, and so on. From a psychological perspective (not a peripheral aspect for the game developer), the reality of these experiences is not debatable; it is the gaming environment that is virtual [1]. Herein, we deal with the psycho-medical issues involved in these very real experiences; the psychological domains that are characterized by high activation of affective states [2]. Typically, they trigger the above-listed stressful responses — just what the game developer intends.

In this article, we do not deal with psychological issues involving erotica; instead, we focus on the other scenarios in which humans exhibit a high resemblance to the real environment response. Vertigo, fear-inducing animals, and scary scenarios with villains unpredictably appearing with the intention to harm — these are typically used in gaming plots to provoke adrenaline rush. Typically, the fight-or-flight response, a primal adaptation, is triggered [3].

1.2 A scenario

A woman is wearing a goggle set and playing an XR game — a horror game. She is motivated to challenge herself more and more as the game progresses. She stayed awake longer than usual and drank, prior to gaming, a few energy drinks to achieve a higher state of alertness. In the game's plot, she is on the verge of being attacked by an opponent and she believes she has no more resources at her disposal to avert her ultimate death.

In the next moment, this woman perceives herself to be eaten alive by a gigantic spider-resembling monster that has jumped on her from apparently nowhere. There is no one to help her, and she hears her bones crack as massive teeth bite into her flesh. The whole sequence of terror-inducing events resembles a nightmare she had for several months after having seen a horror movie as a child.

In this proof-of-concept essay, we desist from continuing with the plot and its (programmed) outcome, especially the outcome for the gamer. Rather, we discuss a plethora of issues that occur during the crescendo up to the moment we described above.

1.3 Horror plot issues

There are several issues in horror and comparable VR games:

- (a) the psychic stability of and the psychological risks to the gamer;
- (b) whether the programmers have devised an AI (artificial intelligence) support so that an imminently dangerous course of events can be averted or ‘de-fused’ when the above scenario or a similarly dangerous one arises;
- (c) whether VR gamers should be wearing appropriate devices that monitor, perhaps independently (i.e. not all using the same device) heart-beat-rate, oxygen consumption, breathing amplitudes, galvanic skin response, etc.;
- (d) what algorithmically derived combination of monitoring device outputs can be used to reliably predict the imminent psychic crisis of the gamer;
- (e) whether VR games of this horror and violence severity should incorporate a suite of augmented predictor algorithms designed to anticipate the moment when ‘de-fusing’ is to be triggered.

These issues we have listed pose considerable challenges for the game developer. We address their algorithmic challenges here and elaborate technical details below. Plots, far from having a linear progression, must be designed with tree structures along their evolution. The branching points we are referring to must be of a safety fuse nature: on at least one branch, the plot must de-escalate and evolve further without referral to the experiences that may have induced panic, etc. that was on the verge of causing potentially far-from-trivial psychological (and perhaps physiological — think of an exorbitantly excessive heart beat rate!) harm.

Even more challenging for the game developer is the predictive nature of issue (d). There is little research on how to regress or cluster psychological and physiological crisis states from the device exports. Technically, this is a far from straightforward problem. The inputs we have listed are continuous variables, and the regressed prediction is a categorical variable; if the predicted categorical variable has the two states ‘continue’ / ‘de-escalate’ then it is tempting to consider a logistic regression [4]. However, psychologists can quite often list risk states that are not binary, and emergency physicians can list many more such non-binary risk states, because many physiological parameters are interdependent via feedback cycles. For non-binary branching scenarios, one-hot encoding [5] is necessary and the seemingly-attractive multi-level logistic regression [6] is ill-advised; we describe alternatives.

2 Psychology

2.1 Fight-or-flight response

In natural environments, there is a linkage between emotional stress and sympathetic activation — the so called “fight-or-flight” response. Psychologically: individuals then

feel anxious or aggressive. In certain individuals, namely those with existing pre-dispositions, this may lead to emotional instability or even “freezing” (described as extreme condition of panic [7]). These symptoms lead to future alterations of behavior. Psychologically, fight-or-flight response is characterized by an increased activation that prepares the body for strenuous actions that consume the body’s glycogen reserves.

Physiologically, fight-or-flight response is characterized by increased heart beat rate, sweating, heavy breathing, tunnel vision, and muscle tension. Increased levels of cortisol, testosterone, and neurotransmitters — adrenaline, dopamine, and serotonin — cause these characterizing reactions. Perceived control over the situation is altered, but to what degree depends on each individual’s mental level and previous relatable experience that may have positively — but sometimes perhaps very negatively — impacted the overall outcome. We note that this suite of reactions is what gaming programmers intend to precipitate. A XR horror or fear game necessitates such reactions, if commercial success is to be ensured. The gamer wants to experience such reactions, otherwise he/she would choose a different type of game.

2.2 Ingestion of psychoactive substances

To what intensity these reactions are experienced is further modified whenever psychoactive substances impacting the balance within the homeostatic system are (literally) incorporated. Legal substances such as caffeine, taurine, and alcohol but also illegal ones (‘drugs’ in common parlance) are such modifiers. We need to address this aspect, actually a concern, because it can be considered common knowledge that players often ingest some of them prior to gaming. Professional players are not permitted to incorporate any of these substances prior to gaming competitions and transgressions are controlled by anti-doping agencies, but there are no restrictions for amateur gamers. We, the authors, are debating among ourselves whether to insist that a warning to gamers be displayed in the title frame of the game, but we currently remain undecided. We are aware of many experts and professionals debating the possibilities of impact on human mental health; and that some deny the possibility of negative impact on wellbeing and mental health. We disagree with the deniers — our position will be elaborated below. Consumption of psychoactive substances makes the algorithmic inclusion of where to place branching points in the demanded tree structure within the plot extraordinarily challenging (see below).

Our concern for psychological risks, which is one *raison d’être* for this paper, cannot be overstated. The issue of consumption of psychoactive substances prior to gaming sessions becomes more and more urgent as XR is becoming better and better (both in quality and immersion intensity), more popular (more time spent gaming), and more widespread (more and more gamers enter the market as consumers).

2.3 Virtual Reality and Psychological Reality

In VR, psychological systems are affected differently from in RR (‘real reality’). In RR scenarios humans have evolved adaptations and calibrations for these systems. Thus, in VR, the individual ‘knows’ (or, rather: ‘should know’) that the experienced horror,

terror, or other fearful scenario is not real. For remedial therapies that use VR, knowledge of the difference between ‘reality’ in VR and RR seem to be the reason these therapies are successful [8–9].

The differential impact on the systems under control of the solely sympathetic system (GSR), or in combination with the parasympathetic system (HRV) could serve as proxy for the stress experienced by the individual, irrespective of whether he/she is a therapy client or an (avid) gamer of horror plots. GSR and HRV are related to the Behavioral Inhibition System (BIS) and the Behavioral Activation System (BAS) scales [10–11] that can be tested on every user and aid in predicting the future physiological responses [12].

2.4 Physiological (continuous) random variables

Electro-dermal, cardiovascular, and breathing intensity changes are measures that have been commonly used in the past studies focused on affective state processing. Galvanic skin response (GSR) predominantly indicates sympathetic activity, and heart beat rate variability (HRV) has been closely linked to parasympathetic activity [13].

The heart beat rate increases in reaction to sympathetic activation and decreases with parasympathetic activation [14].

The arousal dimension is quantifiable by the combined readings of GSR, HRV, and other physiological measures. In particular, combinations of multiple measures should yield better predictions of discrete affective states. Therefore, the chosen psychophysiological measures are a valuable way to assess affective state processing and judgment.

2.5 Psychological (categorical) random variables

To address individual profiles of categorical variables, standardized questionnaire responses are an option.

Behavioral Inhibition (BIS) and Activation System (BAS): BIS is thought to be related to sensitivity to punishment as well as to avoidance motivation, while BAS to sensitivity to reward as well as to approach motivation [10]. BIS is more activated during VR gaming than BAS.

Furthermore, even though registrations of two motivational systems are not only differently distributed between the two sexes [10] but also the multivariate distributions vary within each, systematically affecting ratings, behavioral responses, and psychophysiological responses [15]. Women were shown to have stronger inhibitory systems than men [15].

2.6 Potentially-harmful experiences during computer gaming

Parallel to the inclusion of branching points by game developers, we list the following categories of the VR gaming environment to mitigate risk-controlled, potentially-harmful psychical experiences in VR gaming:

- a ‘simple’ VR arena with limited interaction options based on ferocious antagonists;

- an interactive VR arena with standard peripherals and game controllers (game pad, etc.);
- an interactive VR arena with realistic and artificial (experimental) locomotion;
- an interactive VR arena with extended peripherals (haptic, endless pavement, etc.).

Those attempting to develop ‘fuses’ that trigger branching should also consider adapting some previous ‘extreme’ computer game scenarios that are no longer *en vogue*. Although current levels of photorealism in computer (horror) gaming do not (as of this writing: yet) fully match reality, we list several pre-VR gaming experiences that have offered already near-reality authentic state of mind alteration and extreme decision making in the potentially harm-generating gameplay situations. As early as 2001, in *Return to Castle Wolfenstein*, a gamer was thrust into a dreadful situation upon being astonished by a sudden zombie attack in the (dark) castle subterranean vaults. In *Postal 2* (2003), the gamer could use different urinating strategies both as a weapon and as a fire extinguisher. In *Manhunt 2* (2007), the gamer is forced to kill an enemy by stabbing his neck with a pencil whereupon he could progress to the next game level. In *RapeLay* (2006) the gamer adopts the role of the rapist stalking a mother and her daughter in a subway/underground environment. In *Silent Hill: Homecoming* (2008) the gamer proceeds to experience numerous torture scenes. More recently: in *Hatred* (2015) the gamer is portrayed as a suicidal mass murderer shooting innocent civilians; in *Agony* (2018), the gamer is a tormented soul not remembering his or hers past while being possessed by various demons. While this list of controversial game products cannot be considered comprehensive, the aforementioned ‘experience game’ designs serve as a quite impressive set of examples of potentially harmful experiences by gamers. By specifically referring to the horror features in this list, we argue that in a VR environment such game designs lead to situations with an increased potential for psychologically harming the players; therefore, game producers need to implement certain types of branching options to be the harm-avoiding ‘fuses’.

In all the above mentioned scenarios, we can perceive another potential beyond instilling fear and inducing harm, namely the violation of moral codes. This twist, surely intentionally designed by the game developer, may again impact some gamers more than others and inflict damage because the gamer is forced to behave in a very brutal and sadistic manner, against their will (we hope!). So, while some will enjoy the freedom — and we do not doubt that there exists compensatory mechanism in human psyche that will benefit some players — others may find this frame extremely harmful and bothering to their persona [17].

3 Algorithms

3.1 Regression Algorithms: Generalities

In modern machine learning environments, a prediction based on the analysis of numerical random variables is called a regression and a prediction that is based on categorical variables is called a clustering [5].

There has been some research into how the change in several physiological parameters is indicative of altered psychological states that are brought about by horror/terror games. Most of this research is based, however, on reports of observed effects experienced by clients undergoing VR exposure therapy [17–18].

The reported results have two serious shortcomings:

1. Healthy individuals' responses (i.e. those who do not need anxiety disorder treatments — at least not prior to a damaging experience in a VR game) have not been monitored during gaming (and not controlled for the ingestion of psychoactive substances).
2. Many reported results rely on (i) fallacious statistical approaches (NHST — null hypothesis significance testing, for example [19], rather than calculating Bayes Factors); (ii) assumptions about the normality of the continuous variables, and the attendant ANOVA (rather than using maximum likelihood methods to determine the ML distributions); (iii) assigning numerical values to categorical variables (rather than using one-hot encoding).

In order to avoid a dangerous psychological state from arising, the gaming algorithm should continuously evaluate the state (a vector including the real-number-valued physiological parameters) and create a branch whenever a certain (vector) state indicating a dangerous level is predicted by the algorithm to be imminent. This algorithmic approach may, of course, require a time series analysis of several prior readings while the gamer is gaming. The knowledge of what constitutes a dangerous state is wherein one of the challenges lies. We see no other option other than running many learning algorithms on many personality types of gamers using the conventional training/test set paradigm of AI (artificial intelligence), possibly using neural networks. Other options, when attempting to determine boundaries between 'continue' and 'de-escalate' can include clustering algorithms of multi-variate categorical variables (among these: the BIS and BAS scales).

3.2 Regression Algorithms: Specifics

The description of algorithm details assumes that large data sets have been collected in order to construct predictions based on machine learning techniques [4], preferably those using AI [5]. The AI paradigm requires the repeated, random splitting of each data set into a training and a test set, perhaps necessitating the acquisition of still larger — or at least many more — data sets.

The components of the input vector for each gamer are realizations of two types random variables; some, such as age, and all the physiological variables (heart beat rate, skin conductivity, etc.) are continuous, real-valued, while others, such as sex (or gender, if the gamer is willing to reveal not only his/her chromosome-23 count, but also his/her sexual orientation) and a host of psychological scores, are categorical. The data matrix of the gamers used to determine the thresholds for branching points is therefore a formidable 'animal' (formidable for the programmer, not for the threatened gamer). The categorical variables, if not binary, need to be one-hot encoded, increasing the dimensions of each gamer's vector considerably. One consequence of this increase is, of

course, the need to increase the sample size. (This makes sense, because, irrespective of the complexity of the statistical techniques of the algorithm, the more options for some categorical variable, the larger the number of ‘guinea pig’ gamers for this variable, so as to ensure an adequate number for each option.)

Building algorithms that output predictions from a data matrix that contains a mixture of continuous and categorical variables is a task comparable to the *Titanic Challenge* (www.Kaggle.com): use the passenger lists of the eponymous passenger ship (containing names, class, age, family size, sex — but not gender —, fare paid, title: 3 categorical and 3 continuous random variables), and the inventories of who was rescued, to predict the survival chance for each line in the data matrix (i.e. for each passenger). Currently, there are more than 16 thousand teams that have submitted almost 81 thousand algorithms.

Spiegelhalter [20] describes one algorithmic approach: using (binary) classification trees while suppressing greediness. At each step in building the tree, the algorithm decides which of the two branches a passenger is assigned.

Another approach is based on constructing contingency tables and using KDE (kernel density estimation) to predict which cluster a passenger belongs to. Each cluster has a survival probability. The challenge therefore involves finding KDE algorithms and cluster detection methods so that, optimally, all passengers in a cluster are either survivors or not.

The third approach involves using NN (neural networks), a method that appears to be very promising. Build a neural net with several layers and let the NN (literally) learn which entries generate a prediction of survival or not. There are several flexibilities available for the design of NN.

The implementation of one of these three AI approaches to avoiding serious psychological harm are clear. During the gaming session, the continuous random variable inputs are constantly being updated (the categorical variables presumably stay constant). Based on the trained algorithm, the output switches from ‘continue’ to ‘de-escalate’ based on the prediction generated by the algorithm.

We warn against simplifying the data set used for generating predictions as a matrix of continuous variables and using a simpler regression algorithm. This simplification would require an enormous number of algorithms, one for each combination of categorical variable realizations (combinatorics would show how the number of possibilities explodes). If, for example, there are n_{BIS} BIS states, n_{BAS} BAS states, n_{SIS} SIS states, and n_{gender} gender states, then the number of data matrices of continuous variables would be

$$n = n_{\text{BIS}} \times n_{\text{BAS}} \times n_{\text{SIS}} \times n_{\text{gender}}$$

Assuming the number of states in each categorical variable is 5 (a conservative assumption), then $n = 5^4 = 625$ data matrices would be needed, each with roughly 1000 gamer entries. Because no gamers can be in two different data matrices, considerably more than half a million ‘guinea pig’ gamers must be surveyed and analyzed with one suitable, or, better yet, several de-fusing algorithms.

On the other hand, it would be highly unusual for the states (except gender, perhaps) to be independent. Because the AI paradigm results in highly optimized outcome prediction, interdependencies will automatically be accounted for, reducing the computational load.

A further optimization can be achieved by finding higher-dimensional manifolds which are close to the registrations post one-hot encoding. Applying dimension-reduction algorithms, prior to AI learning, will most likely (pun intended!) be possible.

More detailed descriptions of algorithm development strategy we cannot supply, because strategies depend on the population profile of the gamers, including their psychoactive substance consumption habits. In any case, including the categorical variable(s) in the data matrix and then applying AI learning promises to improve performance, efficiency and tractability.

Much to the chagrin of psychology researchers, AI learning approaches do not offer insight into what is ‘going on’ in the mind of the gamer. But, for the game developer, this lack of insight is of minor concern, as long as prediction reliability is ensured (and the scariness to be instilled in the gamer retained). The reliability is the necessity we are arguing for: it protects the gamer from psychological and physiological harm.

4 Conclusion

We have argued that induced psychological harm is a health risk that should not be underestimated and, in particular, be addressed with both a device-reliant and an algorithmic approach to be developed using AI.

Devices: Prior to rigorous multivariate statistical analysis of physiological data involving dimension reduction, learning and prediction algorithms, gamers should play only while being equipped with suitable devices that measure at least heart beat rate, galvanic skin response, blood pressure, and respiratory pattern. Modern technology has developed such data acquisition devices that are small, reliable, and neither physically constrain nor distract the gamer.

Algorithms: Gaming plots must be based on a tree structure (not necessarily a binary tree) so that the program can pre-emptively side track a gamer before dire scenarios cause psychological damage to him/her. Algorithms must employ state-of-the art AI statistical learning tools, such as kernel density estimation, decision trees, or neural networks tuned and trained on to-be acquired data sets with suitably distributed (i.e. non-biased) categorical variable realizations.

We expect the protection of gamers from being psychologically harmed will be dramatically enhanced by implementation of the algorithms we demand.

We fear the industry and the gamers will resist proposed solutions that avoid harm; yet we insist on ‘fuse’-mechanism being included in gaming arenas. It may be that the industry will fear considerable extra investment in programming, and gamers might fear losing the chance to experience the ‘ultimate kick’. We point out that the same devices and algorithmic tools can be used to track the state of any individual and therefore create appropriate vector descriptions in other situations. They have already been successfully implemented in (remedial) treatment-cum-gaming scenarios. The future of

VR is promising, as long as it can benefit from additional safety by including the above described tools. As many physiological measurements can be collected during the gaming session, we suspect that the prediction accuracy will increase when machine-learning algorithms are included in the gaming package.

We know that our safety approach has a speculative aspect, due to the fact that we cannot let several players experience a physical and mental state that would lead to harm and deduce data-based algorithms from these extreme cases. Game developers do not solely rely on reliability progress through amassing data sets. Prior to mature, ‘fuse’-based algorithms, gamers could volunteer to wearing both head-mounts and bracelets with detectors that could be used to signal when they are exhausted, frightened, and so on. A mechanical option, such as a simple switch, could also be supplied as a last resort. Such provisional measures would allow for using gamers’ physiological profiles as stepping stones for AI development schemes.

We are aware that it is almost impossible to forbid or prevent gamers at home to ingest substances that alter their psychological dispositions and the physiology of their body (most notably the legal ones). Thus, physiological measures could be used to infer that an alarmingly harmful situation is imminent. There are recorded cases in which people have hurt themselves because of their inability to retain their posture/balance due to the demanding action in VR [9]. If individuals already become stressed while not under the influence of a psychoactive substance, imagine what can happen after the consumption of, say, ethyl alcohol and/or taurine. We do not delude ourselves to believe that we can forbid gamers from ingesting psychoactive substances and so we resign ourselves to knowing they will. These changes of homeostasis will occur and algorithms must monitor the individual’s physiological state and save him/her from harm.

We know that the needed *devices* are already available and claim that the appropriate *algorithms* can be developed, allowing for even better — and harm-free — gaming arenas in the brave new worlds of XR gaming.

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Bolest a slast v sexuálním chování

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Abstrakt

Z evolučního hlediska jsou bolest a slast jedním z nejdůležitějších procesů pro přežívání živočišných druhů. Indikace bolesti napovídá organismu, že se má aktu, který mu bolest způsobuje, vyhnout, že pro něj představuje nebezpečí a že je pro něj škodlivá. Naopak slast přináší organismu uspokojení a říká mu, co je pro něj přínosné a příjemné. Slast tak může přinášet téměř cokoliv, jako je například uspokojení z dobrého jídla, které je rovněž důležité pro přežití. Avšak ne vždy jsou tyto dva procesy vnímané jako rozdílné a protichůdné. Jsou oblasti, kdy jeden z prožitků může způsobit či ovlivňovat druhý. Konkrétně co se týká oblasti lidské sexuality, je mnohdy rozdíl mezi těmito dvěma velmi intenzivními stavy stírán; prolínají se a vydávají se, obrazně řečeno, na stejnou cestu. Bolest totiž může přinášet, nebo potencovat i slast. To má za následek vyhledávání těchto velmi intenzivních stavů.

Klíčové slová: bolest, slast, sexuální vzrušení, lidská sexualita

Abstract

From evolutionary point of view, pain and pleasure are some of the most important processes for survival. The pain serves as indicator that the causing activity or stimulus should be avoided for its potential to cause harm. Conversely, pleasure is pleasing and shall guide the organism or individual towards repetition and benefit. There are various stimuli that may bring pleasure such as food that is also beneficial for survival. Thus the two processes are not always distinct and countering each other. There are moments when one experience can cause or potentiate the other. Concretely, human sexuality is a field where the two can coexist and share the paths. Pain may bring or potentiate gratification and pleasure. This may be the final reason why people intentionally search for these intensive experiences.

Keywords: pain, pleasure, sexual arousal, human sexuality

Úvod

Evoluční pohled

Vnímání bolesti je komplexní fenomén, který má v centrální nervové soustavě významnou odpověď. Dá se říci, že v lidském mozku spolu neustále zápasí, ovšem se i navzájem doplňují, prožitky bolesti a prožitky slasti. Jsou to totiž dvě motivace, jelikož vyhledávání slasti či něčeho, co přináší příjemné pocity a vyhýbání se bolesti a nepříjemným pocitům, jsou jedny z klíčových motivací pro přežití. Bolest a slast tedy bývají v odborných výzkumech zkoumány jako dva rozdílné intenzivní stavy, ovšem propast mezi nimi není až tak velká, jak se může zdát (např. Seymour a kol., 2007; Scott a kol., 2007; Fields, 2007).

To že je bolest významným činitelem v lidském chování si můžeme snadno demonstrovat na případu osob, které trpí mutací, která jim znemožňuje cítit bolest. Tato mutace dokonce významně ovlivňuje jejich prožívání

strachu a stresu – které se sekundárně vyvíjí na základě prožitků bolesti (Habib a kol., 2019).

Bolest je navíc velmi dobře studované téma, jako mnohé negativní emoce u člověka. Je jednoduché (fyzickou bolest) vyvolat v laboratorních podmínkách, je relativně univerzální, co se stimulů týče (Edwards a kol., 2004), i přesto, že existují rozdíly v závislosti na osobnostních charakteristikách (Diener a kol., 2009). Strach a hněv vyvolává tendence utéct a bojovat (Tooby a Cosmides, 1990; McCarty, 2016). Naproti tomu existuje široké spektrum pozitivních stimulů, které jsou velmi kulturně ovlivněné, a existuje velmi málo stimulů, které jsou pozitivní a naprosto univerzální. Jako příklad si můžeme uvést vazbu na jídlo, které obsahuje vysoký obsah tuků a cukrů, které byly v lidské evoluční historii klíčové pro přežití (Tooby a Cosmides, 1990; Drewnowski a kol., 1992). Vyvolávání slasti, je v laboratorních podmínkách velmi těžké s výjimkou podávání psychoaktivních látek (Haney, 2009) a sexuálního vzrušení (Hamilton a kol., 2008). Naše porozumění těmto mechanismům je ovšem

velmi malé v porovnání s prožitky negativními, a to ani nezmiňujeme bolest a slast psychickou způsobenou prožitkem.

Bolest, tedy fyzický diskomfort může být i jakýmsi mezistupněm ke slasti, resp. k potěšení ve formě odměny. Dobrým příkladem je forma bolesti u sportovců, kteří jsou schopni, za vidinou odměny vítězství, tuto bolest částečně potlačit (Bentham, 1996). Slast je tak logickým vyústěním předešlého utrpení, které však zpětně jako takové utrpení vnímané není a je „přebito“ pozitivním prožitkem z vítězství. Prožitek slasti může být rovněž tím větší, čím větší je předešlá bolest. Typickým příkladem je obranný mechanismus u organismů – čím je hrozba pro organismus větší, tím větší bývá i bolest, která agresivnější spustí obranné mechanismy a mechanismy snažící se hrozbě vyhnout (Price a kol., 1987). Tento stav se nazývá homeostáze, jedná se o rovnováhu vnitřních procesů v těle organismu. Jakmile dojde k vybočení z této rovnováhy negativním směrem (bolest), snaží se organismus tuto rovnováhu vyrovnat opačným pocitem, tedy slastí (Craig, 2003).

V tomto případě lze hovořit také o tzv. Motivation-Decision Model (model motivace a rozhodnutí), který funguje na bázi nevědomých rozhodovacích procesů (Fields, 2006). Do tohoto modelu pak spadají informace o vnitřním stavu organismu, tedy o homeostatické rovnováze, jako je pocit hladu, senzorické vjemy a povědomí o přítomné hrozbě a potenciální odměně. Dle Motivation-Decision Model tak teoreticky cokoliv, co je důležitější pro přežití, má potlačit způsobovanou bolest a pozornost má být směřována převážně na přežití.

Bolest a lidská sexualita – sadomasochistické chování

Konkrétní oblastí, ve které figuruje bolest a slast, a které se chceme věnovat, je lidská sexualita. Prožitek z bolesti totiž může být natolik intenzivní, že přináší sexuální vzrušení, potažmo je schopen přivodit orgasmus ve chvíli jejího náhlého odeznění (Mayberry a Daniel, 2016). Vztah sexuálního vzrušení a bolesti či diskomfortu lze nejlépe zkoumat na sadomasochistickém chování, tedy sexuálním chování, které je založeno na přijímání či způsobování bolesti, na cíleném ponižování či na dominanci a submisivitě.

V úvahu by připadaly ještě studie o sexuálním násilí, ovšem nejedná se samozřejmě o konsenzuální styk a k sexuálnímu vzrušení nedochází u obou stran. Některé zdroje navíc uvádějí, že agrese působí naopak jako „anti-vzrušivý“ element, a tudíž není kompatibilní se sexuálním vzrušením, jelikož neuropřenašeč nazývaný sympatický katecholamin, který souvisí právě s hněvem a agresí, rovněž zapřičiňuje ústup sexuálního vzrušení u mužů, penilní detumescenci (Hnasko a kol., 2005; Pecina a kol., 2003). Ve studiích, které se zabývaly sexuálními zločiny, v některých případech k erekci vůbec nedocházelo (Barbano a Cador, 2006; Barbano a Cador, 2007). Vzrušení ze sexuálního násilí – mluvíme-li o nekonsenzuálním styku – nicméně častý jev je. Zde ho ovšem rozebírat nebudeme.

Ačkoliv je sadomasochistické chování považováno některými zdroji za sexuální poruchu, v tomto textu to tak vnímáno nebude a bude přijímán názor SM komunity, tedy že se nejedná o poruchu a případné deviantní chování,

ale o sexuální preferenci (Wismeijer a van Assen, 2013). Rovněž z hlediska psychoanalýzy se sadomasochismus považuje za psychopatologii, ovšem sociologické a sociálně psychologické výzkumy takový postoj nezastávají – jedná se o osoby emočně a psychicky vyrovnané, které přijaly svou sexuální roli a nevybočují z rolí sociálních (Weinberg, 2006). Jedním z nejdůležitějších aspektů je však konsenzus. Není možné provozovat sexuální sadomasochistické praktiky bez souhlasu všech zúčastněných (Lawrence a Love-Crowell, 2008; Lindemann, 2011; Kolmes, Stock a Moser, 2006).

Je však nutné poznamenat, že ne vždy je při sadomasochistických praktikách přítomna bolest. Pod pojem sadomasochismus mohou spadat rozličné praktiky – pro tyto praktiky je často používán pojem BDSM, který se skládá ze tří zkratk – B/D (bondage and discipline neboli svazování a poslušnost/výcvik), D/s (dominance a submisivita) SM (sadismus a masochismus). (Kolmes, Stock a Moser, 2006).

Rovněž způsobování či přijímání bolesti nemusí prvoplánově sloužit právě za účelem bolesti. Účelem může být vyjádření hierarchického rozdělení, tedy k vyjádření dominantní a submisivní role (Cross a Matheson, 2006; Wismeijer a van Assen, 2013). Jak tedy lze vidět, v těchto případech nemusí sexuální uspokojení či slast pocházet ze samotné bolesti či způsobování bolesti, ale právě z rozdílného postavení účastníků sexuálních praktik. Jedinci praktikující tuto formu erotických her tyto aktivity mohou vykonávat spíše kvůli smyslovému uspokojení, a ne tolik kvůli erotickému uspokojení (Newmahr, 2010).

Jak již bylo zmíněno výše, slast může být způsobena úlevou od bolesti. Toto by bylo možné aplikovat i na sadomasochistické chování. Slast ani tak nepřináší samotná bolest, jako právě uvolnění od bolesti. Čím je bolest větší, tím větší je úleva, když bolest pomine a tím větší je i vzrušení z tohoto zážitku. Stále se však jedná o intenzivní stavy, kdy jeden doplňuje druhý, ani v tomto případě nejsou protichůdné.

Sadomasochismus je v dnešní době přijímán téměř jako normativní sexuální chování (Weinberg, 2006; Wismeijer a van Assen, 2013), kdy je brán a provozován bez různých předpokladů, kterým čelil v minulosti a dostává se jak do běžného života, tak do mainstreamových médií (Wilkinson, 2009). Sexuální vzrušení z bolesti, popřípadě z dominance a ponižování (případně přijímání bolesti a submisivity) je totiž jev, ke kterému má každý člověk blízko. Bolest, poslušnost a oddanost je brána jako „zpestření“ „klasického“ sexuálního styku a paradoxně je to právě bolest, která je nejjednodušší „dostupná“. Ze všech lidských prožitků má nejbližší ke vzrušení a je v podstatě velmi jednoduché ji provozovat. Existuje několik vysvětlení, proč je tímto prožitkem právě bolest.

Nejednoznačné prožitky – nesprávné určení vzrušení

Do schématu vzrušení z bolesti může také spadat nesprávné určení příčin vzrušení (anglický originál: *Misattribution of Arousal*), kdy nesprávné čtení emocí a jejich následný přenos může ovlivňovat vnímání celé situace.

Například v klíčové studii Schachtera a Singera z roku 1962 měli mužští účastníci výzkumu za úkol přejít jeden ze dvou mostů společně s ženskou výzkumnicí. Jeden z mostů byl zavěšen nízko, druhý vysoko a houpal

se. Následne vyplňovali tzv. tematický apercepcný test (přisuzování významů nejednoznačným obrázkům) a měli možnost ve dnech následujících po testu kontaktovat výzkumnici pro případ jakýchkoliv dotazů. Ukázalo se, že pokud muži přecházeli po vysoko zavěšeném mostě, měli tendenci častěji přisuzovat obrázkům sexuální význam a častěji zpětně kontaktovali spolupracovníci. Pokud tedy došlo k nespecifickému vzrušení (v podobě adrenalinu z přecházení mostu), měli účastníci tendenci vykládat toto vzrušení jako sexuální a přikládali mu sexuální význam.

Je tedy možné, že tento fenomén je přítomný i při sadomasochistickém chování, respektive v takovém chování, kdy je vzrušení z bolesti připsáno sexuálnímu vzrušení. Je však zřejmé, že tento fenomén nenastává u všech jedinců. Někteří jedinci mohou být na toto nespecifické vzrušení citlivější, a tudíž právě jim pak může bolest přinášet slast. Kromě výše popsaného fenoménu však do celé problematiky spadá i lidský mozek.

Bolest a lidský mozek

Z výzkumů totiž vyplývá, že požitek bolesti i požitek slasti v naší nervové soustavě aktivují insulární kortex, tedy oba požitky aktivují stejnou část mozku (Casey a spol., 2001; Komisaruk a spol., 2004). S použitím magnetické rezonance bylo dokonce zjištěno, že při orgasmu je v mozku aktivních až 30 oblastí, a to včetně těch, které jsou aktivní i při bolesti (Komisaruk a kol., 2011). Může tedy docházet k interakci těchto dvou požitků, pokud jsou v této části mozku aktivovány, což by vysvětlovalo podobnost výrazu tváře bolesti a slasti – viz níže (Komisaruk a spol., 2006).

Kontext je tak často velmi důležitým prvkem, dle kterého lze tyto dvě emoce od sebe rozdělit. Nicméně v určitých případech si tyto dva pocity konkurují nebo přinejmenším mohou nastat ve velmi krátkých intervalech po sobě. Vrátime-li se k sexuálně motivovanému násilí, mnoho sexuálních násilníků si často vyloží emoční stav oběti jako konsenzuální a sexuálně žádoucí, nikoliv jako stav strachu a bolesti (Johnson, 2006).

Bolest a slast v lidské tváři

Z evolučního hlediska je rovněž zajímavé, že výrazy bolesti a slasti u člověka se velmi podobají a často je složité je od sebe rozeznat, ačkoliv, jak již bylo řečeno výše, jsou tyto dva velmi intenzivní stavy kritické pro přežití organismu, a to právě i co se týče výrazu tváře druhých.

Odečítání emočních stavů z výrazů tváře ostatních se objevuje i u ostatních primátů, kteří jsou člověku příbuzní (Darwin, 1872).

Výrazy bolesti mohou varovat ostatní před hrozbou nebo naopak vyvolávají empatické pocity, a tudíž zvyšují šanci na přežití ve formě pomoci od ostatních (Williams, 2002). Fyzické vyjádření požitku slasti je tak klíčem k úspěšnému rozmnožení, potažmo k uchovávaní vztahu.

Dalším zajímavým příkladem je zjištění, že pozitivní výrazy tváře jsou rychleji rozpoznány než ty negativní, a to obzvláště výrazy ženské tváře (Grimshaw a spol., 2004; Hugenberg a Sczesny, 2006). Ovšem toto platí spíše při rozpoznávání individuálních tváří. Pokud je například více tváří v davu, jsou zde rychleji rozpoznány výrazy agrese, tedy negativní emoce, a více přitahují pozornost

(Eastwood a kol., 2001). Toto je zřejmě určené tím, že rozpoznat výraz agrese ve velkém davu zvyšuje šanci na varování před potenciální hrozbou a na včasné reagování (Hansen a Hansen, 1988).

Ženy jsou přitom zdatnější ve správném odečítání emocí z výrazů tváře ostatních (Hall a Matsumoto, 2004; Hampson, van Anders a Mullin, 2006), ovšem muži lépe a rychleji rozpoznají z výrazu tváře hněv (Rotter a Rotter, 1988). Nicméně, studie Chena a kolegů z roku 2016 zjistila, že výrazy tváře bolesti a slasti naopak od sebe odlišitelné jsou. Respondenti správně určili emoci, což by značilo, že ačkoliv objektivně tyto dvě emoce je těžké rozlišit, podvědomě poznáme jejich správný význam z kontextu.

Výrazy tváře, ať již před započatím sexuálních aktivit, či v jejich průběhu, jsou klíčové pro prožívání sexuálního vzrušení nebo pro vytváření vazeb mezi partnery a měly by být studovány s ohledem na přesnost určení. V BDSM komunitách je pro případ nesprávného pochopení prožitků druhé osoby určeno gesto (například zdvihnutí ruky), nebo tzv. safe-word (slovo, při jehož vyřčení je jakákoli další aktivita zastavena), což dovoluje stupňování negativních prožitků, které jsou součástí těchto aktivit (Dancer a kol., 2006). Alternativou může být tzv. semafor, kdy partner, který přijímá submisivní pozici, může vyřčením barvy (zelená = mám zájem pokračovat intenzivněji, oranžová = zůstaňme nejvýše v této intenzitě, červená = okamžitě sniž intenzitu / zastav) intenzitu prožitku regulovat. Je však otázkou, nakolik je takový přístup praktikován v párech, které nemají předem nastavené hranice a je nutné odečítat emoce pouze z tváře či hlasového projevu.

Závěr

Z uvedeného vyplývá, že je velmi důležité vnímat stavy bolesti a slasti nikoliv jako protichůdné prožitky; nebo respektive chápat jejich vzájemné propojení. Nelze je však ani vnímat, že jeden prožitek spouští druhý, tedy že se nutně střídají. Tyto dva velmi intenzivní stavy totiž spíše koexistují spolu, vyvolávají podobné reakce a navzájem se doplňují. To je z velké části podmíněno tím, že bolest i slast vyvolávají velmi podobné fyziologické reakce těla, o čemž svědčí i aktivování stejných oblastí mozku. Fyziologická reakce těla na vzrušení je velmi podobná reakci na stresové podněty a organismu, i nám subjektivně, mohou tyto dva „požitky“ připadat stejné; „slévají“ se dohromady a je těžké subjektivně, objektivně, i za pomoci laboratorních přístrojů určit původ výsledného prožitku. Je potřeba dalšího výzkumu pro pochopení vzájemné interakce těchto prožitků, což ztěžuje fakt, že některé observační metody v laboratorních podmínkách nedovolují správné odečtení emocí z výrazů tváře. Naturalistický výzkum a kvalitativní sběr dat ve spolupráci s komunitami, které se těchto výzkumů účastní, je tak klíčový pro budoucí pokrok v této oblasti a předem jim za jejich ochotu děkujeme.

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Vliv pornografie na přejímání emocí a sexuálního chování

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Abstrakt

Emoce jsou důležitým aspektem v lidském vývoji i v sociálním chování a jejich správné čtení je kritické při interakci s ostatními, ať už se jedná o běžnou sociální interakci či romantické či sexuální chování. Kromě čtení emocí je důležitým aspektem také jejich přejímání, resp. zrcadlení na nevědomé úrovni, empatie. Typicky je takovéto chování viditelné u dětí, kdy také dochází k vývinu těchto emotivních složek. Přejímání emocí však může být také negativní, jako je například duplikování agresivního chování. Co se týče sexuálního chování, může docházet k tomu, že toto chování je přejímáno z pornografických materiálů, kde se však jedná o emoce falešné, což vytváří mentální obraz určitého sexuální chování, který je považován za správný, avšak je zkreslen nároky (pornografické) filmové tvorby. Zejména důležitá je tato diskuze v oblasti sexuálního násilí, kdy zobrazované sexuální násilí či agrese v pornografickém materiálu může značně zkreslovat představy o povaze násilí. Tyto témata jsou diskutována zejména s ohledem na sexuální edukaci a vzdělávání.

Klíčová slova: emoce, přejímání emocí, sexuální chování, pornografie, sexuální násilí

Úvod

Konzumování pornografie a sexuální násilí

Pornografie, tedy prezentace vzrušivých neuměleckých materiálů, které jsou vytvořeny za účelem vyvolání vzrušení u konzumenta, jejíž vkusnost a přípustnost je dána dobou, zákonem a obecným náhledem jednotlivce (kompilace několika definic upravená autory) je častěji sledována muži než ženami. Tento rozdíl se však v posledních letech snižuje (Ramlagun, 2012).

Sledování pornografických materiálů může ovlivňovat emoční odpověď na nevědomé bázi. Ačkoliv testované osoby nemusí reportovat subjektivní pociťování emocí při určité zobrazované emoci v pornografickém snímku, při laboratorním měření frekvenční odezvy mozku se ukazuje,

Abstract

Emotions are an essential aspect of human psycho-social development, and their correct ascription is a crucial element when interacting with others. That goes for casual everyday interactions as well as romantic or sexual interactions. Reading emotions and emotional coupling or mirroring – empathy – is what makes such interaction understandable and pleasant. It is important, particularly in children who can absorb the emotional and behavioral responses to certain situations from adults, such as aggressive behavior observed in adults. Pornographic movies may be a source of imitation models. However, the emotional states depicted in the erotic material can be manipulated or even completely false, possibly creating a perception of appropriateness in a viewer. The images of violence can further grow in the imagination of the consumer. Therefore, the role of pornography should be discussed from a didactic point of view, which we attempt in this article.

Keywords: emotion, emotional coupling, sexual behavior, pornography, sexual violence

že dochází k přejímání emocí podvědomě (Kunaharan et al., 2017).

Ačkoliv někteří jedinci mohou vykazovat sklony k sexuálnímu násilí při zvýšené konzumaci pornografie, není stále jednoznačné, zdali se jedná o kauzalitu. Výzkumy na tuto otázku nepředkládají jednoznačnou odpověď a často může být tato argumentace ovlivněna přístupem dané společnosti i konkrétního výzkumníka (např. Bachman et al., 1992; Bouffard, 2002). Nicméně problémem zůstává nedostatečné rozlišování mezi korelací a kauzalitou, což je bohužel stále častý jev.

Především výzkumy dokonce naznačily, že zvýšené konzumování pornografie může vést k vyvolání negativních emocí, a tudíž i k sexuálnímu násilí (Wright

et al., 2015; Paolucci et al., 1997). Sexuální predátoři přitom mohou konzumovat pornografii i signifikantně ve větší míře, než průměrný konzument (Johnson, 2015). I jiné studie ukazují užší souvislost mezi konzumováním pornografie, kde se jmenovitě vyskytuje nějaký násilný akt, a sexuálně motivovanými násilnými zločiny (Hald et al., 2010).

Jiné studie věnující se vztahu zvýšené konzumace pornografie a sexuálního násilí však nenašly žádnou signifikantní souvislost (např.: Allen et al., 1995; Ferguson & Hartley, 2009). Existuje také několik studií, které se spíše věnují negativním efektům zvýšené konzumace pornografie z hlediska emocí a škodlivého dopadu na sociální a potažmo sexuální chování. Zvýšená konzumace pornografie totiž může vést například ke zvýšeným úzkostem (Szymanski & Stewart-Richardson, 2014), depresím (Conner, 2014), či k potížím s erekcí při interakci s partnerem (Park et al., 2016).

Při častějším sledování pornografických materiálů také dochází k tomu, že konzumenti vyhledávají postupně čím dál tím víc explicitnější materiály, aby dosáhli stejné úrovně fyziologického vzrušení (Harper & Hodgins, 2016). Tedy jejich fyziologické vzrušení zůstává stejné, avšak je potřeba stále silnějších podnětů.

Jedná se o tzv. habituace, tedy navyknutí si na stejné prezentované stimuly, k čemuž následuje slabší sexuální odpověď; tento proces je přitom přítomný více u mužů než u žen (Koukounas & Over, 2000; Laan & Everaerd, 1995; O'Donohue & Plaud, 1991). Je možné, že tento proces je navíc přítomný i v reálných partnerských vztazích, kdy může docházet k navyknutí si na sexuální podněty, a tudíž i k případnému nesprávnému určování sexuálního vzrušení. Toto však může být obzvláště komplikované v případě, kdy u mužů dochází k sexuálnímu vzrušení a automaticky předpokládají stejný emoční stav u partnerky. Dochází tedy k nesprávnému čtení komunikovaných informací.

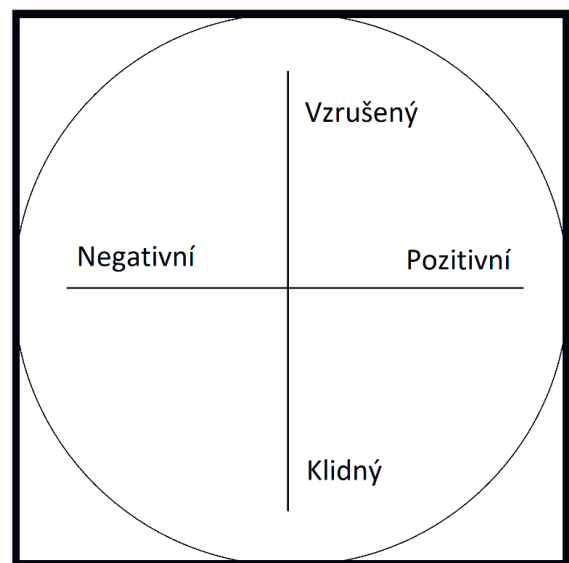
Určování emocí a dvoufaktorový model emocí

Schopnost odečítat výrazy tváře ostatních a dostávat tak tím informace o jejich momentálním mentálním stavu, náladě a emocích patří k základním a velmi důležitým prvkům v lidské komunikaci. Již Charles Darwin (1872) a později Paul Ekman (2006) upozorňovali na důležitost emocí a univerzálnost ve výrazu tváře. Odečítání emočních stavů z výrazu tváře se navíc neobjevuje pouze u člověka, ale i u jiných primátů člověku příbuzných (Darwin, 1872).

Určování emocí lze rozdělit do tří složek: a) *valence* (pozitivní a negativní, anglický originál: *Positive and Negative Affect*); b) *salience* (vysoká a nízká; značí míru prožívaného emočního stavu, značí míru vzrušení); c) kognitivní přiřazení (slouží k označení určitého psychofyziologického stavu jako „emoce“). Na základě kognitivního přiřazení spouštěče je následně psychofyziologický stav určen a označen jako emoce.

Emoce jako taková je nejenom prožívána, ale její prožívání je také některým z komunikačních kanálů vysíláno a přijímáno druhými osobami. Při takové komunikaci je však velmi důležitý vlastní emoční stav příjemce, který může významně ovlivňovat příjem a vnímání vysílané emoce. To se ukazuje zejména důležité při komunikaci s potenciálním partnerem či v již probíhajícím partnerském vztahu. Správné čtení a určení emocí mohou být kritické pro další interakci s potenciálním partnerem či k uchování současného vztahu. Emoce mohou být určeny i nesprávně.

V klíčových studiích Clarka a Sensibara z roku 1955 a Schachtera a Singera z roku 1962 bylo zjištěno, že při afektivních stavech může být k danému emočnímu stavu či vyladění přiřazen nesprávný význam. Konkrétně vzrušení z přívalu adrenalinu může být vyhodnoceno jako sexuální vzrušení. Autoři na základě těchto výzkumů vytvořili dvoufaktorovou teorii emocí (anglický originál: *Two-Factor Theory of Emotion*; Schachter & Singer, 1962) na jejímž základě byl později vytvořen Dvoufaktorový emoční model (Feldman, 1995; viz Obr. 1). Dle této teorie není fyziologická změna dostatečným podnětem, aby mohlo dojít k vnímání emocí. Kromě fyziologické změny je totiž také nutná přítomnost kognitivní složky. Tedy daný podnět v dané situaci může zapříčinit, že je fyziologická odpověď prisuzována jinému podnětu, než který ji vyvolal.



Obr. 1: Dvoufaktorový emoční model Feldman, L. A. (1995)

Jedním z nejznámějších výzkumů, který se věnoval přejímání a kopírování emocí, jmenovitě tedy agrese a násilného chování, je experiment Alberta Bandury z roku 1961. Při něm jedna skupina dětí v předškolním věku sledovala videa, kde figurantka fyzicky napadala a nadávala hadrové panence. Této skupině pak byly ukázány hračky, se kterými si však děti nesmějí hrát. Pokud jim však byla představena panenka z videa, měly děti tendenci směřovat svou frustraci ze zákazu hraček a následnou agresivitu právě na onu panenku. Druhá skupina dětí, která videa neviděla, toto agresivní chování nemělo. Došlo tedy k tomu, že děti replikovaly chování, emoce, které viděly, a které považovaly v tu chvíli jako za „správné“, adekvátní. Zjednodušeně řečeno jako něco, co by se mělo dělat.

Na tomto místě také považujeme za důležité zmínit efekt tzv. emočního párování (*Emotional coupling*; Budell et al., 2010; Caruana, 2020), kdy mají jedinci tendenci přejímat komunikované emoce protějšku. Z hlediska sexuálního je to pak především sexuální vzrušení nebo naopak diskomfort, jejichž správné komunikování je důležité pro správné čtení situace (Aviezer et al., 2008; Clark & Sensibar, 1955; Younis et al., 2015).

Co se týče dlouhodobých partnerských vztahů, je toto emoční párování zejména důležité, jelikož je kritické pro spokojenost obou jednotlivců ve vztahu, tudíž i pro

potenciální dlouhodobost tohoto vztahu. A právě sexuální složka partnerského vztahu je jedním z nejdůležitějších atributů (Montesi, 2011), přičemž muži obecně přikládají sexualitě ve vztahu větší důležitost než ženy (Peplau, 2003). Pro spokojenost ve vztahu je tudíž důležité správné určení původu sexuálního vzrušení, jelikož frekvence sexuální interakce je pro oba partnery stejná, ovšem prožívaná emoce či informace, které obě strany komunikují, mohou být odlišné (Birnbau, 2006). To je dobře vidět na příkladu, že pokud mají ženy nižší svou vlastní sexuální vzrušivost, mají tendenci přisuzovat nižší spokojenost se sexuální interakcí ve vztahu. U mužů se tato tendence neobjevuje (Baumeister, 2000).

Pokud toto přejímání sexuálního chování vztáhneme na sexuální chování u lidí a potažmo i na přejímání emocí, můžeme usoudit, že tento efekt může být velmi ovlivněn pornografickými materiály. Pornografie se stala běžnou součástí naší kultury (Paul, 2010; Weiss & Zvěřina, 2001) a pro dospívající jedince tak může představovat vlastní jediný způsob, jak přejímat sexuální chování. Co je však problematické je fakt, že sexuální chování a emoce zobrazované v těchto snímcích jsou většinou hrané, falešné. Scénáře jsou svou zápletkou nereálné. Zejména se pak jedná o nesouhlas se sexuálním stykem a záměrně zdůraznění překonání nesouhlasu. Scénáře totiž často představují vzrušující fantazie a touhy, které však nekorespondují s typickým sexuálním chováním. Svou charakteristikou jsou velmi extrémním zobrazením oproti typickému sexuálnímu chování. Sexualita je zde nadhodnocována a zdůrazňována. Emoce běžně vyskytující se v sexuální interakci v běžném životě či partnerském vztahu jsou tak většinou potlačovány nebo naopak přeháněny. Sexuální chování jednotlivců pak tímto může být velmi zkresleno a nekoresponduje s preferencemi a požadavky partnerů/partnerek.

Emoce v pornografii

Účinkování v pornografických snímcích je i pro herce a herečky významnou emoční prací (*Emotional labour*). Jde o aspekt pracovní činnosti, který odráží míru nutné emoční investice do zaměstnání, která je extenzí fyzického vykonávání zaměstnání (Parvez, 2006). Pro snadné pochopení bychom si tento pojem mohli vysvětlit na povolání servírky. Při práci není jejím jediným účelem zajistit objednávku, donesení jídla, kasírování a sklizení ze stolu. Její práce, navíc s ohledem na spopitné, spočívá také v příjemné komunikaci se zákazníkem, doporučení a nezřídka také v investici do vzhledu a vyjadřování (Erickson, 2004). Pravděpodobně všichni čtenáři si vybaví situaci, kdy byla obsluha nepřijemná a dojem z návštěvy zařízení tím trpěl. A také velmi dobře poznáme, že se obsluha přetváří. Stejně tak nekvalitní výkon u herců a o to víc pornoherců vybudí spíše výsměch nežli vzrušení. Proto je zvýšený tlak na to, aby byly snímky velmi realistické, a to zejména v extrémnějších polohách pornografie (jako např. BDSM snímky, tvrdý anální sex, dávání při orálním sexu, bolestné výkřiky při bičování, zavírání bradavek do svěráku, fackování a plácání atp.).

Pornografie krom toho totiž může působit jako tzv. supernormální stimul (*Supernatural stimuli*; Barrett, 2010). Supernormální stimul je koncept pozorovatelný v živočišné říši; využívá evoluci zafixované vnímání a preference a působí jako extrémně silný stimul díky svému charakteru. Typickým příkladem je kukaččí vejce. Kukačka snese do cizího hnízda své vejce, které je ovšem

několikanásobně větší než vejce ptáka, který zde již své budoucí potomky nakladl. Daný druh ptáka má však zafixovaný „stimul“ vejce a mnohonásobně větší vejce na něj působí jako supernormální stimul, byť se jedná o vejce cizí. Díky svým extrémně odlišným proporcím vzbuzuje silný efekt a matka poté upřednostňuje toto vejce před svými vlastními a pečuje o něj více (Barrett, 2010).

Pornografie jako kompenzační chování

Je otázkou, zda by pornografie měla být tedy přístupná široké veřejnosti v takové formě jako doposud. Na základě výzkumu typů konzumentů pornografie se zdá, že takový přístup není problematický a že pornografie genericky neznamená problematický sexuální život, prožívání, nebo problémy ve vztazích. Je však zřejmé, že stejně jako tomu je u návykových látek jako alkohol, kde občasná uměřená konzumace může mít pozitivní účinky (ve formě mírného uvolnění a zvýšení prožitku), u určité populace může vyvolat závislost a může být nebezpečná jak konzumentovi, tak jeho okolí. Bylo by vhodné, a v jiných zemích již existují zaměřené organizace, vytvořit poradnu pro osoby, které mají s takovým chováním problém. V české republice podle osobních sdělení autorů od odborníků je takovéto chování řešeno v rámci sexuologické péče, pokud je potřeba, ale nejde o častý problém. V rámci preventivních programů je tomuto tématu věnován prostor, i když limitovaný.

Výsledky studie provedené vědeckým týmem vedeným Vaillancourt-Morel (2017) ukázaly, že konzumace pornografie je u jednotlivých skupin spojená s odlišnými riziky i benefity. Konkrétně rozdělila konzumenty na 3 rozdílné skupiny: asi 75 % bylo vyhodnoceno jako rekreační uživatelé, kteří spíše získávají inspiraci, a jejich sexuální život není negativně ovlivněn. Tato skupina je více zastoupena mezi ženami a zadanými jedinci obou pohlaví, s malým množstvím sexuálních problémů. Každý týden tato skupina průměrně 24 minut sledovala pornografické materiály. Skupina nekompulzivních uživatelů (13 %) i skupina kompulzivních uživatelů (12 %) byla více zastoupena muži. Skupina nekompulzivních uživatelů byla typická vysokým emočním stresem spojeným s konzumací pornografie, kdežto skupina kompulzivní měla středně silný emoční stres spojený s konzumací. Kompulzivní skupina také měla nejmenší poměr zastoupení zadaných jedinců.

Je však také nutné zvážit vliv extrémní pornografie jakožto kompenzačního chování. Ve studii na velkém vzorku (více než 5000 osob; Barker, 2014), byl diskutován vztah sexuálních fantasií a kompenzace reálné sexuální aktivity formou získávání v realitě potlačovaných prožitků, což dále přímo na příkladu pornografie ukazuje studie Efrati & Amichai-Hamburger z roku 2019 u studentské populace. Obě studie poukazují na mechanismy, které souvisí s prožíváním druhotného dopadu na vytváření sebe sama skrze sexuální chování bez interakce s jinou osobou, které jsou ovlivněny medií a konzumací materiálů s erotickou a pornografickou tematikou.

Závěr

Pornografie a její potenciální škodlivost či naopak prospěšnost vyvolává debaty i v současné době. Nejednoznačný efekt pornografie totiž vede k nezodpovězeným otázkám, jak sledování těchto materiálů může ovlivňovat sexuální chování. Především u dospívajících jedinců, kteří začínají svůj pohlavní život, může být jejich sexuální chování velmi ovlivněno právě

chovániím, ktoré pozorujú v pornografii, často negatívnym, resp. takovým, ktorý je v nesúladi s nastavením a preferenciami protějšku. O to více je problematické, když jediným sexuálním chovániím, které lze nezúčastněně pozorovat, je právě pornografie, která může vyvolávat zkreslenou představu o sexuálním životě. Tyto materiály jsou navíc často vytvořeny tak, že na lidské smysly působí jako supernormální stimul.

Debatu o sexuální výchově mladistvých by bylo vhodné vést spíše k edukaci o užívání a rizicích pornografie obecně. Pro rodiče/zákonného zástupce/dospělého/pro jedince samotného je těžké přesně vědět, co "jeho dítě" sleduje a "navíc vhodně posoudit", kde jsou hranice mezi běžným sexuálním chovániím a extrémně zobrazovanými sexuálními praktikami. Je stále nutné omezování sledování a dostupnosti videí kvůli zachování nepřístupnosti snímků zobrazujících skutečné nelegální aktivity (např. dětská pornografie, skutečné extrémní nekonsenzuální násilí).

Tato otázka je rovněž důležitá především v diskuzi o tzv. Rape myths, tedy stále se vyskytujícím nesprávném stereotypním předsudku o tom, že ženy si za znásilnění či jiné nevyžádané sexuální chování mohou samy. V pornografii je totiž velmi častým scénářem a tématem znásilnění. Pohlavní styk, který žena odmítne, je vynucen a ve většině případů žena nakonec na sexuální interakci přistoupí a vyjadřuje spokojenost. Zde je velmi problematická právě falešnost emocí. Jednak je zde velmi zkreslený zákonitý koncept „ne znamená ne“, kdy žena odmítá pohlavní styk pouze zdánlivě, a nakonec k němu přistoupí, a jednak je to nejednoznačnost emocí. Ta se týká jednak hraní emocí a jednak již zmíněného zdánlivého odmítnutí a následného přistoupení na sexuální akt a jeho prožívání.

Diskuze problematiky pornografie je dlouhodobějšího charakteru, avšak stále aktuální a velmi komplexní. Doufáme, že se nám v budoucích výzkumech podaří objasnit vztah čtení a komunikování emocí v pornografii, převážně sexuálního vzrušení a sexuální agrese a následné poznatky přispějí k celkové edukaci a povědomí o lidské sexualitě a vlivu nových technologií na ní.

Věříme, že zvýšení informovanosti o dopadu supernaturálních stimulů na prožívání sexuality jedince dovolí zvýšení míry benefitů ze sledování pornografie, a naopak ke snížení dopadů negativních.

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**THE INTERNATIONAL SOCIETY FOR
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Sex a jídlo – slasti a cyklické stavy, které procházejí obdobnými procesy: jídlo kořeněné chilli a sex kořeněný sado-masochismem mají společné rysy

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Abstrakt

Rozmnožování a příjem potravy jsou jedním z nejzákladnějších procesů pro přežití organismu. Zatímco příjem potravy je tím prvotním, díky čemuž organismus přežívá, rozmnožování je základem pro přežití daného druhu. Jídlo a sex jsou však zároveň také prvky, na kterých mohou vznikat obdoby na substanci nezaložené závislosti, resp. formy obsesního chování, které mohou přinášet závažná zdravotní rizika. Na rozdíl od substančních závislostí či jiných behaviorálních závislostí se však nejedná o jakousi „nadvahu“, tedy chování, které není základním a společným pro všechny organismy (jako v případě jiných závislostí), ale o „zextremění“ běžného chování. Při stále častějším vystavování podnětu ovšem vzniká také adaptace, resp. tolerance na tento podnět a tudíž neustále se zvětšující potřeba tyto podněty zintenzivňovat. Tento fenomén je v tomto článku zajímavě ilustrován na případech konzumace pálivého jídla a preference sadomasochistických aktivit. Tedy jakási forma extrémního prožitku. Jakékoliv prožitky však mohou přejít do fáze, kdy nedochází tolik k prožitku ze samotného prvku, jako spíše k neustálé potřebě tohoto prvku. V tomto bodě pak dochází k závislostem podobným stavům. Důležitým prvkem je v tomto případě znechucení, které by mělo sloužit k regulaci kompulzivního chování.

Klíčová slova: sex – jídlo – závislosti – sadomasochistické chování – znechucení

Úvod

Jak jsme již tento koncept nastínil v našem předešlém článku (Binter et al., 2020), v lidské evoluční historii dochází k určitým procesům a motivacím, které jsou velmi důležitým kritériem pro přežití daného organismu. Jako příklady, kterým jsme se v předešlém článku věnovali, uvedme bolest, která je důležitým indikátorem hrozby; indikuje organismu, že se činnosti, která mu bolest způsobuje, má vyhnout. Je pro něj nebezpečná a škodlivá. Naopak slast přináší jistou formu satisfakce. Tato

Abstract

Mating and food consumption are processes that ensure survival of an organism. Whilst food consumption is essential for survival of the organism itself, the mating is crucial for survival of the survival of the species. Both are also discussed to be potentially possible causes of non-substance based addiction, respectively obsessive behaviors that may cause discomfort and health-related risks. As opposed to substance-based addictions and other behavioral addictions, these seem to be some kind of extreme manifestations of regular behavior. With increased exposure to certain types of stimuli and adaptation, or rather tolerance creation, is created and need for further increase of consumption is taking place. Such phenomenon is currently discussed for case of hot food and sado-masochistic behaviors. Both provide a form of extreme experiences. The risk may be that the element of behavior is later considered mandatory and becomes center-point of related behavioral patterns which later constitute the compulsive addiction-like states. An important element differentiating the addiction-like behavior from a substance based one is disgust-based regulatory mechanism that ensures regulation of the motivation which is missing in substance-based one.

Keywords: sex – food – adiction – sadomasochistic behavior – disgust

satisfakce může být v nejrůznějších podobách, ať už je to uspokojení z dobrého jídla, které je důležité pro přežití, či uspokojení a slast sexuální, která je rovněž kritická pro úspěšné rozmnožování a zachování daných genů daného organismu. Jak jsme nastínil, ne vždy mohou být prožívané stavy (jmenovitě bolest a slast) protichůdné či postupně na sebe navazující. Mohou spolu v jistém smyslu koexistovat a jeden stav může doplňovat druhý.

Intenzivní či afektivní stavy mohou být velice podobné, i co se týče fyziologické reakce. Jmenovitě bolest a slast sdílí část nervových propojení a v určitých případech

tak môže byť prožívaný stav nesprávne určen, např. stres či strach môže byť považovaný za vzrušení. Mechanismy, jakými lidský mozek disponuje a funguje, a reakce lidského mozku na určité podněty, mohou být do jisté míry velice podobné, dalo by se říci, že i totožné (Binter et al., 2020; Casey et al., 2001; Seymour et al., 2007).

Rozmnožování a příjem potravy jsou jedny z nejzákladnějších motivací pro přežití daného organismu. Zatímco díky příjmu potravy přežívá samotný organismus, a je tak tím prvotním, o co organismus usiluje, rozmnožování sice nikterak nepřispívá k přežití jednoho konkrétního jedince, avšak stále patří k naprosto prvotním a základním motivacím. Organismus tím totiž usiluje o předávání svých genů a přispívá k zachování svého druhu. Geny jsou to, co usiluje o rozmnožení a „nutí“ tak svého nositele přežít a rozmnožovat se (Dawkins & Davis, 2017).

Zároveň se už ze své podstaty jedná o slastné pocity. Slast, jak si ukážeme, prochází povětšinou stejným procesem. Vjemy, které jsou pro jedince příjemné, aktivují v mozku centrum odměn, čímž se zvyšuje tendence tyto vjemy vyhledávat (Berridge, Robinson & Aldridge, 2009). A právě jídlo a sex jsou nejvíce základními cykly slasti, protože přímo přispívají na přežívání. Příjemné věci, které indikují, že jsou pro organismus dobré a tudíž důležité k přežití, totiž na rozdíl od stavů nepříjemných, jako je bolest, procházejí určitými procesy, které je zafixují jako něco, co by organismus měl dělat (pro review podobnosti cyklu přijímání potravy a sexuálního uspokojení viz Georgiadis & Kringelbach, 2012).

Slasti, které jedinec prožívá, můžeme rozdělit na substančně a nesubstančně založené. V obou případech však může docházet ke kompulzivnímu chování, kdy jedinec danou látku nadužívá či opakuje dané chování. Takové užívání látky či chování však může být potenciálně zdravotně nebezpečné a rizikové. Typicky mezi substanční kompulzivní obsese řadíme drogy, jejichž užívání s sebou nese vážná zdravotní rizika a na nichž snadno vzniká závislost, tedy stav, kdy má jedinec nutkavou potřebu opakovaně aplikace látky, přičemž dochází k toleranci na tuto látku, tudíž k potřebě stále většího množství (Zou, 2017).

Mnoho alkaloidů, jako kofein, lidé využívají ke zlepšení koncentrace, ale v excesivní míře může poškozovat tělesné i duševní zdraví (Andrade et al., 2018). Dokonce existuje látková závislost, zvaná kofeinismus, byť se obvykle nevyskytuje v nebezpečné míře (Mackay & Rollins, 1989). Může však být, s ohledem na fakt, že kofein je nerozštěvenější konzumovanou látkou a její širokou akceptací ve společnosti, nesnadno identifikovatelná. Obecně se dále v textu látkovým závislostem věnovat nebudeme a naopak, s ohledem na dobře popsané mechanismy takových závislostí doporučujeme prostudování primární literatury pro toto téma.

V případě nesubstančního kompulzivního chování, které je založené právě na chování, nikoliv na konzumaci určité látky, dochází k obdobným procesům (García-García, 2014). Co se týče právě jídla a sexu, je nutné upozornit, že jejich definice jako „závislost“ může být značně problematické a proto spíše užíváme pojem *závislosti podobný* (z anglického *addiction-like*). Jedná se spíše o kompulzivní přejídání se či o obsesi pornografií či sexem. Závislost je velmi široký koncept, ve kterém panuje nejednoznačnost v kategorizování různého typu chování. Dále tedy budeme mluvit spíše o kompulzivním

nadužívání jídla a obsesí pornografií či sexem, než toto chování definovat jako závislost.

Kompulzivní přejídání se s sebou nese značná zdravotní rizika. Co se týče obsesivní konzumace pornografie či praktikování sexu, zde příliš závažná zdravotní rizika nejsou, ovšem tato obsese může způsobovat rozsáhlé problémy v osobním životě jedince i mít dopad na jeho psychické zdraví (Ford et al., 2012). Samozřejmě je i četné množství činností, které nemají zdravotní benefit žádný nebo téměř žádný, a závislost na nich může být vysoce riziková, až fatální, jako je například gambling (patologické hráčství) u něhož jsou jednotlivé fáze vytváření nelátkové závislosti dobře popsány. Je ovšem nutné mít na paměti, že i v tomto případě je jedinec „hnán“ motivačním cyklem liking-wanting (tedy vytvoření pozitivního vztahu k podnětu a následné motivaci k získání přístupu k dané látce či aktivitě, viz níže). Je těžké něčemu odolat, když je to pro jedince příjemné a tudíž i falešně prospěšné. Stejně tak je důležité se naučit odlišovat podněty od takových, které vyvolávají reakci averzivní, což zahrnuje část učení (learning).

V těchto případech je systém regulován endokanabioidy, opioidy, a monoaminy. D2 dopaminový receptor, v odpovědi na dopamin, pak plní roli motivační a *nukleus acumbens* pak reguluje spojení s libými pocity při konzumaci. Serotonin hraje pak roli regulátoru příjmu skrze receptory 5-HT1A a 5-HT2C, zejména u chutné potravy (Finlayson, King & Blundell, 2007).

Zde je vhodné také připomenout, že existuje dvojí motivace k chování samému. Jenou z nich je kompenzace stavu – tedy například nevolnosti či špatné nálady. Cílem je tedy zlepšení současného stavu. Druhou motivací je stav, kdy je jedinec ve stavu dobrém a cílem chování je tento stav ještě vylepšit. V západní společnosti tohoto století bude pro uváděné případy klíčem spíše motivace druhá. Byť první námitkou může být, že sexuálně i kaloricky deprivovaný člověk bude spíše reagovat motivací první, právě druhá motivace bude zadržovat důvod pro vznik problematického chování.

Sex a jídlo

Sex a jídlo mohou být vnímány jako odměna, přičemž vystavení se jednomu z podnětů může podněcovat touhu po druhém podnětu. Například vystavení se sexuálnímu stimulu může vyvolávat chuť k jídlu, resp. ke sladkému, které je vnímáno právě jako odměna (Van den Bergh et al., 2008). Jídlo bývá také důležitým prvkem, který je sdílen s partnerem a například sdílení jídla s někým jiným, než s partnerem vyvolává větší žárlivost než pouhé povídání si, elektronická komunikace či sdílení kávy (Kniffin & Brian, 2012).

Některé poruchy příjmu potravy se typicky vyskytují u populace, která je sexuálně netypická. Kromě toho mozek, podobně jako v případě bolesti a slasti, zmíněném výše, vykazuje aktivaci stejných drah jak v případě jídla, tak v případě sexu (Georgiadis & Kringelbach, 2012).

Například s výskytem bulimie, anorexie či naopak excesivního přejídání je také častější výskyt homosexuality, bisexualy, promiskuitnějšího chování atp. (Ackard et al., 2008; Blashill, 2011; Culbert & Klump, 2005). Tento fenomén je však třeba chápat odděleně – jejich výskyt je spojen s preferencí vypadat přitažlivě pro konkrétní skupinu (tedy být atraktivní pro skupinu heterosexuálních mužů v případě heterosexuálních žen a homosexuálních mužů v případě homosexuálních mužů; Van Den Berg, 2012).

Ovšem sex, stejně tak jako i pokrmy, je velmi kulturně i osobnostně vázán. Co je v jiných kulturách považováno za nepatřičnou praktiku, v jiných může být zcela běžné. Stejně tak pokrmy, které jsou v určité kultuře pochoutkou, mohou být jinde shledávány jako nechutné.

Stejné mechanismy procházející stejnými procesy

Sexuální odpověď je kombinací sexuálně excitacních a sexuálně inhibičních procesů. Tedy procesů, které navozují vzrušení nebo ho naopak tlumí. Sexuální odpověď je tak, v negativním slova smyslu, ovlivněna, pokud sexuální inhibice převyšují sexuální excitaci (Bancroft et al., 2009). V těchto případech, kdy jsou excitační procesy „slabší“ než procesy inhibiční, pak také může docházet k různým sexuálním poruchám a dysfunkcím, jako je nízká sexuální vzrušivost či erektilní dysfunkce. Excitační proces je pak silně ovlivněn intrapersonálními procesy, jako je nervozita, depresivní stavy, úzkosti, či strach z nedostatečného sexuálního výkonu (Graham et al., 2004; Janssen et al., 2002; Janssen & Everaerd, 1993).

Sexuální slast či uspokojení ze sexu prochází určitými fázemi, třemi neurobiologickými procesy, které by se daly označit jako Wanting-Liking-Learning (Georgiadis & Kringelbach, 2012), tedy chtít-mít rád-učit se. V případě sexuálního chování tak první fází je sexuální touha a vzrušení, druhou fází plateau (pohlavní vzrušení před orgasmem) a orgasmus a třetí fází uvolnění, která zahrnuje refrakční fázi a tzv. hédonickou adaptaci, kterou se rozumí emocionální vyrovnávání se s danou situací. A právě fáze učení, tedy *learning* je zcela zásadní pro postupné fixování určitého typu sexuálního chování. Se zvyšujícím se počtem opakování těchto fází dochází k dalšímu a dalšímu zafixování si takového sexuálního prožitku, který je jedinci přijemný.

Zároveň ale proces musí být dokonán. Tedy aby došlo k zafixování věci jako přijemné, musí dojít k fázi uspokojení a následné percepce a vyhodnocení věci jako přijemné a žádoucí, tudíž takové, kterou je dobré opakovat.

Velice podobný proces lze hledat i při příjmu potravy. Obě tyto činnosti zahrnují motivaci (hlad/sexuální potřeba – potažmo „potřebu“ se rozmnožit), příjem (příjem potravy/samotný sex) a uspokojení (ukojení hladu/ukojení sexuální potřeby; Georgiadis & Kringelbach, 2012).

Příjem potravy i sex rovněž shodně vykazují ztrátu motivace, pokud k uspokojení dojde. V případě potraty ovšem může tato motivace znovu částečně podněcovat jedince k další konzumaci, pokud se jedná o jídlo nové, tedy o takové, které nevedlo k uspokojení a ukojení hladu (Rolls et al., 1984; Weingarten, 1983). V případě sexu ovšem k tomuto novému podněcení, v případě vystavení novým stimulům, empiricky dokázáno nebylo. Je však otázkou, zda mnohé články vyjadřující se k formám psychické obdoby závislosti na konzumaci pornografie a snížená apetence ostatních sexuálních praktik, není takovým případem – k čemuž se autoři článku částečně kloní.

Potrava a sex, jakožto základní prvky lidského přežití, jsou rovněž velmi ovlivňovány zážitky a zkušenostmi v raných letech vývoje člověka. Příjem potravy v raných dětských letech ovlivňuje preferenci potravy v dospělosti a rovněž sexuální výchova ovlivňuje sexualitu v dospělosti (Pfaus et al., 2012; Woodson, 2002).

Sex rovněž není zcela krucální pro přežití. Na rozdíl od něj bez potravy žádný organismus nepřežije. Potřeba potravy je rovněž přítomna od narození, zatímco potřeba sexu se objevuje až v pubertálním věku lidského jedince

(Georgiadis & Kringelbach, 2012). Je třeba mít na paměti, že se zde bavíme o penetrativním sexuálním styku a nikoli o socio-sexuálním vývoji jedince, který je přítomen mnohem dříve a zahrnuje fyzický kontakt s jinými osobami či auto-sexuální praktiky. Sexuální potřeba je rovněž velmi ovlivněna osobnostními charakteristikami jedince, prostředím či aktuálním psychickým rozpoložením jedince a sexuální potřeba rovněž velice variuje v průběhu života. Nehovoříme-li o poruchách příjmu potravy, chvilkovém nechutenství, nepotřebě potravy kvůli psychické zátěži či o prostém nedostatku jídla, potřeba potravy/hladu se objevuje vždy. Navíc, na rozdíl od ukojení sexuální touhy při sledování pornografie třením pohlavních orgánů, je tření jazyka neúčinné, byť naplňování žaludku nízkokalorickým jídlem, nestravitelnými objekty či vodou (kompenzační mechanismy v extrémních podmínkách či dietách) skýtá jakousi možnost alternativy.

Rovněž je nutné mít na vědomí, že ženská a mužská sexualita neprochází stejnými procesy. Jednak fáze uspokojení nemusí být nutně determinována orgasmem (Levin, 2002), a rovněž sexuální vzrušivost se u žen a mužů liší co do přístupnosti vědomého vzrušení – muži jsou si svého vzrušení obvykle vědomí (vizuální a senzorické podněty jsou mužům snáze dostupné), ženy do menší míry (Bailey et al., 1994).

Když slast přeroste v závislost

Ovšem velmi podobné procesy jsou přítomné i při vzniku závislosti. Jedinec v poslední fázi shledává daný podnět velmi příjemným a hledá tak další opakování těchto fází, tedy vyhledává stejný či intenzivnější podnět. Při častějším proběhnutí celého tohoto procesu dochází také k častějšímu vyhledávání podnětů a rovněž ke zvykání si na podněty a tedy k vyhledávání silnějších podnětů.

Fáze slasti, které jsme si ukázali, jsou přítomné ve více podnětech, které člověk může prožívat, a ne vždy se jedná o slast fyzickou či substanční. Takovými příklady může být spokojenost se svým sociálním postavením, prožitky z estetika, z úspěchů, z různých uspokojujících aktivit (Frijda, 2010; Kringelbach & Berridge, 2009). Slast také může přinášet bolest, přičemž v tomto případě se jedná o slast v případě úlevy od bolesti. Čím větší bolest, tím větší následná úleva a tím větší slast (Craig, 2003).

Závislost, pokud mluvíme o více prozkoumané závislosti na substancích, vzniká, pokud u jedince dochází ke kompulzivnímu vyhledávání a užívání substance (drog) na úkor jiných aktivit (Edwards, 1981; Jaffe, 1990). Samotné užívání drog se ještě nepovažuje za závislost, závislost vzniká, až když dochází k opakovaně replikaci a zvyšujícímu počtu konzumace této substance, jak z hlediska intenzity, tak z hlediska množství, a dochází ke stále větší potřebě tuto látku užívat (Robinson & Berridge, 1993). Toto intenzivní chtění a vyhledávání dané látky se nazývá *craving*, přičemž tento výraz je do českého jazyka překládán jako *bažení* a používá se především v případě závislosti na alkoholu.

Pokud zde použijeme výše zmíněných tří fází, *craving* je složen z elementů *wanting* a *liking*. Ovšem pokud toto bažení dosáhne patologické úrovně, fáze *liking* se stává méně intenzivní na úkor *wanting* (Robinson & Berridge, 1993). Zjednodušeně řečeno potěšení či uspokojení z dané látky klesá na úkor samotného chtění a potřeby této látky.

Co se týče jídla a sexu, kompulzivní obsese, nadužívání či vykonávání těchto činností se liší od jiných závislostí už jen v tom, že jde spíše o *zvýraznění* chování, které je ale jinak kritické pro přežívání. U jedince se tak neobjevuje nový typ chování, pouze je intenzivnější či se existující

chování stává variabilnějším a v rámci něj je hledána nová oblast (Georgiadis & Kringelbach, 2012).

Teprve v 5. a posledním vydání *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) z roku 2013 je poprvé zmíněna existence behaviorálních závislostí (American Psychiatric Association, 2013). Z těchto nových poruch, nesubstančních závislostí, je zde však uveden pouze gambling. Existují však nepopíratelné důkazy, které ukazují, že stejné znaky závislosti vykazují i právě výše zmíněná závislost na jídle, na sexu, na pornografii, ale například i na nakupování, na cvičení a zejména užívání internetového připojení, užívání sociálních sítí atd. (Potenza, 2014). Zde by autoři rádi poukázali na fakt, že závislost na masturbaci při sledování internetové pornografie je významně odlišná od samotné sexuální aktivity energeticky a také svým dopadem na celkovou spokojenost v partnerství či sociálním životě. Stejně tak prostředků nutných k zajištění takového chování je v době dnešní třeba velmi málo v porovnání s alternativami.

Ohledně potavy problematika spočívá v kompulzivním přejídání se, v příjmu potavy nad množství větší, než je potřebné, v bažení po jídle a v neschopnosti odmítnout jídla, která jedinec shledává jako velmi chutná. To platí zejména u jídel bohatých na tuky, cukry a sůl, které sami o sobě podněcují nadměrnou konzumaci a závislost (Gearhardt et al., 2011; Davis & Carter, 2014).

Kompulzivní přejídání se má také někdy velice podobné klinické a neurofyzilogické projevy a znaky jako závislost na drogách (Davis & Carter, 2009; Davis, 2013).

Obsese jídlem a sexem se ovšem liší od ostatních obsesí či závislostí tím, že může v podstatě substituuovat jiné potřeby. Kompulzivní přejídání se tak vlastně může kompenzovat jiné chování, časté jsou příklady přejídání při pokusech zbavení se závislosti na cigaretách (Odum & Baumann, 2007). Typickým příkladem v sexualitě může být substituuování intenzivních sexuálních prožitků za sledování zážitků jiných, zejména takových, které zahrnují prvky BDSM kompenzující nemožnost získání obdivu a plnění sexuálních přání obdobným zobrazením či oddání se submisivní roli do míry, která je zobrazena (Schuerweggen, 2021).

V případech závislosti je však toto kompenzování velmi nebezpečné. Docházet totiž může také k tzv. *coping* neboli zvládací strategii, která je přítomna zejména při stresové a psychické zátěži. Jedinec tak substituuje nějaké chování jiným – příjemným, žádoucím (Eisenberg et al., 1997; Wechsler, 1995). Při takové strategii ovšem hrozí velké riziko závislosti, jelikož při kompulzivním chování – tedy takové, kdy jedinec chce potlačit svůj negativní stav – daleko rychleji dochází k upevňování příjemného pocitu oproti nepříjemnému, a tudíž se i rychleji rozvíjí potenciální závislost. Naproti tomu impulzivní chování – tedy takové, kdy není v intencích člověka kompenzovat negativní stav, ale naopak podpořit stav pozitivní či zkrátka nutkání vyhledávat intenzivní zážitek – je spojeno s tzv. *Sensation Seeking*, o kterém hovoříme později (Raymond et al., 2003).

Znechucení jako potenciální blokátor chování a sexuální vzrušení jako blokátor znechucení

Ačkoliv se znechucení ukazuje jako jedna ze základních emocí napříč kulturami (Darwin, 1872; Ekman, 2006), je těmito kulturami také různě ovlivněna a rovněž se utváří podle jednotlivců (Sawchuk, 2009). Znechucení jako takové je adaptivní reakcí, která napovídá organismu, že je pro něj daná věc nebezpečná či škodlivá, je tedy jednou z nejdůležitějších evolučních strategií.

Znechucení můžeme rozdělit do tří typů: patogenové, morální a sexuální (Tybur, Lieberman & Griskevicius, 2009). Patogenové se jako adaptace vyvinulo k tomu, aby bránilo kontaktu s potenciálními bakteriemi, které jsou obsaženy například ve zkaženém jídle či lidských výměšcích (Curtis, de Barra, & Aunger, 2011). Zajímavým příkladem je pocit nevolnosti od žaludku či případné nutkání zvracet, pokud vidíme zvracet někoho jiného. Toto chování je zřejmě pozůstatek z evoluční historie člověka, kdy předek člověka ještě žil v menších společenských uspořádáních, tlupách, které se živily stejnou potravou. Pokud jeden z členů tlupy začal zvracet, indikovalo to, že potrava je zkažená, jedovatá a měla by být vyzvrácena. Jedinec s citlivějším žaludkem tak v podstatě chránil ty, jejichž trávicí soustava by potravu sice přijímala, ovšem posléze je například otrávil (Buss, 2005).

Morální znechucení se v lidské evoluční historii etablovalo především ze sociálních důvodů. Kooperace a následné benefity z ní se stala důležitou částí v přežívání a morální znechucení tak předchází porušování zavedených sociálních norem (Tybur, Lieberman & Griskevicius, 2009; Kelly, 2011). Vyvolání znechucení/odporu tak v nás automaticky budí pocit, že je to špatné, nemorální (Rachman, 2004).

Sexuální znechucení velmi úzce souvisí se znechucením morálním. Jako nejvíce ilustrativní příklad je příklad znásilnění. Stejně jako předchozí typy znechucení, i sexuální znechucení jednotlivců, značně variiuje, na čemž má zásluhu nepřeberné množství vlivů, jako je kultura, výchova, sexuální preference, sexuální orientace, a jiné (Rozin et al., 1999; Tybur et al., 2018).

Co se týče sexuálního znechucení, můžeme za takové považovat to, ke kterému jistým způsobem může docházet při výběru partnera. Nejedná se ale o znechucení jako takové, jako spíše o signály, které protějšek shledává jako neatraktivní, a které mohou značit pro něj ne příliš vhodnou genetickou výbavu pro zplození potomka (Tybur et al., 2009). Znechucení při samotném sexu může nabývat různých rozměrů. Některými kulturami i jedinci je za nechutný považován například orální sex, anální sex či určité sexuální pozice a praktiky (Crosby et al., 2020).

Sexuální znechucení společně s morálním bývá velmi problematické a často nekonsenzuální, nezákonné a nepřijatelné. To je především velmi problematické z hlediska již zmíněných sexuálních excitačních a inhibičních procesů. Sexuální excitaci často chybí pomyslná „stop fáze“ a kromě zmíněného znásilnění se pak objevují jevy jako je pedofilní, nekofilní či zoofilní chování (De Jong et al., 2013; Georgiadis & Kringelbach, 2012; Stein et al., 2010). Toto nezastavení excitačního procesu je velice silně ovlivněno prostředím, ve kterém jedinec vyrůstá, jeho osobnostními rysy (s případnými poruchami chování), i nedostatkem zkušeností a „naučením“ se toho, co je považováno za nechutné či nepřijatelné (De Jong et al., 2013).

Co se týče znechucení a BDSM, tedy sadomasochistického či dominantně/submisivního chování, je znechucení prvek, který hraje v BDSM poměrně značnou roli. Důležité je ale mít na vědomí, že zatímco jedinci nepraktikujícími BDSM můžou být některé aktivity považovány za nechutné, pro BDSM participanty jsou naopak vzrušivé. V tomto případě se jedná o hledání jakéhosi equilibria mezi znechucením/bolestí a sexuálním vzrušením. Přičemž s nabývajícím četností zkušeností, se rovněž objevuje adaptace na podněty a dochází tedy k intenzivnějším a novým praktikám (Simula, 2019). Za snad nejextrémnější praktiku, ke které může docházet při

dosažení pomyslného konce pomyslné linky vzrušení/znechucení, je (z pohledu práva konsensuální – receptivní) zoofilní chování, o kterém autoři článku zjistili, že může být extrémním případem důkazu poslušnosti a poddání se za účelem maximalizace ponížení, studu a podřízenosti, kterou někteří jedinci potřebují k dosažení požadované intenzity prožitků (Binter et al., 2015).

Sexuální vzrušení totiž může sloužit jako dočasný blokátor znechucení. Při četných experimentálních měřeních (např.: Ariely & Loewenstein, 2006; Borg & de Jong, 2012; Stevenson et al., 2011) bylo dokázáno, že participant, kterým byl prezentován sexuální stimul, byli následně méně znechuceni při vystavení se stimulu, který má vyvolávat znechucení. Sexuálně excitační proces v této chvíli převládá sexuální inhibitory a potlačí tak nástup znechucení, tedy signálu, že by se dané věci měl vyhnout. Což je problematické a nebezpečné při právě zmíněných případech pedofilie, znásilnění atp.

Kapsaicin a BDSM jako intenzivní a extrémní příklady běžného chování

Jedním z extrémnějších případů, na kterém lze ovšem velmi dobře ukázat propojení prožitku z jídla a prožitku ze sexu, je konzumace velmi pálivých jídel, jako jsou papriky obsahující rostlinný alkaloid Kapsaicin (Fattori et al., 2016), který je zodpovědný za intenzivní pocit pálivosti, hraničící s bolestí. Kapsaicin aktivuje receptory, které jsou zodpovědné za vnímání tepla. Pálivá vlastnost kapsaicinu tak ve skutečnosti není cítit ve smyslu chuťového vjemu, ale je vnímána skrze prožitek (Smutzer & Devassy, 2016). Tato pálivá bolest je tak vnímána stejným procesem, jako fyzická bolest. Je samozřejmě upozornit, že primárním účelem konzumentů však není vyhledávání bolesti, jako spíš slasti, kterou tento prožitek přináší. Jako u slasti z úlevy, která se dostavuje po odeznění z bolesti, i v tomto případě se aktivuje uvolňování endorfinů za účelem potlačení či eliminování bolesti (Dishman & O'Connor, 2009).

Takovýto druh prožitku je i přesto ze svého základu bolestivý a tudíž averzivní. Prožitky bolesti ať už v sexu či jídle sice nejsou ničím výjimečným, avšak stále je vyhledávání těchto prožitků vnímáno jako něco okrajového, speciálního. Mnohými jsou však tyto vjemy vyhledávány být třeba jen na základě větší adaptivnosti (schopnosti zvládnutí) na tyto prožitky, která je způsobená ať už geneticky (Allen, McGeary & Hayes, 2014), fyziologicky (Duffy, 2007) či kulturně (Spence, 2018). Nicméně, zdá se, že větší tolerance k pálivému jídlu je také úzce provázána s vyšší hladinou testosteronu (Bégué et al., 2015). Většinou jsou to muži, kteří lépe snášejí tento velmi intenzivní vjem. Zajímavým zjištěním nicméně je, že preference pro pálivá jídla bývá spojována s osobnostními znaky jako je agrese (Ji et al., 2013) či extravertze (Wheeler & Berger, 2007).

Vyhledávání a konzumace pálivého jídla bývá také spojována se samotným zážitkem (Terasaki & Imada, 1988). Tento fenomén je znám jako tzv. *Sensation Seeking*. K takovému typu chování řadíme vyhledávání zážitků, které jsou velmi intenzivní či riskantní, které však přinášejí uspokojení v podobě adrenalinu (Byrnes & Hayes, 2016). Mnoho osobnostních vlastností, jako například impulzivita či nekontrolovatelnost, které také bývají spojovány se *Sensation Seeking*, však bývá spojováno i se zdravotně rizikovým chováním, od nadměrné konzumace alkoholu či drog, přes rizikové sexuální chování až po řízení automobilu pod vlivem alkoholu atp. (Stout et al.,

2005; Zurborg et al., 2007; Hopko et al., 2006).

Tímto se opět dostáváme k BDSM, čili k sado-masochismu. Ačkoliv může být vnímán některými zdroji jako sexuální porucha či psychopatologie, BDSM komunity a někteří výzkumníci se proti tomu vyhrávají, jedná se pouze o sexuální preferenci (Wismeijer & van Assen, 2013) a jedná se o osoby emočně a psychicky vyrovnané, které přijaly svou sexuální roli (Weinberg, 2006). Nejnovější verze diagnostického manuálu psychických poruch DSM-5 tuto situaci řeší tak, že sadismus i masochismus je variací sexuální preference, pokud nemá negativní dopad na jedince či jeho okolí. Pak je diagnostikován jako sadistická, respektive masochistická, porucha (American Psychiatric Association, 2013).

Na případech pálivého jídla a BDSM tak lze zajímavě ilustrovat paralelu těchto dvou velmi intenzivních praktik. BDSM, stejně jako preference pálivého jídla, bývá spojováno se zmíněným *Sensation Seeking*. Oba tyto pojmy jsou praktiky a následné stavy, které jsou velmi intenzivní a pro svou intenzitu také vyhledávané (Byrnes & Hayes, 2016; Schuerwegen et al., 2021). Ze své podstaty se jedná rovněž o praktiky riskantní, ovšem obvykle nikoliv život ohrožující. Důležité je však z tohoto hlediska mít na vědomí, že i zde opět dochází k procesu postupného zvyšování intenzity. Pokud jedinci zkusí tuto praktiku poprvé např. s extrémně pálivým jídlem či velice intenzivní a složitou BDSM praktikou, na životě to sice ohrožující není, ovšem nedochází k procesu postupných příjemných stavů a učení se na podněty, tudíž na jejich zvykání, a takoví jedinci zřejmě tyto praktiky jen tak znova vyhledávat nebudou.

Konzumace pálivých jídel či BDSM praktiky je tak kombinací pocitů slasti a bolesti, čímž se opět vracíme k již zmiňovanému vztahu těchto dvou intenzivních stavů. I v tomto případě jde o jakési hledání equilibria mezi těmito prožitky, o ideální kombinaci, kdy je bolest natolik velká, aby přinášela jedinci jistotu míru slasti (částečně i z jejího zvládnutí), ale není natolik velká, aby mu byla nepřijemná.

A opět, v případě časté konzumace pálivého jídla, resp. jídla obsahujícího Kapsaicin, dochází k adaptaci receptorů na tento vjem a tudíž ke snižování citlivosti (Touska et al., 2011). To stejné lze hledat i u sexuálních podnětů – dochází k navyknutí si na stejné podněty a následuje tedy slabší sexuální odpověď a dochází k hledání stále explicitnějších podnětů či materiálů (pornografických), aby bylo dosaženo stejné úrovně fyziologického vzrušení jako před navyknutím si na tyto podněty. Nutné je však upozornit, že tento jev je více přítomný u mužů než u žen (Harper & Hodgins, 2016; Koukounas & Over, 2000; Laan & Everaerd, 1995; O'Donohue & Plaud, 1991).

Tuto podobnou paralelu lze ovšem hledat i u závislosti, které, jak jsme zmínili, spočívají v postupném a stále častějším a intenzivnějším vystavování se určitým podnětům/substancím. Z hlediska zneužívání drog však dochází k velmi závažným zdravotním rizikům, protože například stejné množství určité drogy, které pro zkušeného konzumenta je „normální“ z hlediska adaptace na tuto látku, může být pro nezkušeného konzumenta fatální (Gable, 2004).

Feederism – spojení jídla a sexuálního vzrušení

Na závěr bychom chtěli zmínit zajímavý a extrémní příklad spojení sexuálních prožitků a prožitků z jídla na poměrně neprobádaném jevu. Jedná se o tzv. Feederism, tedy fenomén, který by se dal popsat jako vzrušení z tloustnutí, příjmu potravy a celkově „erotizování“

jídla (Gates, 2000; Giovanelli & Peluso, 2006; Kulick, 2005; Murray, 2004). Ačkoliv preference väčší telesné hmotnosti u partnera není ničím zvláštním a je ovlivněna jak osobnostními preferencemi, tak například i evolučně (Singh, 1995) a kulturně (Henss, 2000), u *Feederismu* nedochází ke vzrušení ze samotné telesné hmotnosti, ale ke vzrušení z nabyvání tuků. Tento jev bývá častější u mužů, kteří shledávají uspokojující, když svou partnerku „vykrmují“. Tyto jedinci jsou označováni jako *Feeders*. Naopak jako *Feedees* se označují ti jedinci, u kterých dochází k sexuálnímu vzrušení z jídla, ze samotného aktu příjmu potravy, z pocitu „být krmen“ či ze samotného nabyvání váhy. Tato strana tohoto fenoménu bývá častější u žen (Kulick, 2005). Tento jev je tedy více přítomný u heterosexuálních párů, kdy žena zastává roli, kdy se nechává od partnera „krmit“ (Gates, 2000; Kulick, 2005). Jeví je přítomný i v gay komunitě, kde tyto role plní převážně muži a označují se jako „příjemci“, „povzbuzovači“ (v příjmu potravy), „vzájemní příjemci“ či *belly builders*, tedy cílem a vzrušujícím prvkem je tolik známé, a mnohými obávané, mužské břicho (Gates, 2000; Monaghan, 2005).

Jídlo tedy nejenom, že prochází podobnými procesy, jako sexuální uspokojení, ale dokonce může samo působit jako excitační prvek. Odměna ve formě jídla a ve formě sexu je tak spojena a tvoří jeden intenzivní prožitek. Což je koncept velice podobný zmiňované kombinace bolesti a slasti a potvrzuje kombinaci různých podnětů jakožto mechanismu k dosažení co možná nejintenzivnějšího prožitku a slasti, byť tato paralela není stoprocentní.

Ačkoliv v tomto případě panuje oboustranný konsenzus, může být tato praktika potenciálně velmi zdravotně nebezpečná a škodlivá. Jedná se tedy o sexuální fetiš, na který by měla být zaměřena větší pozornost, jelikož je přímo ohrožující zdraví jedince.

Závěr

V tomto článku jsme se zabývali obdobou dvou procesů, které jsou na první pohled velmi odlišné, ovšem při bližším pohledu se ukazují jejich podobnost. Napsání tohoto článku bylo motivováno faktem, že vysvětlit některé zákonitosti lidské sexuality, její abnormality a přístup k jejímu studiu je vhodné paralelou s jídlem doprovázet. Seminální studii Georgiadise a Kringelbacha (2012), kteří se věnovali právě obdobám cyklů těchto dvou aktivit, bychom rádi doporučili k přečtení i našim kolegům.

Ačkoliv mechanismus závislosti je v těchto případech do určité míry podobný závislosti na substancích, jako jsou drogy, závislost na jídle a sexu či pornografii není příliš probádána a je stále otázkou, zda taková „závislost“ skutečně existuje. Jedním z důvodů je nejednotná etiologie, a ne vždy prokazatelné patologické chování, resp. panuje nejasnost v kategorizování závislostí, pokud chování není patologicky fatální. To ovšem neznamená, že toto chování není škodlivé. V dnešní době, kdy dochází k daleko více případům behaviorální závislosti než v minulosti, je však věnována pozornost i těmto případům, ovšem přesné mechanismy a možnosti, jak tyto závislosti potlačit, příliš probádány nejsou. Ve všech těchto případech však dochází k adaptivním procesům, tedy ke zvykání si na dané podněty a k postupnému zvyšování dávek či hledání intenzivnějších a extrémnějších stavů a podnětů. Tyto procesy jsou přítomné jak u substančních látek, tak i u chování, přičemž stále častější opakování společně s adaptací na tyto vjemy může vyvolávat závislost, nebo jejich obdoby.

Jak už jsme však zmínili, rozdíl mezi substančními a nesubstančními závislostmi je značně problematický a ne vždy panuje konsenzus, aby se dané chování dalo označit za závislost. Například důvodem patologizace gamblingu

je zřejmě jeho dopad na psychiku a časté sebevražedné sklony či dokonané sebevraždy hráčů. Jeví je tedy dále široce patologizován laickou veřejností i odborníky. Hraní na počítači či konzolách může nabývat obdobných rozměrů (co do fyziologické reakce), ale finančně ani sociálně není tak penalizující. Několik významných publikací na toto téma zapříčinilo, že obdobné chování a nesubstanční obsese nebyly zahrnuty do manuálu DSM-5. Toto téma by jistě vydalo na mnohonásobně obsáhlejší článek, na což zde již, z důvodu obsáhlosti, nebyl prostor.

Závislost jako taková může být často výsledkem zacyklení se v procesu *wanting-liking-learning* a je velice snadné těmto vjemům podlehnout a mít poté neustálou potřebu tyto vjemy vyhledávat a zintenzivňovat je.

Zároveň doufáme, že se nám podařilo ukázat extrémní formy jídla a sexu jako hledání velmi intenzivních prožitků, které jedinci vyhledávají nikoliv na základě jakési osobnostní poruchy či patologie, ale na základě kombinace extrémního, až bolestivého zážitku, a pocitu slasti. Tento pocit slasti může vycházet ze skutečné preference pro takový zážitek, z jeho zvládnutí i z vzájemného překrývání drah v nervové soustavě. A zrovna „nenormální“ formy jídla, souvisejícího vzhledu a (konsenzuálních) sexuálních praktik a značné variability konzumace obou těchto „koření života“ jsou jedinci často odsuzováni a podléhají předsudkům.

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Securing Your Relationship: Quality of Intimate Relationships During the COVID-19 Pandemic Can Be Predicted by Attachment Style

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The COVID-19 pandemic along with the restrictions that were introduced within Europe starting in spring 2020 allows for the identification of predictors for relationship quality during unstable and stressful times. The present study began as strict measures were enforced in response to the rising spread of the COVID-19 virus within Austria, Poland, Spain and Czech Republic. Here, we investigated quality of romantic relationships among 313 participants as movement restrictions were implemented and subsequently phased out cross-nationally. Participants completed self-report questionnaires over a period of 7 weeks, where we predicted relationship quality and change in relationship quality using machine learning models that included a variety of potential predictors related to psychological, demographic and environmental variables. On average, our machine learning models predicted 29% (linear models) and 22% (non-linear models) of the variance with regard to relationship quality. Here, the most important predictors consisted of attachment style (anxious attachment being more influential than avoidant), age, and number of conflicts within the relationship. Interestingly, environmental factors such as the local severity of the pandemic did not exert a measurable influence with respect to predicting relationship quality. As opposed to overall relationship quality, the change in relationship quality during lockdown restrictions could not be predicted accurately by our machine learning models when utilizing our selected features. In conclusion, we demonstrate cross-culturally that attachment security is a major predictor of relationship quality during COVID-19 lockdown restrictions, whereas fear, pathogenic threat, sexual behavior, and the severity of governmental regulations did not significantly influence the accuracy of prediction.

Keywords: attachment style, relationship quality, COVID-19, intimate relationships, machine learning, pair bond

INTRODUCTION

Viral Threat and Political Measures

In spring 2020, the world-wide spread of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) led to stressful and insecure conditions across many nations – which corresponded with severe health, economic, and social disruptions (United Nations [UN], 2020; World Health Organization [WHO], 2020). In Europe, the actual spread and effects of the virus, as well as national counter measures, differed between countries. For example, Spain had one of the highest infection and mortality rates in Europe, leading to limited access to medical care and the modification of public facilities to be used as field hospitals and morgues. Consequently, a nationwide state of alarm was issued, and the free movement of citizens was drastically restricted (Ministerio de la Presidencia, 2020). Despite lower case counts, Austria responded with curfew restrictions to limit the spread of the virus (Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentenschutz [BSGPK], 2020), and even countries with very low case numbers such as Czech Republic and Poland adopted strict defensive measures, such as prohibiting gatherings and introducing minimal distance measures (Dziennik Ustaw, 2020; Dziennik Ustaw, 2020). Varying viral impacts and medical capacities notwithstanding, all of these countries eventually introduced strict regulations, and all of them encouraged or reinforced “social distancing” by prohibition of gatherings or movement restrictions.

The Crisis and Intimate Relationships

Previous research has shown that stress impacts both relationship quality (i.e., how good people subjectively perceive their relationship to be) (cf. Randall and Bodenmann, 2009, 2017), and the way intimate partners conjointly deal with stress (Falconier et al., 2015). Relationship quality in turn is closely linked to many parameters of well-being, including psychological and bodily health (South and Krueger, 2013; Pieh et al., 2020). Independent of the elicited stress, social isolation that removes other contacts facilitates an exclusively dyadic relationship for couples living together, and the rise in domestic violence since the implementation of movement restrictions suggests that this is not healthy for all romantic relationships (Bradbury-Jones and Isham, 2020).

Importantly, attachment style may be an influential factor that might determine how such restrictions and stressors influence relationship quality. Attachment theory has originally been proposed as an ethological framework that explains children's reactions to stressful situations (Ainsworth and Bowlby, 1991). Individual developmental trajectories of attachment remain highly influential in adulthood, becoming activated upon stress exposure (Gillath et al., 2006) and influencing behaviors within intimate relationships as adults (Mikulincer et al., 2002). Similar to relationship satisfaction, secure attachment is significantly correlated with greater health and well-being (McWilliams and Bailey, 2010), where securely attached adults, whether in a relationship or not, may have overall more

psychological resources to cope with distress. A variety of studies have found that securely attached individuals, as opposed to those with non-secure attachment styles, are affected more by distress (Zakin et al., 2003), and in turn are more prone to distort their representations of themselves and their social environment (Mikulincer et al., 1998). Furthermore, attachment security is crucial for maintaining satisfactory intimate relationships, and several studies have shown connections between attachment security and relationship outcomes, although determining causality poses a problem (see Mikulincer et al., 2002 for a review). A variety of dynamic factors may at least partially account for such effects—for example, securely attached persons are known to engage in more mutual forms of conflict resolution than anxious or avoidant types (Corcoran and Mallinckrodt, 2000), and conflict style in turn has a major influence on relationship satisfaction (Cann et al., 2008).

Feeney (2002) notes that as opposed to securely attached persons, insecurely attached individuals' evaluation of their own relationship as more strongly influenced by their partners' recent behavior. Therefore, when predicting reported relationship quality, taking recent events into account (e.g., amount of fights) in addition to attachment style to the partner may aid in the prediction of models aiming to capture such interactions. Moreover, the same events could be appraised differently by securely and insecurely attached individuals (Collins, 1996), making it essential to consider both actual events relevant to relationships and inner working models (i.e., the attachment to the partner). Thus, depending on the inner resources to deal with external stress and the inner representations of social relations, the COVID-19 crisis could turn out to be stabilizing for some relationships, and destabilizing for others.

Stressful periods such as the 2003 SARS outbreak have been shown to have significant impacts on intimate relationships that last far longer than the actual threat, evidenced by higher stress levels and increased divorce rates (Census and Statistics Department, 2007; Lee et al., 2007). One of the social behavioral systems affected severely by stress is sexual satisfaction and engaging in sexual activity with a partner (Bodenmann et al., 2006; Yehuda et al., 2015), an important and often defining feature of intimate relationships in humans (Hazan and Shaver, 1987). Critically, however, the role of sexuality in stable relationships and its impact on psychological aspects such as well-being and relationship quality is still omitted in many studies (cf. Heiman et al., 2011). Notably, frequency of sexual intercourse has indirectly been shown to be affected by external crises, where around 9 months after severe threats, birth rates reliably go down throughout cultures, whereas milder threats such as low-severity storm advisories lead to increased birth rates (Evans et al., 2010; Chandra et al., 2018; Richmond and Roehner, 2018a,b). A more subjective measure of sexuality in couples, sexual satisfaction, has been shown to relate to relationship quality as well as relationship stability, where interestingly, this effect seems to be stronger for men than women (Sprecher, 2002). Indeed, the “relationship state model” proposed by Birnbaum and Finkel (2015) concludes based on empirical evidence that sex plays an important role in dyadic

bonding processes, but varies in influence over different stages of relationship development.

Importantly, recent studies have linked attachment systems to a variety of sexual behaviors (e.g., Davis et al., 2006; Butzer and Campbell, 2008), where interestingly, sexual satisfaction might even mediate the effects of attachment anxiety on relationship satisfaction in women (Birnbaum, 2007). Moreover, securely attached persons tend to have less promiscuous and casual sex (Bogaert and Sadava, 2002). It has furthermore been suggested that low levels of environmental pathogens coincide with more liberal sexual behavior including promiscuity and casual sex and may even account for the evolution of cross-cultural differences in sexual norms (Thornhill et al., 2009; Tybur et al., 2015). Both aspects make sexual behavior a particularly interesting facet of human functioning and behavior during a world-wide medical crisis, and an indispensable factor to consider when observing intimate relationships. Here, we consider the frequency of engaging in sexual behaviors with a partner and sexual satisfaction as potential predictors of relationship quality during an external crisis, the COVID-19 pandemic.

Predicting Relationship Quality Using Machine-Learning

The present study investigates a period in the spring of 2020, during which strict movement restrictions in response the COVID-19 pandemic were implemented and subsequently relaxed in Austria, Poland, Spain and Czech Republic. Over a period of 7 weeks, individuals from these countries completed self-report questionnaires in relation to their romantic relationships, partner attachment, and sexual behavior, as well as questions related to the pandemic and the perceived threat associated with the virus. Our goal was to determine which variables predict (i) relationship quality during this crisis, and (ii) changes in relationship quality during the crisis. More specifically, we hypothesized that attachment security (both anxious and avoidant dimensions) and sexual behavior (sexual activity with partner and sexual satisfaction) would be major predictors of both overall relationship quality and maintaining relationship quality during these unstable times, where more secure attachment, higher sexual satisfaction, and more sexual activity would lead to higher relationship quality.

Based on literature, we explored a range of other variables that may improve the prediction accuracy, or potentially influence, the effect of attachment and sexuality on relationship quality (see **Table 1**). Variables related to the relationship itself include: (i) duration of the relationship, which is expected to be inversely related to overall relationship satisfaction (Birditt et al., 2009), however, relationships that have existed for longer prior to the pandemic might be more stable and less subject to changes in quality over the course of the lockdown, (ii) whether dyadic partners live together, (iii) physical contact in general and specific to the partner, since touching interactions are known to relate to bonding as well as stress management, yet are poorly investigated (Brennan et al., 1998; Ditzen et al., 2007; Van Anders et al., 2013), and (iv) demonstration of affection in romantic couples (i.e., kissing) which has been

found to relate to conflict resolution and relationship satisfaction (Gulledge et al., 2003; Floyd et al., 2009). Moreover, we also investigated aspects known to load on the dimensions independence, intimacy, and agreement/conflicts of relationship quality, respectively (see Hassebrauck and Fehr, 2002). Except for “conflicts,” which are known to negatively influence relationship satisfaction, we expected that these dimensions would positively contribute to maintaining high relationship quality during the crisis. Additionally, environmental measures included (i) actual pathogenic threat (local spread of infections and mortality), and (ii) stringency of measures introduced by a given nation’s government. Here, we aimed to explore if macro-level factors related to the pandemic would have a predictive value for relationship quality or change in relationship quality, and if so, how they interact with psychological variables. Further, we directly included a subjective assessment of threat associated with economic loss, as well as the subjective fear of the virus (independent of local prevalence or mortality). Moreover, we included demographic information potentially influencing aspects of romantic relationships.

We employed two types of robust, cross-validated machine-learning models: Least Absolute Shrinkage and Selection Operator (LASSO) (Tibshirani, 1996), and Extremely Randomized Trees (ExtraTrees) (Geurts et al., 2006). These models allow one to incorporate many variables while avoiding over-fitting, and potentially to make accurate predictions in a novel pool of participants. Extremely randomized trees are in addition non-parametric and can detect complex non-linear interactions between the variables beyond linear correlations. Taken together, this approach outperforms conventional statistical models in sufficiently large datasets when dealing with multiple input variables and allows one to make generalizable conclusions about the relations between predictor variables and target variables.

TABLE 1 | Input features (“predictors”) used to predict reported relationship quality and change in relationship quality.

Target	Relationship quality; change in rel. quality
Predictors	Country; stringency of restrictions Existential economic losses Spread of SARS-CoV-2; COVID-19 mortality Perceived threat of virus Age + ; Sex; Sex. orientation; family status Relationship duration; living with partner ECR-R anxiety + ; ECR-R avoidance Sexual activity; sexual satisfaction Kissing; physical contact to partner and in general Partner is tolerant Discussing important problems with partner Joint activity + Partner takes time + Conflicts with partner +

Features with a median permutation feature importance (PFI) greater than 0.05 for the target relationship quality are marked with “+.” None of the features had a median PFI greater than zero for the target change in relationship quality.

MATERIALS AND METHODS

Participants

Our sample consisted of 313 adult participants (mean age = 32.02 years, SD age = 12.99; 236 female; 267 heterosexual) who reported to be in a romantic relationship (mean duration = 7.18 years, SD = 8.58 years) and who repeatedly participated over a 7-weeks period. Participants resided in four main countries: Austria ($n = 104$), Poland ($n = 87$), Spain ($n = 65$), Czech Republic ($n = 33$), and four additional regions (Germany, Netherlands, Italy, Pakistan; $n = 24$).

No exclusion criteria were applied, but all cases with missing variables of interest were excluded for the machine learning models (see section “Results” for the number of samples included in each model).

Characteristics of the Studied Countries and Time Period

We actively sampled within four European countries, which markedly differed in the prevalence of the virus and rates of mortality, as well as the stringency of implemented measures by governments and economic change (Petherick et al., 2020, see also **Figure 1** in Eder et al., 2021). In a sufficiently large sample, these local differences allow for characterizing the predictive value of aforementioned macro-level variables. The chosen study period coincided with the implementation and loosening of governmental measures, including curfews in the participating countries. Accordingly, the first survey was completed by participants between March 16th and 22nd (coinciding with the first curfews in Austria, a nationwide state of alarm in Spain and Czech Republic and a state of epidemic danger in Poland). The last survey was completed between April 27th and May 3rd, 2020, when the most drastic restrictions had been lifted in all countries.

The following section characterizes the socio-political climate during the study period within the investigated countries.

Highly Affected: Spain

In Spain, a nationwide state of alarm was issued on March 14th 2020 (Ministerio de la Presidencia, 2020). Within the first week of the survey, free movement of citizens was limited to essential activities, and international borders were closed except for the return of residents (March 15th, 16th). The dramatic increase of infections during the second week of the study lead to limited access to Intensive Care Units and to triage regulations (Redacción la Vanguardia, 2020). Facilities such as hotels were used as provisional hospitals (Enguix, 2020), others as morgues (Redacció i agència la Vanguardia, 2020). At the beginning of the third week (March 30th), all non-essential activities were shut down. These restrictions were only slightly lifted in weeks five, coinciding with the governmental prescription of face masks in public transportation (Redacción la Vanguardia, 2020). Throughout the surveys, Spain had one of the highest infections and mortality rates in Europe (cf. Hale et al., 2020) and was objectively under a higher pathogenic threat than the other observed countries.

Middle Field: Austria

In Austria, the first week of the study coincided precisely with the first nationwide curfew, encouragement of social isolation and shut-down of non-essential infrastructure. Public meetings of people not living together were prohibited, where the government insinuated that meetings of people not living in the same household were generally prohibited (the legal foundations for such a wide-ranging prohibition were not necessarily given). Minimum distances of 1 m between persons in public spaces was prescribed (Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentenschutz [BSGPK], 2020). The economic shut-down in Austria was slowly phased out toward the end of the study, while wearing face masks became mandatory in many situations (Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentenschutz [BSGPK], 2020). Infection rates in Austria were successfully decreased by the measurements, and at no time were there shortages in medical aid.

Low Infection Rates and Strict Regulations: Poland and Czech Republic

On March 13th 2020, the Polish government declared a “state of epidemic danger,” which led to limited use of public space, mandatory quarantine at the borders, and closing of public schools and universities (Dziennik Ustaw, 2020). As of March 24th 2020, citizens were only allowed to leave their residences for work or to access essential infrastructure such as grocery stores, and social gatherings were restricted to two persons. Mandatory interpersonal distances were introduced in both public spaces and working environments (Dziennik Ustaw, 2020). Restrictions were phased out starting April 20th, at the beginning of weeks 6 of this study (Dziennik Ustaw, 2020). However, around that time, a third of the population believed that the government deliberately manipulated the case count (Molenda et al., 2020). Thus, the corona crisis in Poland is not only marked by relatively strict regulations, but also by divided opinions on the extent of the medical threat and political divisions (Michalak, 2020).

Similarly, the Czech government declared a “national state of emergency” on March 12th 2020, shortly before the start of this study (Ministry of Health of the Czech Republic [MHCR], 2020). A series of governmental regulations to prevent the spread of COVID-19 had been implemented since March 2nd, including the shutdown of schools, ban on sales in shops and restaurants, closing the national borders, as well as wearing face-masks in public. Gathering of more than two individuals were prohibited, and interpersonal distances of 2 m between individuals were mandatory in all public spaces. The first victim of COVID-19 was confirmed at the end of the first week of this study (March 22nd). The government gradually lifted restriction measures starting April 20th, week six of this study (Ministry of Health of the Czech Republic [MHCR], 2020).

Procedure

Weekly surveys (administered via SoSci Survey)¹ were sent as a link via e-mail to participants who had been recruited over social media at the beginning of the study period and who agreed to

¹www.sosicurvey.com

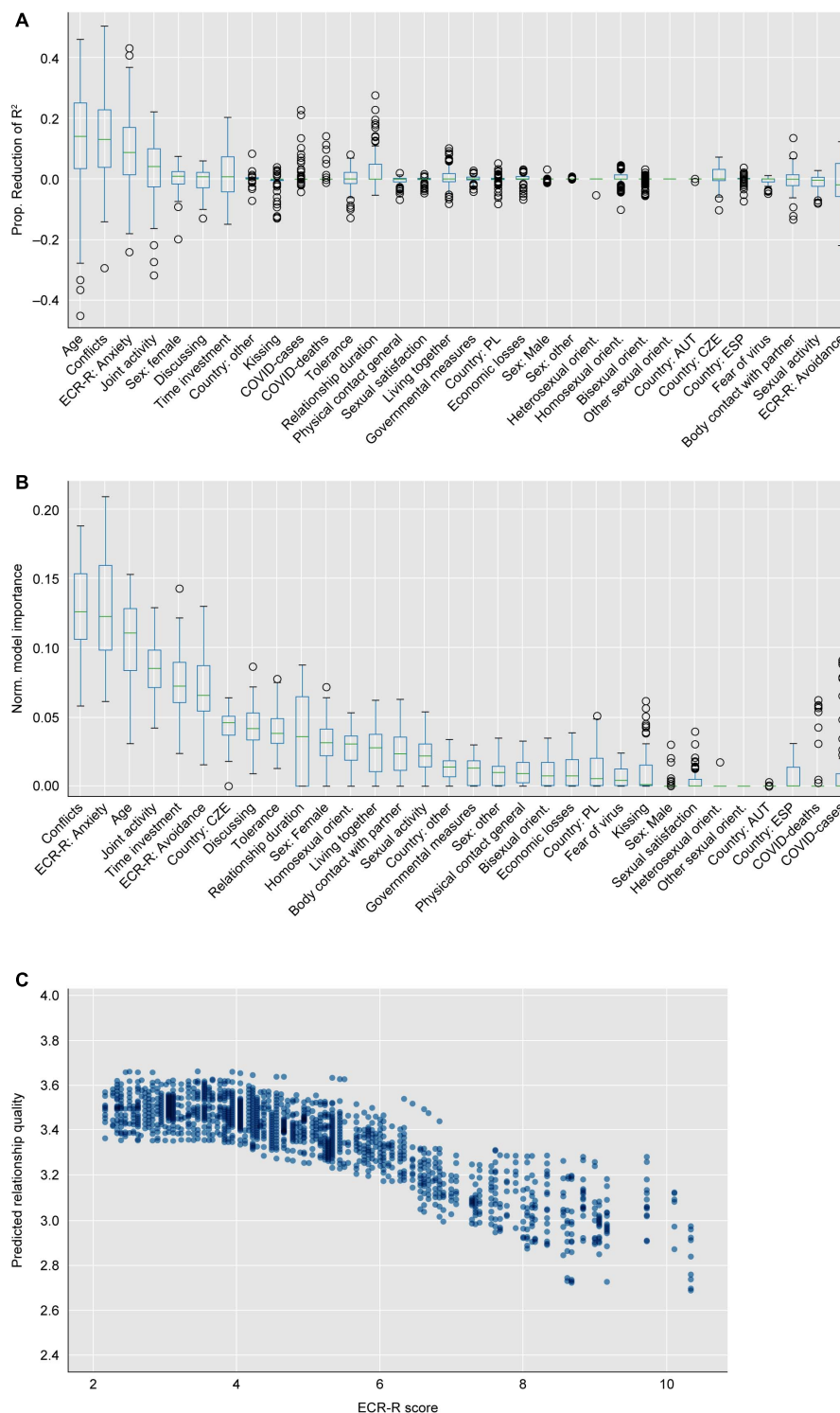


FIGURE 1 | Permutation feature importance **(A)** and model-based feature importance **(B)** over linear models with relationship quality as a target. **(C)** Use of attachment security (overall ECR-R score) as a predictor by the non-linear models.

be contacted for the purposes of the study. Participants were informed about the aim of the study and that they could stop participating at any point; they were fully debriefed and received

the option to leave a contact address to be informed of the results of the study. Communication with the participants took place in their native language.

Surveys

To measure attachment security, we administered the Experiences in Close Relationships Revised Scale (ECR-R, Fraley et al., 2000) at the beginning and at the end of the study, which allowed us to estimate the temporal stability of this input feature. Validated translations of the questionnaire were used, and if no translation was available the questionnaire was translated by a native speaker and reviewed by another native speaker (Polish version: Lubiewska et al., 2016; Czech version: Cígler et al., 2019; Spanish version modified from Fernández-Fuertes et al., 2011).

Additionally, we assessed information regarding participants' romantic relationship. Here, we surveyed one general question directly targeting perceived relationship quality (4-point scale) and one binary question each investigating (i) if the partners engaged in joint activities, (ii) perceived tolerance for each other, (iii) if important topics are discussed with the partner, and (iv) taking time for each other. For each given week, (i) number of conflicts with the partner, (ii) frequency of joint sexual behavior, (iii) sexual satisfaction, (iv) kissing, (v) general physical interaction, and (vi) close physical contact with the partner were assessed (6-point scale from "not at all" to "5x and more").

To include local and temporal changes in governmental restrictions, we utilized a "stringency index" for each country and week as described by Petherick et al. (2020), denoting the gravity of governmental restrictions in response to the pandemic. As a subjective measure of how the restrictions affected the participants' economic status, we asked if they were threatened by economic loss due to responses to the pandemic.

Further, we included confirmed cases and deaths per million citizens (Sources: Eurostat, 2020; Hale et al., 2020) for each week and country as a measure of viral spread and mortality. Again, we probed participants for more a subjective measure of perceived viral threat, defined here as the perceived fear of the virus. Here, questions associated with fear of infection, perceived threat to own health, and to the health of other people emotionally close to the participant were collapsed to create the variable "fear of the virus".

Demographic and personal items were collected, including sex, sexual orientation, relationship status, and country of residence. Categorical features were one-hot (dummy) encoded.

In summary, **Table 1** lists all input features included in our machine learning models. Phrasing and scoring of the questions are publicly available in the OSF-project.

Analysis

We fit two types of machine learning models, each trying to predict the target variables of relationship quality and change in relationship quality. One model was linear (LASSO, Tibshirani, 1996), and the other non-linear (ExtraTrees, Geurts et al., 2006). The models were evaluated within a nested cross-validation procedure (90/10, 100 repeats each), where hyperparameter tuning took place in the inner loop and only used training data from the current loop (Cawley and Talbot, 2010).

Cross-validation was stratified, controlling for participant ID to counteract subject cluster learning.

The chosen models are particularly suited to handle many input features (predictors) while at the same avoiding over-fitting. Extremely randomized trees are non-parametric (the LASSO, in contrast, imposes a linear structure) and handle complex interactions between the variables, beyond what traditional regression analysis could encompass. We compared the models' performance in the respective hold-out sets to a *trivial predictor*, which uses the mean of all target variables for each prediction. The reported *p*-values indicate if the models perform significantly better than such a trivial predictor. We report an R^2 value as a measure of how much of the variance in the target variables can be predicted by our models *in new pools* of participants (the hold-out sets). Notably, this value will be smaller than when a conventional model is being fit to all data, however, the results are models capable of actual predictions for unknown data. Therefore, it is likely that our models capture real existing structures in the data and not artifacts.

To estimate the actual importance of each predictor for the forecast, we report the median permutation feature importance (PFI) for the better-performing model as the proportional loss of explained variance if a variable is replaced by a random (non-informative) array of that variable (Breiman, 2001). Thus, if a given predictor has a PFI of 10%, this indicates that 10% of the previously explained variance in the target is lost when the models cannot meaningfully access the given predictor variable. Further, we also show model-based feature importance. In case of the linear model, this are the coefficients assigned to a variable by the models, normalized each by the sum of all coefficients. In case of the non-linear model, this is how much reduction in the error is caused by a specific variable, averaged over the model.

For computing the machine-learning models, we utilized the free machine-learning library scikit-learn (Version 0.22.2., Pedregosa et al., 2011, scikit-learn.org, most importantly the functions "ExtraTreesRegressor"/"Lasso" to initialize the models, "GroupShuffleSplit" to stratify the cross-validation procedure and "permutation importance" as the main measure of feature importance). All analyses were conducted in Python 3.7.7. and R (R Core Team, 2017).

RESULTS

Relationship Quality Throughout the Crisis

Overall, relationship quality remained fairly constant throughout the aforementioned restrictions, as the majority of all participants did not report any changes. However, exactly one third of all participants did report changes in their relationship quality. We aimed to predict these inter-individual differences regarding the stability of relationship quality below.

Predicting Overall Relationship Quality

On average, around 30% of the variance in relationship quality during the lockdown was successfully predicted by

the linear models (LASSO), whereas the non-linear models (ExtraTrees) on average predicted 22% of this variance (LASSO: $R^2_{\text{avg}} = 0.29$, $R^2_{\text{median}} = 0.33$, $p < 0.001$; ExtraTrees: $R^2_{\text{avg}} = 0.22$, $R^2_{\text{median}} = 0.23$, $p < 0.001$; $N_{\text{trials}} = 731$).

Based on PFI, the most important predictors with an importance over 5% for the linear model were *age* (13.92%, younger age predicting higher quality), *conflicts* (12.88%, less fights predicting higher quality) and *attachment anxiety* (8.62%, less anxiety scores predicting higher quality) (**Figure 1A**); whereas for the non-linear model, *conflicts* (6.32%, same directionality), *joint activities* (5.68%, more joint activity predicting higher quality), *time investment* (7.24%, more investment predicting higher quality) and *attachment anxiety* (5.60%, same directionality) were contributing most to the explained variance.

The most important features remained the same when assessing model-based feature importance, although in a different order: *Conflicts* (0.13), *attachment anxiety* (0.12), *age* (0.11), *joint activity* (0.09), *time investment* (0.07), and *avoidant attachment* (0.07) for the linear models (**Figure 1B**); *joint activity* (0.25), *conflicts* (0.14), *attachment anxiety* (0.13), *avoidant attachment* (0.09), *time investment* (0.09), and *tolerance* (0.06) for the non-linear models. For the better performing linear models, **Figure 1** shows the PFI and model-based importance of all features.

The above models consider attachment anxiety and avoidance as two separate predictors. To assess the overall importance of attachment style relative to other variables, we then combined both subscales of the ECR-R and used it as a single predictor. Here, the ECR-R score indicating overall attachment (in)security is by far the most important feature (responsible for 19.11 and 11.03% of the explained variance in the linear and non-linear model, respectively).

Figure 1C shows how this most informative predictor (the sum of anxiety and avoidance) is linked to relationship quality in our non-linear models. It indicates that a non-linear use of this measure is most beneficial when predicting relationship quality.

Changes in Relationship Quality Were Not Predicted by the Surveyed Variables

As opposed to the overall quality, *changes* in relationship quality could not be predicted by our models better than by a trivial predictor (LASSO: $R^2_{\text{avg}} = -0.14$, $R^2_{\text{median}} = -0.06$, $p = 1$; ExtraTrees: $R^2_{\text{avg}} = -0.31$, $R^2_{\text{median}} = -0.14$, $p = 1$; $N_{\text{trials}} = 708$). The only feature with a model-based feature importance above zero in both model types was the participants' answer to the item "my partner makes time for me" (*model-based feature importance*: LASSO = 0.58; ExtraTrees = 0.24; $\text{PFI}_{\text{both}} = 0$). A *post hoc* analysis revealed a Pearson correlation of $R = 0.21$ ($\text{BF}_{01} = 0.695$) between this time-investment and the change in relationship satisfaction over time.

Temporal Stability of Attachment Security

An important predictor for relationship quality was attachment security as measured by the ECR-R, and we performed a *post hoc*

group comparison with all participants that had filled in the questionnaire both times (around 4 weeks apart). There was no difference in attachment security between the beginning and end phase of the lockdown (mean decrease by 0.05%, $\text{BF}_{01} = 14.924$; $N = 140$). The shared variance was 76.91%, which is in line with the good 3-weeks test-retest reliability reported for the ECR-R (84–85% shared variance, Sibley et al., 2005).

DISCUSSION

The aim of the current study was to predict relationship quality as movement restrictions in response to the COVID-19 pandemic were implemented and relaxed in four European states. Our linear models predicted around 30% of the variance in self-reported relationship quality, where attachment style was one of the most important predictors. This is in line with studies reporting that ECR-R scores explain a large proportion of individual differences in emotional experiences/responses within relationships (Sibley et al., 2005). However, the same variables could not predict *changes* in relationship quality over that time period.

Predictors of Relationship Quality

Nationwide movement restrictions constitute special circumstances for people in romantic relationships, where due to curfews, couples become each other's only form of social contact. Indeed, during unstable times such as the COVID-19 pandemic, people may have to endure increased stress levels in response to the medical threat associated with the virus and subsequent societal changes, which both in turn might further influence relationship dynamics. In line with our hypotheses, attachment security was a major predictor of relationship satisfaction during the time of curfews and social restrictions. These findings corroborate previous studies that have linked attachment styles to relationship quality (e.g., Mikulincer et al., 2002) where these effects may even be exacerbated by the stressful effects of the COVID-19 crisis (cf. Gillath et al., 2006). Mikulincer et al. (2002) propose three main avenues by which relationship quality may be influenced by attachment style: (i) secure attachment may orient individuals toward a positive bias of dyadic interactions; (ii) positive representations of the self and others may affect conflict management; and (iii) the satisfaction of other psychological needs may be enhanced in securely attached individuals (Mikulincer et al., 2002). Interestingly, in the current study, the dimension "anxiety" was a more important predictor than the subscale "avoidance." Potentially, this difference may be enhanced by a general decrease of external security in times of crises.

Secure attachment may further relate to an internal locus of control (Hexel, 2003), where securely attached individuals may have more mechanisms to cope with the stress a world-wide crisis elicits (Feeney, 1995). Indeed, an analysis of subjective health in our sample shows that attachment security is a predictor of a heightened sense of health (Eder et al., 2021). Speculatively, this may mean that the effects of secure attachment are not limited

to the relationship *per se*, but may exert an influence over other psychological mechanisms.

Importantly, the accuracy of predictions for relationship quality could have been enhanced by sampling information from both partners. Senchak and Leonard (1992) report that the pairing of attachment styles, rather than individual attachment itself, is associated with marital satisfaction. Specifically, as compared to couples where both partners are securely attached (“secure couples”), couples where a securely attached person is in a relationship with an insecurely attached person do not differ from “insecure couples” with regards to marital satisfaction. However, securely attached persons tend to pair with securely attached partners (Senchak and Leonard, 1992), potentially buffering this confounding factor. Nevertheless, incorporating information about both partners might have aided in the prediction of relationship quality and possibly even the prediction of changes within this variable. This one-sided perspective and lack of dyadic data must be noted as a clear limitation of the current study and offers a starting point for more extensive research.

Attachment theory has traditionally classified attachment into discrete styles (Feeney and Noller, 1990; Ainsworth and Bowlby, 1991), although many have argued that attachment security should be treated as a continuum (Fraley et al., 2015; Haslam et al., 2020; Lubiewska and Van de Vijver, 2020). Indeed, the method by which our non-linear models utilize the (continuous) ECR-R score in order to optimize the predictions of relationship quality (Figure 1C) suggests that a non-continuous use of the variable (divided to the categories secure/less secure) may be justified as a simplified measure when investigating implications for adult relationship satisfaction.

Interestingly, the age of participants had a relatively high feature importance, where younger participants self-reported higher quality scores with respect to their relationships. Some longitudinal evidence may support this conclusion, such as an increase in unpleasant aspects in the relationship over time (Birditt et al., 2009), where correlations between younger age and higher relationship satisfaction have been reported previously, albeit at small effect sizes (Lenger et al., 2019). Both longitudinal and cross-sectional studies would be of value to follow up on this finding.

In both linear and non-linear models, another important predictor of how participants rated their relationship quality was the number of arguments with their partner they reported per week, where frequency of conflicts has previously been associated with lower relationship quality lowered relationship quality (Kluwer and Johnson, 2007). Our results confirm the predictive value of the amount of conflicts, and suggest that simplified behavioral observations or surveys on relationship quality should include this dimension. Indeed, our findings emphasize the dimension “agreement” over other dimensions of intimate relationships, such as intimacy and independence, but also sexuality (cf. Hassebrauck and Fehr, 2002). This is surprising, since engaging in sexual behavior is an important aspect of pair-bonding that has repeatedly been demonstrated (Birnbaum and Finkel, 2015; McNulty et al., 2016). Moreover, even though sexual satisfaction cannot predict changes in

relationship quality or vice versa in some studies (Byers, 2005; Joel et al., 2020), as is in line with our results, it does seem to relate to relationship quality at a given point in time (Byers, 2005; Joel et al., 2020), and in some studies even to future relationship quality (Fallis et al., 2016). However, the actual frequency of sexual intercourse alone is not a telling measure of relationship satisfaction (Loewenstein et al., 2015), and a curvilinear relationship between sexual frequency and overall happiness has been proposed (Muise et al., 2016), which, if applicable to relationship satisfaction, should nevertheless have been detected by our non-linear models. “Sexual afterglow”—evidenced in elevated levels of sexual satisfaction—might facilitate pair bonding beyond sex (Meltzer et al., 2017); however, the effect could have been captured by our predictor “sexual satisfaction.” Overall, neither sexual activity nor satisfaction was predictive of reported relationship quality in our models, and our data do not provide further evidence to the large body of literature connecting these variables. A deeper understanding of circumstances and motives (“sexual goals”) of sexual behavior in romantic relationships may help to clarify this relationship (cf. Muise et al., 2017).

Previous studies have found that changes in relationship quality are more difficult to predict from self-report variables than relationship quality at a given point in time (Joel et al., 2020). Our results show that this may be the case even in a period where many quantifiable environmental factors act on intimate relationships, since our machine learning models failed to predict changes in relationship quality. The fact that we did not observe changes for most participants may in part account for this difficulty in prediction, since variance in the target variable is important to identify predictors of this target. Possibly, surveying information with respect to interpersonal variations in stress-management and personality characteristics such as optimism, self-efficacy, and resilience (so-called “psychological capital”) could have improved our prediction, since personality-dependent stress management is known to strongly alleviate the effects of “objective” environmental stressors (McCrae, 1990; Mills and Huebner, 1998; Somerfield and McCrae, 2000; Avey et al., 2009). Of course, a dyadic view and information on both partners’ perspective might have further improved our chances.

While none of the environmental features or the features that do predict general relationship quality in the sample seem to add information about changes in quality, there is one exception: perceived time investment by the partner had a non-zero model-based feature importance and was *post hoc* shown to correlate with changes in relationship quality. While this study cannot conclusively support the role of time investment for temporal changes in relationship quality, this may provide an interesting starting point for further studies.

Generalizability

The cross-national composition of our sample and the fact that our models are evaluated by their performance in hold-out sets of “novel” subjects suggests a relatively high generalizability. However, we did not exclude or control for clinical psychological conditions, which might have influenced self-report measures

during these globally stressful times. Cross-cultural studies on similar situations are needed in order to further investigate the role of attachment style in crisis-like situations, where future studies should also take into account both partners in a romantic relationship (see Kenny et al., 2006).

CONCLUSION

The current study provides evidence on the complex interactions between relationship quality, attachment style, and demographic variables in couples during exceptional and stressful circumstances. We examined and predicted relationship quality as lockdown measures due to the COVID-19 pandemic were implemented in four European states. We found that attachment security was a highly important predictor for relationship quality, and that country of residence, case counts, and the stringency of governmental measures did not contribute to accurate predictions. Changes in relationship quality could not be accurately predicted with the given input variables using the currently implemented machine learning approach.

In conclusion, we demonstrate that attachment security is an important predictor of relationship quality during the unstable times of the COVID-19 pandemic, as opposed to fear/perceived threat, sexuality, and macro-level environmental factors such as the stringency of movement restrictions.

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DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: <https://osf.io/ybjre/> Open Science Framework.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements; however, potentially intimate questions were additionally approved by the Institutional Review Board of Charles University, Faculty of Science. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SE designed the study. SE, MS, MP, JM-M, OP, and JB translated items and collected the data. DS, PS, and SE analyzed the data. SE wrote the manuscript. AN and FS revised the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Using Neural-Network-Driven Image Recognition Software to Detect Emotional Reactions in the Face of a Player while Playing a Horror Video Game

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Abstract. Image analysis of the webcam images of the player playing horror video games is used to infer his/her emotional state. We initially relied on the received wisdom that there are three distinguishable emotional states: joy, agitation (a combination of fear and surprise) and neutral. We applied modern image analysis techniques to extract the player's face in three sets of 50 consecutive frames by first generating 150 feature vectors and then using an auto-encoder neural network to dimension-reduce these to a mapping of 150 points on a 2D manifold. We find that these mapped points are not uniformly distributed in a plane and an overlap between neutral and each of the two affective states is highly improbable. We derive convex hulls using a k -medoids clustering algorithm; they seem to indicate a difference between the mouth region expression and that around the eyes. We use kernel density estimation and Monte Carlo methods to determine that the affective states joy and agitation have a small probability of overlap (6.6 % and 10.6 %, respectively), which can be interpreted as a confusion probability. Our advanced statistical analysis thus confirms that modern image analysis can indeed be used to monitor the player's emotional state while playing.

Keywords: image analysis using neural networks, auto-encoder, k -medoids clustering, face alignment algorithm, horror videos, facial expression of emotion, Monte Carlo methods of probability estimation.

1 Introduction

The facial muscles are largely under involuntary control and communicate the affective state to others. The eyes play a major role in allowing inference of one's emotional state as the orbicularis *oculi* muscles around the eyes are more difficult to control than other facial muscles [1]. The so-called “Duchenne smile,” also known as the “true smile” is typically achieved by the contraction of these orbicularis *oculi* muscles, as opposed to the “fake smiles” that involve only the zygomatic major muscles [1].

Since, in this paper, we research facial communication by players of horror games, the negative counterpart to joy is an expression that superimposes weightings of fear

and of surprise. These latter two emotional states are closely related and oftentimes merge [1]. The major difference in the facial expression between these two occurs in the lower half of the face [2]. Neta et al.’s study shows that jaw drop and open mouth (surprise) and lips stretched backwards (fear) are, in an ideal case, the differentiating factor. Thus, these two emotions not only mix to a high degree, especially when they temporally follow each other, but also can be impossible to distinguish due to verbal, such as narrating, and para-verbal communication, such as screams and warnings. We conclude that our AI-driven facial analysis of horror video players must deal with three expressions of emotion: joy, agitation (the intermixing of fear and surprise) and neutral.

While players are emotionally involved in a video horror game, the intensity of their participation is monitored by the image analysis of their face that is being photographed by the webcam, frame by frame, consecutively. In this paper, we investigate to what reliability image analysis can be used for such monitoring. More specifically, we statistically analyze consecutive frames from a webcam so as to confirm or refute whether the emotional states joy and agitation can indeed be monitored and distinguished from each other and from the neutral state.

2 Materials

While playing *Until Dawn* (details: see Appendix), the player presents his gaming experiences on his online channel, wherein he makes comments about them. Involuntarily, he also exhibits his emotional involvement via facial expressions, displayed in a small frame inserted in the upper right-hand corner of the screen. One co-author (TH) selected three scenes (partially relying on the comments by the player) in which the commentator exhibited the emotions joy, agitation, and neutrality. Along with the selected frame, 25 frames before the selected scene and 24 after it were stored for subsequent analyses.

3 Methods

For each frame, we extracted a rectangle that frames only the player’s face. We then aligned the face (primarily via the eyes and the tip of the nose) within each rectangle with every other face in all 150 rectangles. We then applied an image analysis algorithm (supplied by MATHEMATICA[®] from WOLFRAM Technologies[®]) to characterize each image as a feature vector. These 150 feature vectors were combined in a matrix and a non-linear artificial neural network [3], specifically an auto-encoder with seven layers, was used to extract 2D coordinates for each feature vector. These were then graphed as points in a plane. For each emotion represented by the 50 dimension-reduced feature vector points, we used the k -medoid clustering algorithm for finding three clusters (enclosed by the convex hulls in Fig. 1) per emotion. We used KDE (kernel density estimation) with a Parzen window optimized by the Silvermann rule-of-thumb [4] to find three *pdfs* (probability density functions), one for each emotion. We generated contour plots of these *pdfs* in order to identify the distinctness of the regions of highest likelihood. With a Monte Carlo method, we generated 15000 random points for each

pdf and defined a cutoff for lowest likelihood needed for subsequent analysis. We calculated the fraction of random points of one emotion that lay in the region of high likelihood of another emotion.

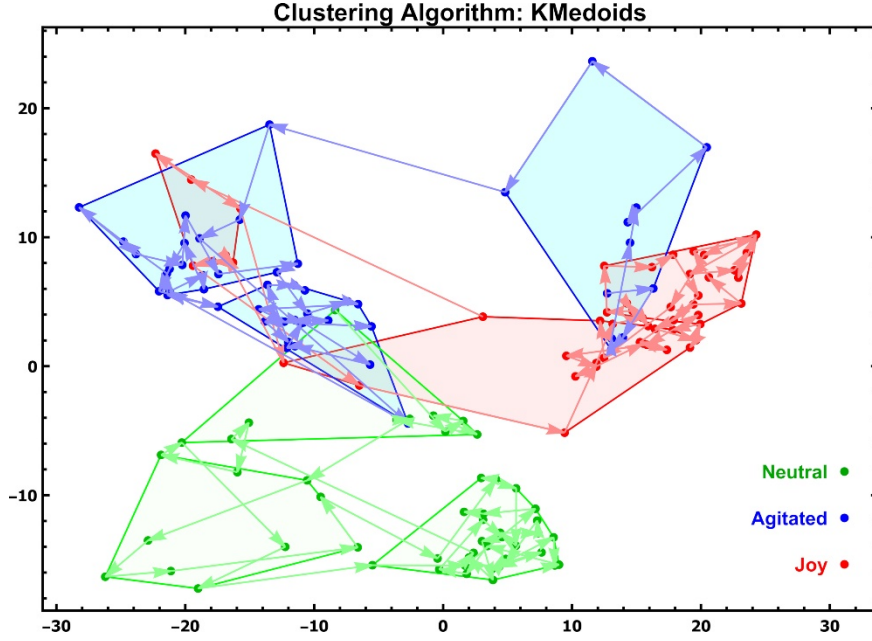


Fig. 1. The dimension-reduced feature vectors projected on a 2D manifold as points and the convex hulls determined using a k -medoids clustering algorithm. Points are the dimension-reduced feature vectors; the arrows show their sequence from one frame to the next. The k -medoids clustering algorithm is supervised; we specified 3 clusters per emotion. We observe that most of the points for each emotion are within only one of the three convex hulls of this emotion.

4 Results

The k -medoids clustering algorithm applied to the points for each emotion documented that the three clusters per emotion only partially overlap (Fig. 1). A display of the sequence of the points for each emotion shows that one convex hull is predominantly occupied (Fig. 1). This observation is a first indicator that the image analysis of facial expression can distinguish emotions. The contours of the KDE-derived *pdfs* confirm this (Fig. 2). Overlapping contours of the *pdfs* of the emotions are those of low likelihood — further confirmed by the distributions of random points above the cutoff $\frac{1}{10}P_{\max}$ (Fig. 3). The probabilities of observing random points above $\frac{1}{10}P_{\max}$ are 79.6 % (agitation), 81.7 % (neutral), and 78.5 % (joy). The choice of this cutoff is very reasonable and allows for a clear, more reliable alternative for identifying separation of facial expressions to using the k -medoids clustering algorithms. Furthermore, convex

hulls, because of their convexity, can overlap, and probability estimates cannot be derived using them.

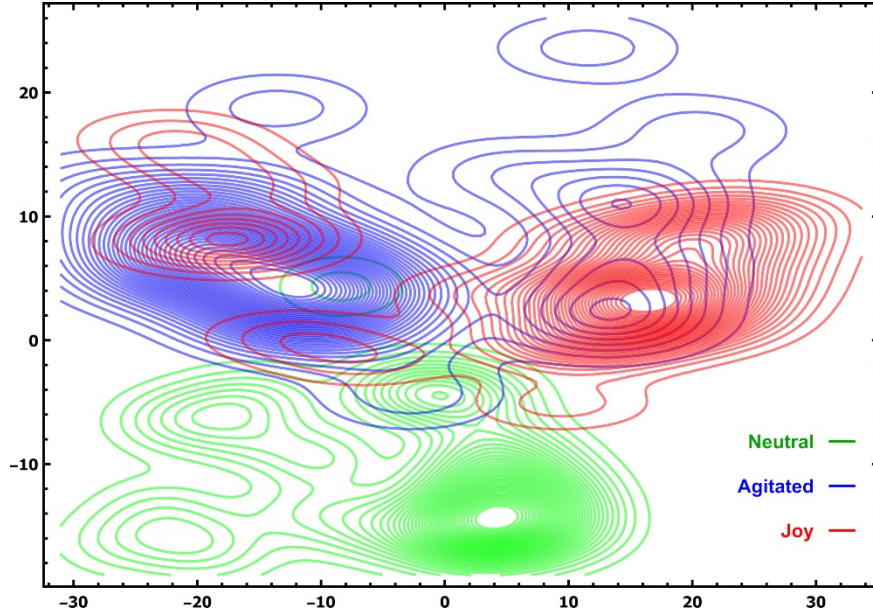


Fig. 2. The contour lines of the pdf (probability density function) obtained with KDE (kernel density estimation) of the points rendered in Fig. 1. The contours are equally spaced in likelihood. We observe that the contours with highest likelihood for each emotion separate very well.

We use the random points to estimate the fraction of overlap, which is interpretable as a measure of confusion probability between emotional states. The confusion probability of a joy expression being an agitation expression is 6.6 %, and the converse confusion (agitation being interpreted as joy) is 10.6 %. We point out that this method of determining confusion via random points and contour overlap does not include the emotion neutral. A neutral facial expression, we find, is never confused with the emotion joy nor with the emotion agitate.

5 Discussion

The images of the face included motions/deformations of the mouth, cheeks and lips due to the commentator verbally expressing his emotions. We interpret the points enclosed by the rarely visited convex hulls (Fig. 1) as those driven by facial expressions predominantly involving mouth, cheek, and lip movement. We cannot construct a control analysis for this interpretation, however, because — even though we can repeat our image analysis for the eyes and nose regions without mouth, cheeks and lips — the extraction of feature vectors and reduction onto a 2D manifold would result in a very different display. We suspect, furthermore, that the feature vectors would detect the

stronger signal of muscle activity while talking, rather than the emotional state expressions. In addition, conventional supervising webcams, used to monitor the ‘flow’ [5] of the participant’s engagement in a horror video game always involves the whole face, not just the part above the nose. We are primarily interested in whether facial image analysis using the AI and statistical analysis methods we present here can distinguish between three emotional states; we show that we indeed can, even when including the lower face. Whether we find indicators of different contributions to the reduced features vectors is of minor importance.

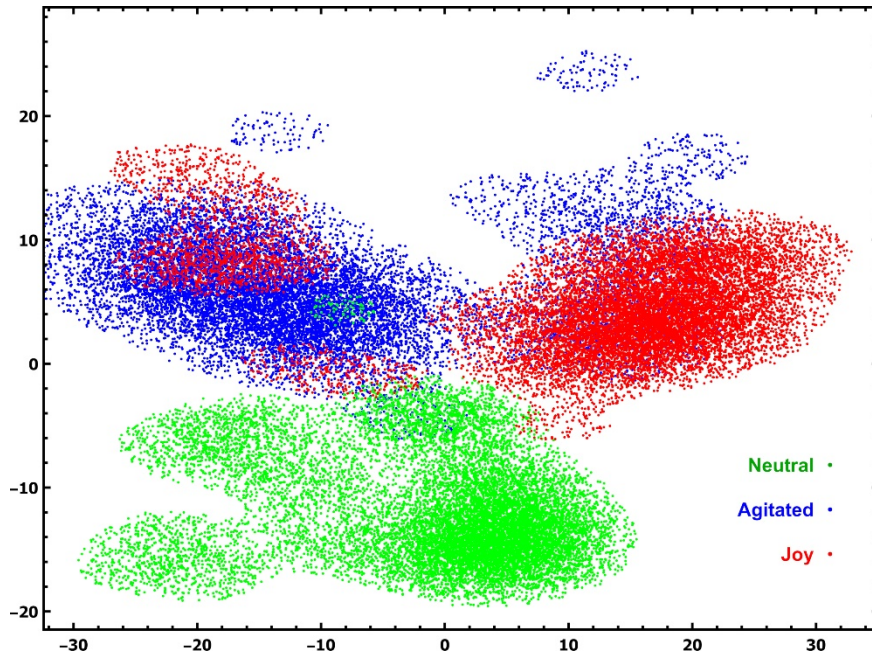


Fig. 3. The distribution of randomly generated points for each emotion *pdf* via Monte Carlo. The displayed points are those within a cutoff of $\frac{1}{10}P_{\max}$ for each emotion. For joy there are 11773 points, for agitated there are 11935 points, and for neutral there are 12257 points. Although 15000 random points were generated for each *pdf*, the cutoff retains differing numbers of points for each emotion-dependent cutoff, because $P_{\max}$ differs from emotion to emotion.

In other, seminal, work, facial expressions were used to distinguish between the emotional states, and that the separate state of boredom (in our case: the equivalent to neutral) was easy to track [5]. Our analysis confirms these claims.

Joy and agitation are the two emotions on the opposite ends of spectrum of facial expressions. They are therefore pertinent to any consequences of assessment, such as when humans derive a putative emotion after looking at a photograph of a face. The general accuracy of emotional assessment was estimated to approximately 92% when one human infers another’s emotion based on still images, such as photographs or drawings (Ekman, 1976). Our findings extend these observations to a sequence of moving

and/or changing faces. We find a confirming parallel. The overlap (Fig. 4) can be interpreted both as a confusion probability and as an unreliability test. We find the confusions to be 6.6 % and 10.6 %; both these derived estimators compare very favorably with Ekman's (1976) findings.

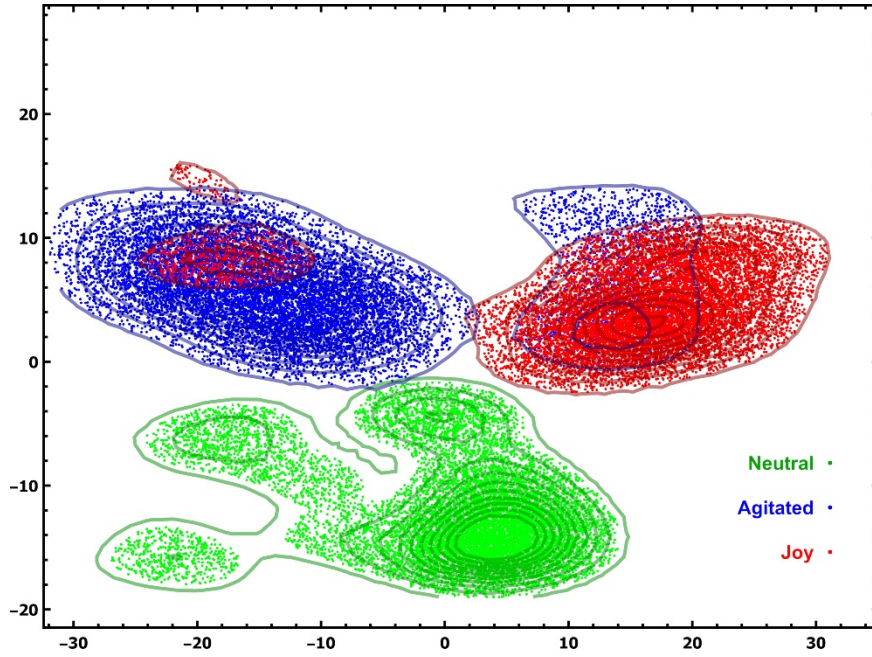


Fig. 4. Contours of the KDE-*pdfs* as well as the randomly generated points for each emotion. The cut-off for the random points is $\frac{1}{10}P_{\max}$ and the contours are at likelihoods $\frac{k}{10}P_{\max}$, with $k = 1 \text{ } \Omega \text{ } 9$. The overlap of some likelihood regions of one emotion within the likelihood region of another emotion can be used to determine confusion probabilities (see text).

The reliability of our findings has a further application when the software attempts to maintain a ‘flow’ [5] of the participant’s attention and emotional reaction while playing a horror video game: the case when several players participate together. Then each participant’s facial expressions communicates their involvement and engagement to the others. Our findings show that such communication can be interpreted reliably by the image analyses presented here and has a confusion probability of about 10 % — arguably a small probability. Because the probabilities calculated in these analyses are not significances, we need not compare probability outcomes with significance levels.

This new method of analyzing facial expressions can be used to clarify the physiological relationship of facial manifestations and the expression of emotions in humans [6]. Previous studies have failed in linking specific facial expression with discrete emotions; the observed predominant link is relating the dimensions of valence and arousal separately. Further application of our new method can bring clarity to this topic. A cautionary note is keeping in mind that neural networks do not allow for a completely

reproducible, external understanding of the neural network’s inner working. There are ways of addressing this problem, most notably via simulations.

Furthermore, we note that the use of the webcam is highly appropriate because it is unobtrusive and does not need the employment of sensors that directly record the physiological activations of the face muscles through EMG monitoring. The applications in gaming would include monitoring the individual player for sake of the scenario adjustment (maintaining the ‘flow’; [5]) as well as gaining information of other players’ emotional states during some crucial moment of the evolving scenario.

6 Conclusion

By using the sequence of five analysis steps: (1) feature vector extraction of the face in each frame, (2) dimension reduction using an auto-encoder, (3) k -medoids clustering algorithms, (4) KDE-determined pdf s, and (5) Monte Carlo methods of probability estimation, we find that the facial manifestations of the three emotions are separable. We observe that there is a small overlap probability of 7 % to 11 % that the emotional states joy and agitation can be confused; but neither of these two states was ever confused with the emotional state neutral. We did not need to limit the analysis to the eye region, because the identification of and distinction between emotional states is remarkably reliable. The use of these advanced methods (AI and KDE-derived statistics) are indeed useful for monitoring the emotional status while a player is playing a horror video game.

Ethics Statement This project has been conducted using only materials publically available online and does not reveal any personal information.

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Appendix

The horror video game is called *Until Dawn* (Supermassive Games / Sony Computer Entertainment, 2015). The game revolves around the story of eight characters that the player may save (or not) by their actions in a “butterfly effect” system whereby each character’s decision can create a situation that intentionally scares the player.

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Konzumace pornografie obyvatel ČR a její vztah k demografickým proměnným: klastrování pomocí umělé inteligence

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Abstrakt

Současný stav poznání: Ve společnostech s vyspělou ekonomikou a prakticky neomezeným přístupem k internetu (jako je Česká republika) je anonymní konzumace pornografie (často i obsahující prvky sado-masochismu) běžnou součástí života. Není však známo, jaké části populace se vystavují jakému typu těchto materiálů a zda taková aktivita souvisí s jejich vzděláním, frekvencí masturbace a do jaké míry je závislá na pohlaví.

Tato analýza dosud ani nebyla možná, s ohledem na dostupnou výpočetní sílu a na ní závislé postupy statistického zpracování dat. Díky užití umělé inteligence můžeme tyto prvky analyzovat všechny najednou a skutečně tak zjišťovat souvislosti mezi nimi.

Cíle: Zjistit souvislosti mezi různými proměnnými (pohlaví, partnerský status, vzdělání) a nepartnerským sexuálním chováním (konzumací běžných i sado – masochistických pornografických materiálů a frekvencí masturbace). Očekávali jsme, že se účastníci výzkumu rozdělí do jednotlivých segmentů s jasně definovanými vlastnostmi. Následně jsme tyto segmenty porovnali s demografickými údaji, konkrétně velikostí místa bydliště.

Výsledky: Pomocí naší analýzy jsme zjistili, že participant se rozdělí do 7 jasně definovaných segmentů. Žádný ze segmentů neobsahuje pouze jedince jednoho pohlaví, většina z nich však obsahuje velkou převahu jednoho pohlaví. Frekvence autosexuálních praktik se významně liší v jednotlivých segmentech, stejně jako konzumace pornografických materiálů obou typů. Vzdělání, oproti našemu očekávání, není významným rozdělovacím prvkem mezi segmenty, stejně tak partnerský status. Vysoká konzumace pornografie, společně s vysokou frekvencí masturbace, charakterizuje dva segmenty.

Abstract

Background: In societies with advanced economies and ubiquitous internet access (such as the Czech Republic), anonymous consumption of porno videos (both BDSM and non-BDSM) has become widespread. However, it is neither clear what fraction of consumers in such a society (and its demographic stratification) consume how much, and how this relates to their education level, masturbation frequencies and to what extent it is sex-dependent.

Aim: First, we are interested in associations between various personal attributes (sex, relationship status, education) and sexual attributes (BDSM and non-BDSM porno video consumption as well as masturbation frequencies). We expect the participants to cluster into distinct segments with well-identifiable features. Second, we suspect that the segments of personal and sexual attributes associate with a demographic parameter, namely the size of the village, town, city in which they live.

The analytical tools were by now unavailable due to computational power and availability of neural-network driven Artificial Intelligence based analytical tools.

Results: We find that the participants cluster into 7 segments; none are exclusively of only one sex, but several are overwhelmingly of one sex only. The spectrum of masturbation frequencies is distinctly different in the segments, as are consumption of porno videos of both types. Education levels and relationship statuses are not good separators. Highly compulsive porno video consumption, together with high masturbation frequencies, characterize two segments, while restraining (conservative) sexual attitudes are characteristic of two others. Associations with demography are as expected: members with conservative sexual attitudes are primarily female and live in small towns and villages, as do males with highly impulsive sexual

Další dva segmenty jsou charakterizovány spíše konzervativním přístupem k sexualitě.

Závěr: Nové a pokročilé formy statistické analýzy dat dovolují identifikaci klastrů dospělých konzumentů pornografie na základě jejich auto-sexuálního chování a demografických proměnných, které by bez užití neuronových sítí nebylo možné identifikovat.

Klíčové slová: Neuronové sítě – algoritmus DBSCAN – konzumace pornografie – frekvence masturbace – demografické parametry – úroveň vzdělání – kompulzivní sexuální chování.

Úvod

“Zaručeně největší a nejsilnější ze všeho zla na světě je to, které vyrůstá z kořenů lidské přirozenosti. Není tomu tak snad, že tato část našeho bytí, jenž se pevně váže k základním silám přírody a jí formované přirozenosti člověka, ta se ukázala být nejvíce zvrácená – neukazuje to snad na veliký problém?” (Hopkinsová, 1899; překlad Binter, 2021).

Puritánství, jehož byla Ellice Hopkinsová zásadní představitelkou poukázalo na budoucí trend v lidské sexualitě. Z některých mužů, kteří jsou daleko snadněji vizuálně stimulováni než ženy, se stali věrní konzumenti (příležitostně se hovoří i o kompulzivní konzumaci až nelátkové závislosti) internetové pornografie. Avšak platí za to náležitou cenu – ovlivněním sexuálního vývoje, stejně jako preferencí a sexuálního chování. U některých jedinců hrozí riziko přetrvávání narušení psychosexuálního vývoje i v dospělosti. Deset procent britského vzorku dokonce tvrdilo, že je přímo závislá na konzumaci pornografie (Logue et al., 2018).

Zvláště u mužů dochází k velkému překrývání sexuálních fantazií a preferencí skutečně sledované pornografie (Chivers & Bailey, 2005; Chivers et al., 2010; Binter et al., 2013; Krejčová et al., 2018). To zřejmě souvisí s dalšími dvěma aspekty: (a) vyhledávání sexuálního zážitku zobrazeného v takových materiálech a s tím související sexuální touhy (Galther & Sellborn, 2003; van Lankveld et al., 2015), a (b) dostupnost sexuálního partnera, se kterým by měl takové sexuální zkušenosti (Binter et al., 2012).

Dostupnost sexuálního partnera, který by splňoval požadavky konzumentů specifických typů pornografických materiálů, se dá spíše předpokládat ve větších městech, kde budou také pravděpodobněji bydlet jednotlivci s vyšším vzděláním (jelikož vysoké školy jsou převážně ve větších městech; Binter et al., 2012). Je rovněž pravděpodobné, že ve větších městech se vyskytuje více osob s menšinovými preferencemi (jako jsou BDSM-pozitivní jedinci; Richters et al., 2008; Wismeijer & van Assen, 2013). Důvody jsou pravděpodobně anonymita, větší partnerský trh, více klubů a lokalit věnovaných okrajové sexualitě.

Dalším vlivem na kvalitu partnerství a uspokojení sexuální touhy, která je často spojována s množstvím konzumované pornografie, je délka partnerského vztahu. Jedinci, kteří jsou v partnerském vztahu déle, s větší pravděpodobností fantazírují o jiných sexuálních partnerech než o těch, se kterými jsou právě ve vztahu. Dále pak jedinci, kteří podváděli své předchozí partnery, a ti, kteří dříve měli více sexuálních partnerů, častěji uplatňují toto své chování ve svých současných vztazích

attitudes.

Conclusion: Modern, advanced statistical methods can identify segments of adults with well-defined sexual attributes and associations with demography that would otherwise remain undetected.

Keywords: Neural networks – DBSCAN algorithm – porno video consumption – masturbation frequency – demography parameters – education status – compulsive sexual behavior.

(Binter et al., 2012, Hicks & Leitenberg, 2001). Naopak ti partneři, kteří fantazírují o svých partnerech, budou pravděpodobně více projevovat chování související s partnerskou spokojeností – jak ukazují předchozí studie (Birnbau et al., 2019). Nevyřešenou otázkou je však to, zda nižší spokojenost ve vztahu souvisí právě s tendencí k podvádění a sledování pornografie či jde o dva spíše nezávislé fenomény.

Důvodů ke sledování online pornografie je několik, například sexuální vzrušení; inspiruje také zvědavost z vlastního uspokojení z rozličných pornografických scén, a zvědavost ohledně technik uspokojování partnera (Sabina et al., 2008). Data z České republiky ukazují rozdíl mezi těmi, kteří jsou ve vztahu, a těmi, kteří jsou nezadaní (Smutny & Sulc, 2018). Nezadaní jedinci častěji (17,1 % vs. 12,5 %) sledují pornografii, aby uspokojili své tajné touhy; hledání inspirace pro sexuální život je však nižší o 13,2 % (21 % nezadaných uvádí takovou motivaci). Obě skupiny jsou motivovány ke sledování pornografie sexuálním uspokojením (v partnerství: 59,9 %; nezadaní: 66,7 %).

Může se zdát, že pornografie má pouze negativní dopady. Existují také pozitivní vlivy – kompenzační účinek, který byl prokázán v Japonsku, Dánsku, Finsku, Chorvatsku, Spojených státech amerických a České republice (Diamond et al., 2011). Zvýšená dostupnost pornografických materiálů je v dané zemi negativně spojena se zločiny souvisejícími se sexuálním násilím. Jinými slovy tam, kde je pornografie dostupná se sexuálně motivovaná kriminalita významně snížila.

Kromě toho se zdá, že pornografie je mysl otevírajícím faktorem, a to zejména pro ženy, které v minulosti nesledovaly pornografii, a bylo málo pravděpodobné, že ji někdy sledovat budou. Nyní však pornografii konzumují. Pornografie ženám pomáhá přesněji definovat, jaké jsou jejich sexuální potřeby, kontextualizovat tyto potřeby a preference a snáze přijmout vlastní sexualitu (McKeown et al., 2018).

Dalším vlivem, který je třeba zohlednit je to, jak často jedinec pornografii konzumuje. V českém vzorku, který je nejrelevantnější pro srovnání s tím, který v této studii prezentujeme my, byla pornografie konzumována velmi zřídka malým procentem mužů (3,4 %), ale přibližně jednou třetinou (29,5 %) žen. Více než polovina žen konzumuje pornografické materiály několikrát za měsíc, zatímco více než polovina mužů konzumuje pornografii 2 až 5krát týdně. Méně než jedno procento žen konzumuje pornografii alespoň jednou denně. 11 % mužů konzumuje pornografické materiály několikrát denně a 14,4 % alespoň jednou denně (Smutny & Sulc, 2018).

Stručná historie vizuální pornografie

Vyobrazování pornografie bylo zdokumentováno: (a) v peripatetickém Řecku, (b) během Římské říše (stále existující pornografické výjevy lze vidět nejen v nevěstinci v Pompejích, ale také na freskách ve vilách, které byly z velké části zničeny erupcí Vesuvu v roce 79 n. l. a nyní jsou vystaveny v Archeologickém muzeu v Neapoli), (c) v čínské kultuře (například Zhou Fang, 8. století) a v japonských (shunga) dřevorytech, (d) v indické Kamasutře (Sinha, 1988), jakož i jako (e) ve známých sochách na fasádách indických chrámů (například chrám Kandariya Mahadeva, 11. století).

V čase poskočíme dále, abychom mohli porovnat možnosti přístupu k pornografickým materiálům v období renesance v Itálii 16. století a biedermeierovského období (po Vídeňském kongresu 1815) v habsburské monarchii. Oba tyto případy nám ukazují snížení exkluzivity tohoto artiklu a dále pak zvýšení a usnadnění distribuce.

Zatímco Raphael (1483–1520) maloval své světoznámé fresky ve Stampe ve Vatikánu, jeden z jeho asistentů Romano (1499–1546; který se měl sám stát velmi slavným malířem) namaloval na zdi řadu lascivních kopulačních poloh. Z nich Marcantonio Raimondi (1482–1534) vyrobil měděné lepty a distribuoval je v Římě. To rozzuřilo Papeže a uvrhl Raimonda do vězení. Nicméně tato zobrazení byla poté znovu reprodukována a distribuována v knižní podobě, doprovázená extrémně explicitními pornografickými sonety napsanými Pietrem Aretinem (1492–1556).

Tyto I Modi (nejlépe lze přeložit jako kopulační pohyby, které zahrnovaly vyobrazení a popisy análního styku – sodomie nebyla ve vyšších vrstvách společnosti vždy kriminalizována) byly opakovaně skrývány a ničeny, když byly nalezeny, a podobně. V roce 1928 objevil Walter Toscanini (syn slavného dirigenta) exemplář z počátku 16. století s dřevoryty místo měděných leptů, který byl posléze prodán jinému soukromému sběrateli. O 62 let později byly publikovány reprodukcce (Lawner, 1984). V kontextu tohoto článku je důležité poznamenat, že lepty a dřevoryty kolovaly pouze mezi bohatými a mocnými v Římě a Benátkách, a byly často přijímány společností.

Během Vídeňského kongresu (1815) bylo erotické (a pornografické) umění distribuováno v tajnosti (a zajisté vášnivě přijímáno). Do obecného povědomí se dostala série 40 akvarelů zobrazujících kopulační scény, které byly falešně připisovány Peteru Fendimu (1796–1842). Na rozdíl od I Modi v době renesance byly tyto materiály mnohem snáze dostupné jak pro prohlížení, tak i k pořízení do vlastnictví a obchodování, a to i lidmi z nižší šlechty a vrstvy zámožných prostých občanů. Protagonisty kopulačních scén byli také Vídeňané střední třídy oblečení v biedermeierovském stylu (i když jen částečně kvůli pornografickým vyobrazením) – což je značný kontrast k oblečení šlechty té doby.

V Evropě a Severní Americe se pornografie po osvícenství (od poloviny 19. století) stávala stále více všudypřítomným a masově konzumovaným artiklem. S vynálezem fotografie a hlavně filmu, byla umožněna prezentace vizuální pornografie přístupná stále větším částem populace – především díky inherentním technikám masové produkce a masové distribuce filmových materiálů. (První společnost, která výhradně produkovala erotické a pornografické filmy, byl Saturn-Film, Vídeň, v letech 1907–1911).

V dnešní době (2021) vedlo zaplavení pornografickými filmy doprovázené jejich snadnou anonymní distribucí ke zdánlivě nekritické a téměř neomezené spotřebě. V tomto

článku však ukazujeme, že spotřeba není tak nekritická, jak se běžně věří (viz níže).

Vývoj BDSM (bondage-dominance-sadismus-masochismus) chování a jeho vizuálních prvků

BDSM je žánr a životní styl. Musíme však rozlišovat mezi aktivitami BDSM, které jsou čistě sexuální, a těmi, které zahrnují sexualitu, avšak jsou jakýmsi souhrnem sociálních interakcí (Foucault, 1990). Raným vyobrazením bičování se sexuálním podtextem je Tomba della Fustigazione (Hrobka bičování), etruská hrobka nacházející se v Itálii, datovaná kolem roku 490 př. n. l., zobrazující jednotlivce, kteří prožívají (sexuální) slast a zároveň jsou bičováni a plácáni rukou (spanking) a bičem (Steingraber, 2006). Poté následuje velká časová mezera v hmotných důkazech tohoto vyobrazování. Jedno z přežívajících ztvárnění je Satyr bičující nymfy uvázané ke stromu, rytina Antonia Carracciho (1557–1602). Donatien Alphonse François, markýz de Sade, napsal 120 dní Sodomy a Justinu; oba romány považované za klenoty BDSM literatury, ve vězení. Většina literárních popisů je však pravděpodobně čistě smyšlená, ale ze soudních řízení a soudních obvinění víme o faktických popisech jeho preferencí, za které byl stíhán zejména ve svém mládí (Gray, 1998).

Richard Freiherr von Krafft-Ebing byl první, kdo ve svém díle Psychopathia Sexualis (1886) nazval takové chování – působení jinému bolesti za účelem vlastního potěšení – jako sadismus a přidal i další pojem, masochismus. Masochismus je pojmenován po Leopoldovi von Sacher-Masochovi, rakouském šlechtici, který strávil mládí v Praze. Jeho spisy, stejně jako jeho sexuální život, se zaměřovaly na záměrně přijímanou bolest, tresty a degradaci. Jeho Venuše v kožichu (1870) zahrnuje pasáže oddanosti, sexuálního násilí, psychického týrání a fetišismu.

Moderní klinické chápání sadismu a masochismu je považováno za nekonsenzuální a liší se od Sacher-Masochova. Konsenzuální sadomasochismus je naproti tomu v poslední době považován za variantu sexuální preference bez negativních důsledků (Federoff, 2008).

Moderní vizuální styl a charakter konsenzuálního BDSM lze hledat u jediného fotografa ze čtyřicátých a padesátých let minulého století, který vytvořil vzhled, jenž s tématem BDSM od té doby spojujeme. Byl jím Johna Alexandra Scotta Cuttsa (pseudonym John Willie; Pine, 2013).

V současné době pornografická videa s prvky BDSM zobrazují sexuální chování, během kterého dochází k (obvykle konsenzuální) výměně moci. Některé praktiky jsou zaměřeny na fyzické vjemy, některé na prožitky a některé na duševní stavy (včetně například trestu a hraní rolí). Bolest přitom může, ale nemusí být přítomna. Myšlenkou je spíše poslušnost a podřízenost. Někdy se k zintenzivnění prožitku používají speciální kostýmy (Binter et al., 2021).

Věk nových technologií

Jeden z největších a život měnících technologických pokroků, vznik internetu, má na svědomí obrovské množství pornografických materiálů. Nabízí tak pestrou paletu materiálů, že snad žádné pornografické téma nechybí. Každé páté internetové vyhledávání je zaměřeno na pornografii; každý čtvrtý respondent výzkumu má ve svém mobilním zařízení uložené pornografické materiály; jedna třetina obsahu internetu celkově je pornografická (Smutny & Sulc, 2018). Přibližně 70 % spotřebitelů používá ke sledování pornografie notebook a nejméně jedna třetina

jej sleduje na chytrém telefonu. 90 % obou pohlaví vždy sleduje něco nového, zatímco méně než 25 % mužů a 10 % žen sleduje pornografické materiály vícekrát. Většina ne-konzumentů pornografie měla za celý život jednoho nebo dva sexuální partnery; téměř 1/5 z konzumentů měla více než deset. To dále ukazuje na celkové propojení sexuality soukromé a sdílené s partnerem / partnery.

Muži, kteří jsou více zaměřeni na vizuální prvky, častěji sledují pornografii téměř všech typů a témat (včetně, ale ne pouze, materiály zaměřené na fetiš, skupinový sex, sexuální interakce dvou žen). U dvou typů pornografických témat v jednom z výzkumů však ženy převyšují muže: (a) v BDSM pornografii, kde dominuje muž a (b) v pornografii, kde je přítomné zobrazení předehry (softcore pornografie). Nebyly nalezeny žádné rozdíly v pohlaví pro zobrazení „běžných“ (někdy nazývaných „obvyklých“ nebo „konvenčních“) sexuálních aktivit (Krejčová et al., 2018).

Jak jsme poznamenávali výše, je účelem sledování pornografie nejčastěji spojované s masturbací. Reprezentativní vzorek české populace ukazuje, že u obou pohlaví je nástup masturbace obvykle ve věku 13 let a frekvence se zvyšuje do 15 let, kdy již tuto aktivitu provozuje pravidelně většina populace (Weiss & Zvěřina, 2001). Předpokládá se, že frekvence masturbace má negativní dopad na spokojenost se sexuálním životem (Brody & Costa, 2009), ale odborníci nejsou v tomto jednotní; v kontextu konzumace pornografie a masturbace probíhá dále diskuze o jejím dopadu na sexuální chování jak v pozitivním, tak negativním ohledu (Dines, 2010; Gyamfi & Zalata, 2018; Boschetti et al., 2021; Průšová et al., 2021).

V kontinuální studii sexuálního chování v České republice (Weiss & Zvěřina, 1993; 1998; 2003; 2008) bylo zjištěno, že muži masturbují častěji než ženy (muži 7,1/měsíc, ženy 5,8/měsíc). V roce 1993 potvrdilo pravidelnou masturbaci 84 % mužů, 83 % v roce 1998, 89 % v roce 2003 a 90 % v roce 2008. 50 % žen potvrdilo masturbaci v roce 1993, 58 % v roce 1998, 61 % v roce 2003 a 65 % v roce 2008. Trvalý nárůst frekvence je u obou pohlaví podobný. 76 % mužů považuje masturbaci za přirozený jev; stejně tak 62 % žen. 20 % mužů považuje masturbaci za špatný, i když neškodný, zvyk, stejně jako 29 % žen. 4 % mužů a 9 % žen považuje masturbaci za škodlivou.

Výše uvedené charakteristiky nám dokládají existenci rozličných tříd konzumentů pornografických materiálů. Vaillancourt-Morel (2017) například identifikoval tři: (a) rekreační uživatele (přibližně 75 %), (b) kompulzivní uživatele (13 %) a (c) ne-kompulzivní uživatele, ne-rekreační uživatele (12 %). Uživatelé rekreační (a) uvedli, že jejich hlavní motivací je vlastní inspirování a že jejich sexuální život nebyl negativně ovlivněn konzumací porna. Ženy byly převládajícími členy této skupiny a strávily přibližně půl hodiny týdně sledováním pornografie. Okolo 13% kompulzivních uživatelů však chápe svou konzumaci jako problematickou.

V další studii bylo zjištěno, že 10,2 % ze vzorku vysokoškolských studentů a 7,8 % kontrolního vzorku je kompulzivními uživateli. Šlo obvykle o heterosexuální muže (především mladší jedince) s klinickými příznaky kompulzivní poruchy sexuálního chování (Castro-Calvo et al., 2020).

Cíle a metody studie

Tento článek se zabývá různým (ale ne nerozlišujícím) stupněm spotřeby pornografie námi přijaté dichotomie (BDSM pornografie versus pornografie bez prvků BDSM)

a tím, jak tato konzumace souvisí s dalšími parametry ve dvou oblastech: a) demografické kategorie (velikosti místa bydliště) ve kterých respondenti žijí) a b) osobní charakteristiky (rodinný stav, úroveň vzdělání a rovněž frekvence masturbace).

Naše metoda analýzy, využívající metody umělé inteligence a klastrovací algoritmus bez učitele (unsupervised clustering algorithm) – vzorem není rozhodování člověka, ale vlastní kategorizace na základě dostupných informací. Výsledky následně budeme porovnávat s výše publikovanými výsledky dosud publikovaných relevantních studií.

Materiály

Výzkum týkající se sexuálních aktivit probíhal online a celkem se ho zúčastnilo 902 respondentů z České republiky. Z toho dotazník vyplnilo celkem 881 osob (Tab. 1).

Charakteristika	Kód	Popis kódu
Biologické pohlaví	A	Žena
	B	Muž
Úroveň vzdělání	A	Základní
	B	Středoškolské bez maturity
	C	Středoškolské s maturitou
	D	Vysokoškolské
Rodinný stav	A	Svobodný/á
	B	V partnerském vztahu
	C	Ženatý/vdaná
	D	Rozvedený/á
	E	Vdovec/vdova
Frekvence konzumace pornografických videí bez BDSM	A	Nikdy
	B	Velmi zřídka
	C	Zhruba jednou za 2-3 měsíce
	D	Zhruba jednou za měsíc
Frekvence konzumace pornografických videí s BDSM	E	Zhruba jednou za 14 dní
	F	Zhruba jednou za týden
	G	Několikrát za týden
Frekvence masturbace	H	Skoro každý den
	I	Nejméně jednou denně

Tabulka 1 Záznam kategorických proměnných, které charakterizují jednotlivé respondenty v našem data-setu. Kategorické proměnné označující frekvenci masturbace a frekvenci konzumace obou typů sexuálních materiálů jsou na stejné škále.

Otázky se týkaly a) biologického pohlaví (binární proměnná), b) úroveň vzdělání (kategorická proměnná o čtyřech prvcích – tj. A-D), c) rodinný stav (kategorická proměnná o pěti prvcích – tj. A-D), d) frekvence konzumace běžné pornografie, e) frekvence konzumace pornografie s prvky BDSM, f) frekvence masturbace (vždy sedmistupňové kategorické škály – tj. A-G).

Metody

Všechny odpovědi byly kódovány jako kategorické náhodné proměnné, některé jako ordinální. Žádné z proměnných nemohou být považovány za proměnné škálové – tedy takové, které mají mezi odpověďmi shodné rozestupy (Blalock, 1960). Místo toho bylo použito kódování tzv. Kód 1 z n (anglicky one-hot-encoding – příklad níže) abychom získali vektor funkce (anglicky feature vector) ze všech odpovědí každého respondenta.

Vytvoření 38-rozměrného vektoru funkcí je popsán níže. Datový soubor k analýze tedy sestává z 38 (počet prvků k analýze) X 881 (respondentů) velké matice.

Příklad kódu 1 z n: pro otázku na “rodinný stav” existuje pět různých odpovědí (pro zamezení záměny s počítatelnými (škálovými) proměnnými převedeno na písmena A – E; Viz Tab. 2).

Segment	Počet jedinců	Věkové rozpětí	Průměr (věk)	Medián (věk)	Modus (věk)
#1	184	18–50	33.8	33.0	29
#2	45	18–47	28.4	27.0	19
#3	134	18–49	32.9	32.5	28
#4	187	18–50	32.9	33.0	32
#5	73	18–49	30.7	29.0	26
#6	52	18–50	32.6	33.5	24
#7	206	18–50	30.3	29.0	29

Tabulka 2 Rozložení věku v každém segmentu a počet členů v každém ze sedmi segmentů. Poznámka: Věk jedinců v každém segmentu je téměř shodný. Maximální fluktuace průměru a mediánu je 10 %, proto je považujeme za podstatné pro určení členství v jednotlivých segmentech. Módy byly určeny na základě KDE rozložení věku participantů. V žádném ze segmentů není věk normálně rozložený – ve skutečnosti žádný ze segmentů ani nemá analyticky definovatelné parametrické rozložení věku.

Vektor funkce pro tuto odpověď je tedy 5-rozměrný. Odpověď “A” je nakódována jako , odpověď “B” jako , odpověď “C” jako , atd. Zjistili jsme, že tyto vektorové funkce jsou (a) ortogonální – jejich skalární součin je 0, tudíž odpověď každého respondenta je nezávislá na odpovědi jiného respondenta a (b) norma každé vektorové funkce je 1 – všechny vektorové funkce jsou normalizovány, tedy tímto překódováním do kódu 1 z n není žádná škála uměle vytvořena. Každý respondent odpověděl na všech 6 otázkách.

Jako příklad si můžeme uvést respondenta, který odpověděl na první tři otázky: první odpověď B (pohlaví je binární proměnná, tedy B je druhá ze dvou možností), druhá odpověď je D (čtvrtá ze čtyř možností na otázku vzdělání – tedy nejvyšší) a třetí odpověď je C, která je třetí z pěti možností a označuje možnost vdaná/ženatý. Následný zápis do 1 z n kódu je následující: (0 1) (0 0 1) (0 0 1 0 0). Vektor funkce je tedy následně 11-rozměrný. Všimněte si prosím, že vektor již není normalizovaný (norma je – protože pro příklad byly užity 3 otázky) a můžeme nalézt vnitřní souvislosti mezi jednotlivými komponenty matice. Když se podíváte na tabulku č. 1, která obsahuje dotazník, zjistíte, že celkový počet otázek je 6. Proto má normu a celkem 38 rozměrů (Tab. 3).

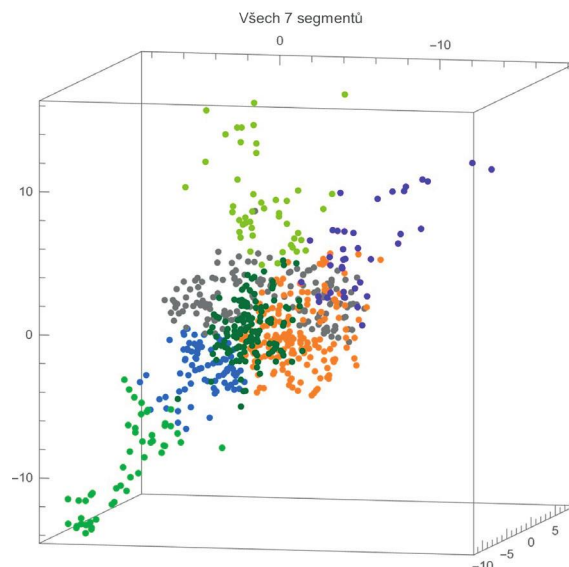
Kategorie populace	Počet obyvatel (v tisících)
A	<1
B	1–5
C	5–20
D	20–100
E	100–1000
F	>1000

Tabulka 3 Vlastnosti vztahující se k velikosti místa bydliště (vesnice, maloměsta, velkoměsta) ve kterém participant žil. Poznámka: V kategorii „A“ jsou vesnice a města s méně než jedním tisícem obyvatel a v kategorii „F“ je město s více jak jedním milionem obyvatel (Praha). Detaily vztahu velikosti města a sexuálního chování jsou diskutovány v textu.

Dá se předpokládat, že obsahuje (a je jich zřejmě velmi mnoho) vnitřní souvislosti. Není třeba, aby 38-rozměrný vektor funkcí byl ortogonální s jiným 38-rozměrným vektorem funkcí.

Abychom mohli využít vzájemných vnitřních souvislostí v datech, použili jsme neuronovou síť o sedmi vrstvách - autoencodér (Mohri et al., 2018; Strang, 2019). Do analýzy vstupuje 38-rozměrný vektor funkcí a vystupuje také 38-rozměrný vektor funkcí. Avšak střední vrstva má pouze 3 uzly (anglicky nodes). Neuronová síť se tak snaží na každé straně symetricky tak, aby se vstup rovnal výstupu (na základě kritéria konvergence). Střední vrstva neuronové sítě o třech uzlech tak vytvoří třírozměrný vektor, který odstraní nadbytečné vzájemné vazby mezi 38 komponenty původního vektoru funkcí. Tyto třírozměrné vektory (nazývané vektory funkcí se snížením rozměrů; anglicky dimension-reduced feature vectors) jsou ve trojrozměrném prostoru (Obr. 1).

Body ve trojrozměrném prostoru, který vznikl na základě redukování rozměrů, nejsou rovnoměrně rozmístěné (Obr. 1). Následujícím krokem je nalézt shluky (klastry - segmenty) těchto bodů. Z mnoha dostupných klastrovacích algoritmů (v případě našich dat jsme vyzkoušeli 7 různých typů) jsme zvolili variantu k průměrů (anglicky K-means), kterou jsme dosáhli nejlepšího, opakovatelného, výsledku. Touto metodou bylo vytvořeno sedm klastrů (barevně odlišené v Obr. 1).



Obrázek 1 Distribuce vektorů funkcí po snížení množství rozměrů dat 881 respondentů, kteří se účastnili studie. Někteří z respondentů měli naprosto shodné rozklady funkcí, proto je v grafu pouze 667 bodů. Z vizuální analýzy distribuce dat je možné vyvodit, že nejsou uniformně rozložené a proto je vhodné tato data rozdělit do jednotlivých segmentů klastrovacím algoritmem. Příslušnost k jednotlivým segmentům je označena pomocí barevné škály, celkový počet barev (a klastrů) je 7 a toto rozdělení bylo dosaženo pomocí k-průměrů algoritmem po analýze neuronovými sítěmi. Osy a vzájemná vzdálenost bodů mezi sebou nemá žádnou výpovědní hodnotu a nelze interpretovat. Segmenty (vzniklé klastrovacím algoritmem) naopak výpovědní hodnotu mají. Skrze analýzu teplotních map (Obr. 2) lze tyto segmenty charakterizovat. V textu jsou popsány jejich konkrétní interpretace.

V tomto článku nazýváme tyto klastry segmenty.

Máme možnost reverzně ověřit, v jakém segmentu se ty které body nachází a jakým způsobem jsou rozděleny v původním 38-rozměrném vektoru funkcí a následně tak

určit, k jakým konkrétním odpovědím se vztahují. Tuto metodu jsme využili k tomu, abychom mohli prezentovat (formou nestatistického sumativního vyjádření – občas hanlivě označovaného jako „počítání fazol“ [been-counting]) rozložení konkrétních odpovědí v jednotlivých segmentech (Obr. 2).

Obrázek 2 Teplotní mapy relativního rozložení odpovědí členů každého ze sedmi segmentů. Segmentace vznikla za užití klastrovacího algoritmu k-průměrů na základě rozložení rozměrově redukovaných dat od 881 respondentů (Obr. 1). Další popis je v textu.

Zajímalo nás, jak se různé atributy členů segmentů (jejich pohlaví, úroveň vzdělání atd.) spojují s populační kategorií, kde žijí (v době, kdy se dotazníku zúčastnili).

Prvním krokem bylo zkontrolovat jednotnost kontingenční tabulky (kategorie populace versus číslo segmentu) pomocí testu . Jak podrobněji rozvedeme níže, výsledek testu zdaleka není informativní. Proto používáme mnohem informativnější vyšetřovací nástroj: Korespondenční analýza (anglicky correspondence analysis; CA; Greenacre, 2007; Beh & Lombardo, 2014). Tento nástroj je založen na singulárním hodnotovém rozkladu (anglicky singular value decomposition; SVD; Leon, 1998; Strang, 2019) škálované kontingenční tabulky.

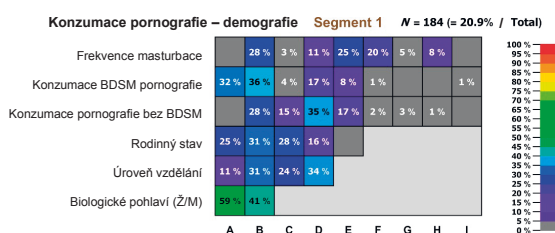
Výsledky

Pomocí algoritmu k-průměrů jsme zjistili rozložení do sedmi segmentů, v nichž se vyskytuje rozdílný počet členů – nejsou tedy velikostně srovnatelné. Tabulka 2 shrnuje počty jedinců v každém z jednotlivých segmentů. Obrázek 1 pak zobrazuje prostorové rozdělení klastrů. Pro každý klast (segment) následně vygenerujeme teplotní mapy (anglicky heat-maps), které nám dovolují vizuálně vyhodnotit rozložení jednotlivých odpovědí v daných segmentech, jak je možné vidět v Obrázku 2.

Na základě společně se vyskytujících znaků následně charakterizujeme jednotlivé znaky společně pro celý segment:

Segment č. 1 („Běžná populace“) (obr. 2a): Ačkoli se jedná „jen“ o zhruba 1/5 z celého vzorku, tito jedinci jsou nejlépe charakterizováni jako členové s neobvyklými sexuálními postoji v liberální společnosti. Ženy a muži jsou téměř rovnoměrně rozděleni; zhruba 1/3 má středoškolské vzdělání. Zhruba 1/3 je vdaná a málokdo je rozvedený. Konzumace pornografických videí bez prvků BDSM je z velké části mezi „téměř nikdy“ a „maximálně jednou za čtrnáct dní“. Konzumace BDSM pornografických videí je mezi „nikdy“ (~ 1/3) a „téměř nikdy“ (~ 1/3). Četnosti masturbace se vyskytují „zřídka“ (~ 1/4) a jednou nebo dvakrát za měsíc (~ 1/2).

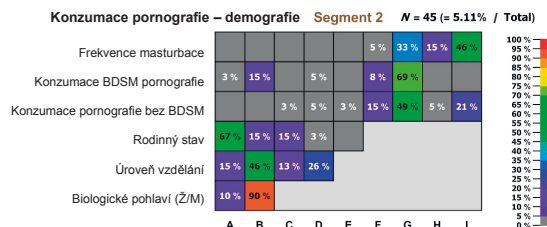
Obrázek 2a



Segment #2 („Sexuálně toužící muži s nízkým vzděláním“) (obr. 2b): Jedinci z tohoto segmentu tvoří ~ 1/20 vzorku, tito jedinci jsou nejlépe charakterizováni

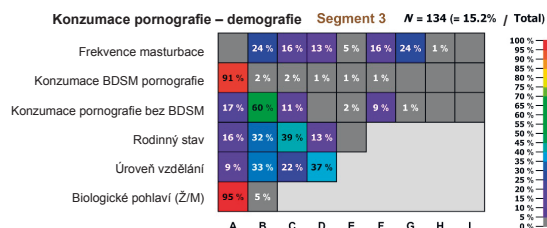
jako převážně muži s velmi vysokou sexuální spotřebou (především neinteraktivní: ~ 2/3 nejsou v partnerském vztahu). Zhruba 1/2 má středoškolské vzdělání bez maturity a zhruba 1/4 má vysokoškolské vzdělání. Spotřeba pornografických videí bez BDSM i BDSM je více než jednou týdně (the former more than daily for ~1/5 of the members). Frekvence masturbace je velmi vysoká, de facto denně až několikrát denně.

Obrázek 2b



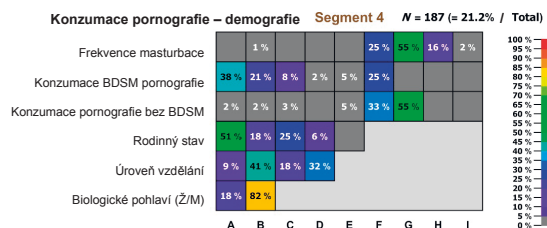
Segment č. 3 („Ženy s velmi nízkou sexuální aktivitou“) (obr. 2c): Jedinci z tohoto segmentu tvoří ~ 1/7 vzorku; tyto de facto všechny ženské participantky jsou nejlépe charakterizovány jako ženy s velmi malou sexuální konzumací, které zřídka sledují pornografická videa bez BDSM a nikdy se nedívají na BDSM videa. Jsou převážně v partnerském vztahu (~ 2/3); ojediněle ovdovělé (~ 1/8). Zhruba 1/3 má středoškolské vzdělání bez maturity a více než 1/3 má vysokoškolské vzdělání. Frekvence masturbace jsou rozděleny: ~ 1/2 zřídka masturbuje, zatímco ~ 1/3 masturbuje několikrát týdně.

Obrázek 2c



Segment č. 4 („Muži s velmi, velmi vysokou sexuální aktivitou“) (obr. 2d): Jedinci z tohoto segmentu tvoří ~ 1/5 vzorku; tito de facto všichni mužští jedinci jsou nejlépe charakterizováni jako muži s velmi vysokou spotřebou videí bez BDSM, kteří nikdy nebo téměř nikdy nesledují video s BDSM. Jsou převážně bez partnerů (~ 1/2); někteří jsou ženatí (~ 1/4). Zhruba 1/2 má středoškolské vzdělání bez maturity a 1/3 má vysokoškolské vzdělání. Frekvence masturbace je velmi vysoká: více než 2/3 masturbuje jednou týdně nebo více než jednou týdně.

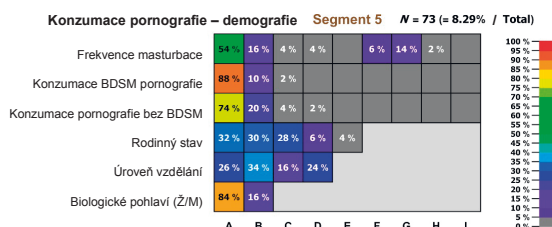
Obrázek 2d



Segment č. 5 („Ženy s téměř žádnou sexuální aktivitou“) (obr. 2e): Jedinci z tohoto segmentu tvoří ~ 1/8 vzorku; tyto de facto všechny ženské participantky jsou nejlépe charakterizovány jako ženy bez konzumace videí s BDSM i bez BDSM a nikdy nemasturbující (malá

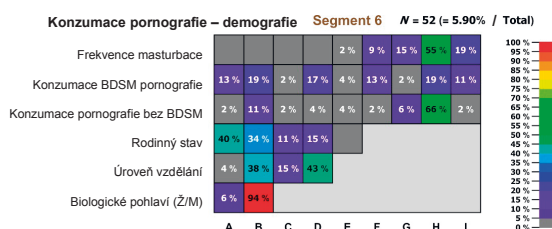
výjimka ~ 1/5). Jsou převážně bez partnerů (~ 1/3) nebo ve vztahu (~ 1/3) nebo jsou vdané (~ 1/4). Zhruba 1/3 má středoškolské vzdělání bez maturity a 1/4 vysokoškolské vzdělání.

Obrázek 2e



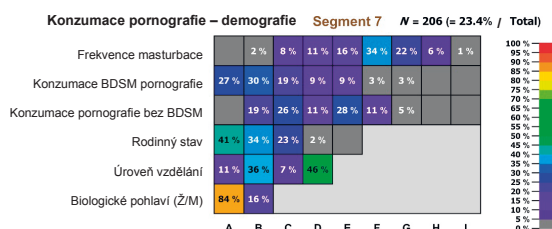
Segment č. 6 („Muži bez partnerského vztahu s extrémně vysokou sexuální aktivitou“) (obr. 2f): Těchto několik málo jedinců z tohoto segmentu tvoří ~ 1/17 vzorku; Tito de facto všichni mužští jednotlivci jsou nejlépe charakterizováni jako muži s velmi vysokou konzumací videí bez BDSM (2/3 denně) a velmi vysokou frekvencí masturbace (více než 1/2 denně a ~ 1/5 více než jednou denně). Jejich konzumace BDSM videí je překvapivě rozličná; téměř rovnoměrně rozložena po celé škále. Jsou převážně bez partnerů (~ 1/2) nebo ve vztahu (~ 1/3), ale jen zřídka jsou v manželském svazku. Mnoho z nich (téměř 1/2) má vysokoškolské vzdělání.

Obrázek 2f



Segment č. 7 („Ženy výjimečně s partnerským vztahem s vysokými frekvencemi masturbace“) (obr. 2g): Jedinci z tohoto segmentu tvoří ~ 1/4 vzorku; tyto de facto všechny ženské participantky lze charakterizovat jako ženy s vysokým podílem vysokoškolského vzdělání (téměř 1/2), převážně bez vztahu (1/2) nebo ve vztahu, ovšem ne vdané (1/3) a s vysokou frekvencí masturbace (1/2 od čtrnáctidenní až po denní; ostatní ještě více).

Obrázek 2g



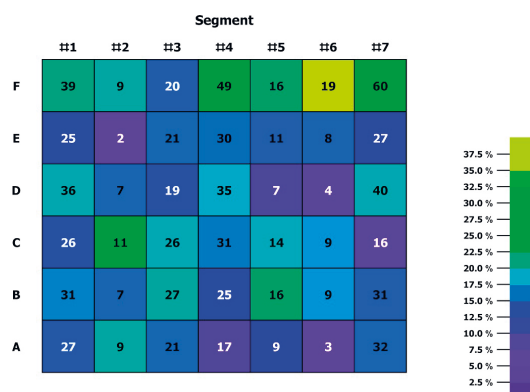
Zaznamenali jsme, že (biologické) pohlaví je ve většině segmentů nevyrovnané. Rovněž jsme také zaznamenali, že extrémní odpovědi (jmenovitě kategorie nad „G“) na spotřebu pornografických videí bez BDSM a s BDSM, stejně jako frekvence masturbace, jsou zastoupeny velmi řídko, pokud vůbec.

Celkově můžeme v každém segmentu pozorovat určité snadno identifikovatelné charakteristiky jednotlivců. Tyto charakteristiky jsou často posměšně charakterizovány jako „stereotypní“. Je pozoruhodné, že bez ohledu na to, že jsou takto označeny, skutečně jde o identifikovatelné

charakteristiky. Například ženy v Segmentech č. 2, 3 a 5 žijí ve vesnicích a menších městech (viz níže). Jejich postoje k sexualitě jsou poměrně omezené („konzervativní“). Mějte prosím na paměti, že ne všechny segmenty populace jsou si velikostně rovnocenné – právě naopak.

Zjistili jsme, že členové v různých segmentech se vyznačují odlišnými sexuálními postoji, ať už jde o frekvenci jejich konzumace porno videí bez prvků BDSM nebo s BDSM, a/nebo frekvenci (self-reportované) masturbace. Obr. 3 ukazuje, že jejich rozdělení pozorovaných frekvencí se jeví jako nejednotné (tj. nezávislé na počtu segmentů), protože počet členů v různých segmentech se navzájem liší.

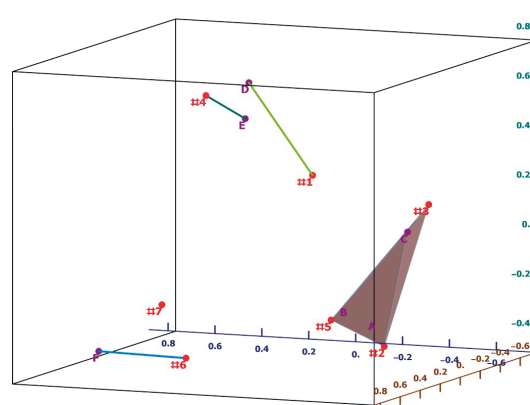
Obrázek 3



Obrázek 3 Rozložení demografických proměnných a členství v jednotlivých segmentech. Teplotní mapa ukazuje vztah mezi jednotlivými segmenty (sloupce) a demografickými proměnnými (řádky). Číslo v každé dlaždici vyjadřuje počet osob, který se v daném průniku vyskytuje. Počty zobrazené v dlaždicích jsou vyjádřením podílu segmentu, jehož členové žijí v lokalitě s danou velikostí místa bydliště. Poznámka: S ohledem na nestejnou velikost segmentů žádáme čtenáře o opatrnost v interpretaci procentuálního zastoupení.

Obr. 4 ukazuje kontingenční tabulku pro vztah mezi kategorií populace a číslem segmentu. Testem jednotnosti této kontingenční tabulky je -test (Baguley, 2012). Tento test však pouze specifikuje pravděpodobnost pozorování nehomogenního rozdělení; neodmítá nulovou hypotézu homogenity rozdělení. Ve skutečnosti je to tak, že -test nedokáže vyhodnotit, zda je zamítnutí nulové hypotézy účinně oprávněné, tento fenomén je známý jako klam ze strany žaloby (anglicky Prosecutor's Fallacy; Spiegelhalter, 2019). „Bohužel, hodnota P je často mylně interpretována jako pravděpodobnost, že nulová hypotéza (H0) je pravdivá.“

Obrázek 4



Obrázek 4 Výsledky korespondenční analýzy zjišťující vzájemné asociace mezi segmenty a velikostí místa bydliště (také viz Tab. 3) Červeně označené jsou segmenty a fialově označené jsou kategorie velikosti místa bydliště. Střepinový graf (Tab. 4 vlevo) ukazuje tři rozměry, které je třeba k vyhodnocení vzájemných asociací. Asociace byly nalezeny za pomoci algoritmu DBSCAN (Ester et al., 1996). Více informací je obsaženo v textu článku.

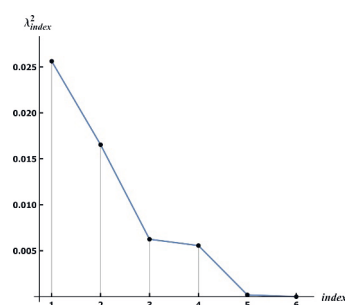
“Tato chyba se nazývá „klam ze strany žaloby“... Malá hodnota P (například $P = 0,05$) nám tedy pouze říká, že v kontextu tohoto předpokladu došlo k nepravděpodobné události.“ (Krzywinski & Altman, 2017).

Kromě toho, že jsou stěží informativní, existují ještě dva další nedostatky testu: (a) výsledek testu (význam) neinformuje výzkumníka o tom, zda a jaký má nehomogenita (je-li přítomna) za následek pozorované rozdělení a (b) jaká část distribuce (rovnoměrná nebo jiná) je způsobena šumem (statistický šum, anglicky statistical noise – šum je způsoben náhodností a nevysvětlitelnými změnami v datech, jeho opakem je signál, který se snažíme v datech odhalit). Poměr šumu a signálu v datech je možné testovat. Také je možné použít metody, které nejsou šumem penalizovány, jako korespondenční analýza (CA; Greenacre, 2007; Beh & Lombardo, 2014).

Abychom demonstrovali rozdíl ve výsledku běžně užívaných metod, data jsme zanalyzovali pomocí - testu i pomocí CA, abychom zjistili, zda se členství v jednotlivých segmentech dá asociovat (nikoli korelovat) s dalšími demografickými proměnnými.

Pro -test: bylo dosaženo signifikance 0,596. Znovu upozorňujeme, že tato hodnota jednoduše uvádí, jak pravděpodobné nebo nepravděpodobné je zaznamenání tohoto rozdělení demografických kategorií, aniž by bylo možné učinit závěr o platnosti nulové hypotézy. Hodnota 0,596 tedy naznačuje, že tento výsledek není neobvyklý, pokud předpokládáme nulovou hypotézu rovnoměrného rozdělení – nic víc (Altman & Krzywinski, 2017).

Dále jsme užili singulární hodnotový rozklad na (škálované) kontingenční tabulky a získáme jejich singulární rozklad a to nakolik přispívají k druhé mocnině Frobeinovy normy (Tab. 4).



Index No.	Singular Value λ_{index}	(Singular Value) ² λ^2_{index}	Fraction (%)	Cummulative Fraction (%)
1	0.160	0.0256	47.3	47.3
2	0.129	0.0165	30.5	77.8
3	0.0790	0.00625	11.5	89.4
4	0.0746	0.00556	10.3	99.6
5	0.0139	0.000192	0.4	100.
6	0	0	0.	100.

Tabulka 4 Výstup z analýzy SVD (Leon, 1998) ze (škálované) kontingenční tabulky (Obr. 3) Nalevo: Sutinový graf (anglicky Scree Plot) druhých mocnin hodnotových rozkladů. Vpravo: Výčet hodnotových rozkladů; jejich druhých mocnin; hodnoty

jednotlivých částí Frobeinovy normy těchto druhých mocnin; součet podílů částí Frobeinovy normy druhých mocnin. První tři hodnotové rozklady mají nejvyšší hodnotu, téměř 90 %. Musíme vzít v potaz, že 10 % druhých mocnin Frobeinovy normy tvoří šum. Je tedy nutné vytvořit 3D graf, který nám pomůže interpretovat vztah hodnot ze (škálované) kontingenční tabulky (Obr. 4).

Uvedené druhé mocniny singulárních hodnotových rozkladů (normalizované) kontingenční tabulky nám podávají informaci o tom, že existují asociace mezi jednotlivými segmenty (sloupce) a demografickými proměnnými (řádky), jak je patrné v Obr. 4. Můžeme vyvodit, že 3 singulární hodnotové rozklady nám vysvětlují 90 % signálu obsaženého v datech. Naproti tomu -test nás pouze informuje o tom, zda jsou hodnoty rovnoměrně rozloženy (respektive dostatečně rovnoměrně rozloženy). Analýza pomocí kontingenčních tabulek nás tedy jednoznačně informuje o existenci asociace mezi segmenty a jednotlivými proměnnými.

Obr. 4 demonstruje tyto souvislosti. Tyto souvislosti byly určeny za pomoci klastrovacího algoritmu DBSCAN (Ester et al., 1996) v kombinaci se (3-rozměrnými) souřadnicemi získanými ze singulárního hodnotového rozkladu. Vztahy, které jsme odhalili, jsou následující. Segment č. 1 („Běžná populace“) se nejvíce pojí s velikostí města D (20 – 100 tis. obyvatel). Segment č. 4 („Muži s velmi, velmi vysokou sexuální aktivitou“) je nejvíce asociován s velikostí města E (tedy nad 100 tis. obyvatel) a segment č. 6 („Muži bez partnerského vztahu s extrémně vysokou sexuální aktivitou“) je asociován s velikostí města F (Praha). Segment č. 7 je („Ženy výjimečně s partnerským vztahem s vysokými frekvencemi masturbace“) se neasociuje s žádnou velikostí místa bydliště a je tedy relativně rovnoměrně rozložen mezi všechny tyto velikosti. Segmenty č. 2, 3 a 5 jsou asociovány současně s velikostí bydliště v kategorii A, B a C, tedy obecně vesnicemi a městy do velikosti 20 tis. obyvatel.

Upozorňujeme, že tyto tři segmenty (č. 2, č. 3 a č. 5) mají 252 členů (29% vzorku), ale že sexuální postoje v těchto segmentech se značně liší. Z tohoto důvodu nemusí být členové v různých segmentech považováni za jednotné ve svých sexuálních postojích, přestože žijí ve vesnicích a malých městech. Je pozoruhodné, že segment č. 2 obsahuje převážně mužské členy, kteří jsou sexuálně velmi, velmi aktivní, a to jak s ohledem na konzumaci pornografických videí, tak na frekvenci masturbace. Segmenty č. 3 a č. 5 obsahují převážně ženy, které žijí ve vesnicích a velmi malých městech. Na rozdíl od mužů, kteří žijí v těchto vesnicích a malých městech, mají pozoruhodně omezené („konzervativní“) sexuální postoje. Stereotypně formulováno, zdá se, že ženy dodržují životní styl, který, jak se zdá, prosazuje vyhýbání se sexuálním touhám, sexuální zvědavosti a aktivitním sexuálním aktivitám. Zdá se, že muži jsou sexuálně frustrovaní a v opačném chování (oproti ženám) hledají uvolnění.

Diskuze

V naší studii jsme použili novou metodu založenou na umělé inteligenci, která odhalila různé shluky charakterizující jednotlivce na základě jejich sociodemografických charakteristik a dvou druhů konzumace pornografie. Naše výsledky jsou porovnávány se zjištěními v jiných, převážně českých studiích. Je třeba zdůraznit, že česká společnost je považována za velmi otevřenou a tolerantní (v politicky liberální terminologii) v sexuálních otázkách (Widmer et al., 1998). Zjistili jsme, že v české společnosti existují značné skupiny jednotlivců, které takto charakterizovat

nelze.

Této studii se zúčastnili účastníci ve věku 18-50 let, kteří měli být reprezentativním vzorkem české populace, jak můžeme vidět v Tabulce 1. Žádný ze vzorků nemá účastníky mladší 45 let. Obr. 4 také ukazuje, že rozdělení účastníků napříč populačními kategoriemi je dosti rovnoměrné (což ukazuje i test). Jakákoli nerovnoměrnost věku (a co se týče vzdělání atd.) je proto způsobena zvláštními sexuálními atributy v každém segmentu.

Další problém: úroveň vzdělání „C“ (ukončení střední školy) je v každém segmentu zastoupena nízkým procentem. Toto nízké procento je nevyhnutelné, protože ve „vyspělých společnostech“ (tj. ve společnostech s dobře strukturovaným systémem terciárního vzdělávání a odpovídajícím ekonomickým základem) studenti středních škol obvykle přecházejí na vysoké školy, univerzity atd. Pouze kvůli náhodnému načasování účasti na dotazníku, kdy mohli být účastníci ve fázi přechodu ze střední školy na instituce terciárního vzdělávání, dává odpověď kategorie C (ukončení střední školy) smysl. Bližší pohled na segmenty odhalí (Obr. 2), že tento fenomén nezpůsobí žádný rozdíl ve vyhodnocení dat.

Charakterizaci a popis atributů členů v různých segmentech mohou kritici nazývat „stereotypem“. Zde uvedené statistické metody však dokumentují, že takové stereotypní popisy jsou nejen vhodné, ale také dobře podporovány našimi zjištěními. Skutečně zjišťujeme, že určité „typy“ mužů a žen se nejpravděpodobněji vyskytují například ve vesnicích a malých městech a jiné „typy“ ve velkých městech. Nabízí se otázka, zda kategorie obyvatel odvozuje sociologické deskriptory, například „liberální“, „konzervativní“, „neprogresivní“ atd. Upozorňujeme, že (a) takové sociologické kategorie zřejmě existují a projevují se ve změnách sexuálního postoje mezi segmenty; a b) sociologické postoje lze zjistit konzumací pornografických videí a rozdílnými frekvencemi masturbace v různých segmentech. Tyto klasy jsou statisticky nezávislé jednotky (a popírají tvrzení o expresi určitých rysů, které jsou normálně distribuovány v populaci; del Giudice, 2009), tedy zjištění, které by mohlo být nápomocné pro budoucí terapeutické a výzkumné práce.

Zjistili jsme, že naše statistická metodologie je velmi účinná při detekci dvou aspektů konzumace pornografie související se sexualitou a četností masturbace (self-reportované). Protože jsme analyzovali velký vzorek (881 účastníků), který má velmi dobré (téměř reprezentativní) rozložení po celé České republice, očekáváme možné podobnosti v těchto distribučních atributů, souběžně s demografickými kategoriemi, v jiných zemích se srovnatelnou infrastrukturou, dobře strukturované terciární vzdělávací systém a vyspělé (více high-tech než výrobní) ekonomiky.

Za účelem nalezení segmentů jsme využili klastrovacího algoritmu DBSCAN (Ester et al., 1996) v kombinaci se (3-rozměrnými) souřadnicemi získanými ze singulárního hodnotového rozkladu. DBSCAN je algoritmus, který pracuje bez učitele (unsupervised clustering algorithm), takže není předem definováno, kolik segmentů vznikne. Dále pak je významné zmínit, že dovoluje možnost vytváření segmentů obsahujících pouze jeden prvek – jednotlivce v našem případě. Toto je výhodou oproti alternativnímu algoritmu K-medoid, který by byl závislý na předem definovaném množství segmentů a nedovoľoval by možnost vzniku výše zmíněných jednoprvkových segmentů.

Pro čtenáře může být frustrující, že při čtení tohoto textu není schopen identifikovat jednotlivé segmenty za použití teplotních map bez dopomoci umělé inteligence

(Obr. 2). Jde o důsledek toho, že umělá inteligence je schopna třídit na základě mnoha kategorií současně, na rozdíl od nás – lidí – kteří jsme „od přírody“ nastaveni na to, abychom se soustředili na jednu či dvě rozlišující kategorie. Algoritmy umělé inteligence jsou navíc schopny, na rozdíl od člověka a jeho přirozeného třídění, jasně a smysluplně vyfiltrovat nepodstatné a opakující se informace, které nepřinášejí zlepšení signálu oproti šumu.

Abychom se mohli zabývat konkrétními poznatky, které můžeme spojit s předchozími zjištěními, považujeme za důležité začít tím, že segmenty nikdy neskládají jednotlivci jednoho pohlaví. Jiné výzkumy ukazují velký přesah mezi sexuálními preferencemi, přestože výhody pro příslušníka jednoho biologického pohlaví nemusí být u druhého evidentně přítomny (Binter et al., 2013). Mezi pohlavími může existovat velmi významný rozdíl (Del Giudice, 2009), ale to nevyvozuje nulovou přítomnost druhého pohlaví v segmentu. Obě pohlaví se vyskytují ve většině našich detekovaných segmentů, konkrétně 4 ze 7 mají alespoň 15 % druhého biologického pohlaví.

Segment č. 1 obsahuje 20,9 % všech účastníků, z toho 41 % jsou muži. Účastníci z tohoto segmentu mají kladný vztah k sexu a baví je pornografie, ale spíše jako inspirace (Smutny & Sulc, 2018) než jako primární prostředek uspokojení; lze je považovat za bezproblémové konzumenty (Logue, 2018). Největší segment č. 7, s 23,4 % všech účastníků, se skládá převážně z žen (84 %), které jsou spíše experimentálně založené a otevřené a sdílejí charakteristiky bezproblémové pornografické konzumace se segmentem č. 1. Jedinci v tomto segmentu však mají vysokou míru konzumace pornografie s prvky BDSM.

U dvou segmentů (č. 2 a č. 6) pozorujeme nutkovou potřebu konzumace pornografických materiálů, jak bylo také pozorováno v jiných studiích (Gaither & Sellborn, 2003; Vaillancourt-Morel, 2017; Logue, 2018). Členové segmentu č. 6 „Muži bez partnerského vztahu s extrémně vysokou sexuální aktivitou“ jsou obvykle muži bez partnerského vztahu, kteří dávají přednost pornografii bez prvků BDSM. Žijí v Praze (jediné město v České republice s více než 1 milionem obyvatel) a mají vysoké vzdělání. Jejich sexuální charakteristiky tudíž nejsou podmíněny nedostatkem partnerů. Pro členy v segmentu č. 2 („Sexuálně toužící muži s nízkým vzděláním“) se naopak spotřeba pornografie a vysoká frekvence masturbace jeví jako kompenzační mechanismus kvůli nedostupnosti konsenzuálního partnera (Binter, 2013; Smutny & Sulc, 2018). Tito, převážně muži, mají nízké vzdělání a žijí v menších městech; takže jejich pozice na partnerském trhu není vysoká (Edlund & Sagarin, 2014). Jejich vysoká spotřeba videa s prvky BDSM naznačuje kompenzační mechanismus a online masturbace (pravděpodobná) během těchto videí slouží jako naplnění jejich sexuální touhy (Smutny & Sulc, 2018). Tyto dva segmenty, ve kterých se frekvence masturbace blíží maximu (denně nebo ještě častěji), dohromady tvoří přibližně 11 % (5,11 pro č. 2 a 5,90 pro č. 7) vzorku – ve shodě se Smutny & Sulc (2018). Mnoho dalších studií zabývajících se problematickou konzumací pornografie rovněž zjistilo úroveň přibližně 10 % (Castro-Calvo et al., 2020). Jedním z předpokládaných mechanismů může být opakované uspokojení způsobené supernormálním stimulem. Takový „superstimulus“ (Průšová et al., 2021) je založen na „vyladění“ percepčního systému jednotlivce tak, aby maximalizoval zisk (Buchholz et al., 2021), když jsou mu prezentovány různé stimuly, z nichž jeden je vnímán jako „lepší než skutečný“ (například nadměrnému vejci ze sádky dává pták přednost před vlastními vejci; Tinbergen, 1953); tedy chování, které je většinou maladaptivní. Zvláště frustrující by pro tyto

muže mělo být sdílení sociálního prostoru se ženami ze segmentů č. 3 a č. 5., které jim nedovoluje dostatečnou (sexuální) interakci.

Segmenty č. 3 („Ženy s velmi nízkou sexuální aktivitou“) a č. 5 („Ženy s téměř žádnou sexuální aktivitou“) mají dva společné rysy; jedním je život v malých městech (což má za následek sníženou šanci na setkání s partnery). Další je extrémně nízká frekvence sledování pornografie. Algoritmus tak ukazuje, že Segment č. 5 se od č. 3 liší a to zejména měrou sexuální touhy, která lze odvodit z frekvence masturbace. Naproti tomu členové v segmentu č. 3 mají různou náchylnost k masturbaci (včetně jejich vysokých frekvencí). Je pozoruhodné, že segment č. 3 zahrnuje nejvyšší podíl rozvedených osob a nejnížší počet nezadaných. Domníváme se, že segment č. 3 obsahuje členy, kteří mají ze sociálních důvodů nízkou sexuální aktivitu. Možná někteří z těchto jednotlivců mohou přecházet mezi partnerskými vztahy. Obecně můžeme očekávat, že tito lidé budou mít nízkou socio-sexualitu (Penke & Asendorpf 2008), pravděpodobně měli v minulosti málo sexuálních partnerů a jsou sexuálně inhibováni.

Závěr

Použití neuronové sítě překonává několik statistických problémů. Jedním z nich je „prokletí dimenzionality / prokletí vícerozměrnosti“ (anglicky curse of dimensionality). Neuronová síť zmenšila rozměry z 38 na 3, aniž by eliminovala jakékoli informace (jmenovitě vzájemné závislosti mezi komponentami původního 38-rozměrného vektoru funkcí). Použití klastrových algoritmů může odhalit společné rysy mezi segmenty populace: jakými charakteristikami sexuality (frekvence masturbace, potřeba pornografických filmů/videí a partnerský vztah – což je také indikátor sexuality!) disponují v době účasti na dotazníku.

V sekci Diskuse jsme vyhodnotili, na základě výstupů analýz, že kategorizace respondentů do jednotlivých segmentů není pouhou možností, ale že jde o rigorózně obhajitelnou metodu, která dovozuje existenci oddělených skupin (segmentů), které mají typické vlastnosti (vztahující se k jejich sexualitě), společně s ostatními členy stejného segmentu a odlišné od vlastností osob v segmentu jiném, za použití umělé inteligence.

Sexuální charakteristiky nejsou rozděleny rovnoměrně ani demograficky. Z lékařských a psychologických hledisek jsou členové v segmentech, které vykazují příliš kompulzivní sexuální chování, jako je masturbace (doprovázená konzumací pornografických videí) výrazně nad normálem. „Normální“ spotřebu lze ve skutečnosti zjistit metodami AI, které zde uvádíme. Je vhodné zamýšlet se nad odbornou pomocí pro tyto jedince, s kompulzivním sexuálním chováním. Sexuologové a terapeutičtí specialisté zabývající se pomocí těmto lidem mohou získat užitečný náhled na to, jak je takové nutkavé chování ve vzájemném vztahu s frekvencemi masturbace a konzumací pornografických videí s prvky BDSM a bez prvků BDSM. Členové opačného extrému, ti s velmi potlačenou sexuální aktivitou a konzumací, mohou také potřebovat terapeutickou intervenci. Důkazy pro tuto potřebu jsou vzácné; společnost, zdá se, nepovažuje tyto lidi za ty, kteří potřebují více naplňující sexuální uspokojení.

Dále zjišťujeme, že pozorovaná stratifikace sexuality má demografický aspekt. Některé typy sexuálních postojů se vyskytují pouze ve vesnicích a malých městech, zatímco ve velkých městech jsou všechny sexuální postoje

přítomné, i když v různých distribucích. Toto je, pokud je nám známo, první studie, která takové souvislosti, založené na datech, poskytuje.

Etické otázky

Projekt byl schválen etickou komisí Přírodovědecké fakulty Univerzity Karlovy (#2018/08). Všichni účastníci byli plnoletí a před účastí v online dotazníku dali souhlas k účasti ve studii. Účastníci byli upozorněni, že mohou svou účast kdykoli ukončit bez uvedení důvodu.

Střet zájmů

Autoři neprohlašují žádný střet zájmů.

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Visual Analysis of Emotions Using AI Image-Processing Software: Possible Male/Female Differences between the Emotion Pairs “Neutral”–“Fear” and “Pleasure”–“Pain”

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Inferring the emotional state of an individual by viewing his/her facial expression seems to be present in all human cultures. Numerous studies have shown that various changes in facial muscles determine the resulting facial expression. The analysis of images of faces expressing emotional states promises to contribute to quantification of the claimed observations. Here, we use a suite of AI (artificial intelligence) algorithms, along with ML (maximum likelihood) estimated distributions to quantify the shift in facial expression from “neutral” → “fear” and “pain” → “pleasure”. The images are single frames of five emotional states (neutral, fear, pain, pleasure, laugh) expressed by actors and actresses in BDSM videos. We extract a feature vector for each image, dimension-reduce these by mapping onto a two-dimensional manifold and calculate the norms of the normalized displacement vectors for each emotional pair. We then find that the ML distributions of the norms are gamma-distributed and that the modes for each pair are different for both males and females. We use Wilks lambda to determine significance. We find that the distributions for the females are significantly different, but not for the males. The methodology we present here has widespread applications: from monitoring the emotional states of humans in various settings; among these: determining whether participants in BDSM and similar videos are indeed volunteering their participation or are victims of criminal activity.

CCS CONCEPTS • **Affective Computing** • **Behavior monitoring systems** • **Computer vision in healthcare** • **Human-Robot Interaction** • **Smart Cities of the Future** • **Technologies for improving the quality of daily living** • **Vocational safety and health monitoring** •

Additional Keywords and Phrases: Image Processing using AI (artificial intelligence), Maximum likelihood methods for Gamma distributions, facial expression of emotions, facial expression of fear, of pain and of pleasure

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1 INTRODUCTION

Interpersonal interaction is often thought to be conveyed by verbal exchanges, albeit not exclusively. Facial expressions are considered a further natural method to “advertise” one’s emotional affective states during the majority of social interactions. This latter claim is supported, it is argued, by their universal perception (Ekman, 1993; Valente, Theurel & Gentaz, 2018).

The ability to express emotional affective states and the further ability to ascertain the displayed emotional affective state has been shown to be universal. A considerable body of intercultural studies have provided evidence that the particular emotional expressions joy, fear, sadness, and anger are to large degree universally understood; the same seems to hold for the expression of pain (which is not a basic emotion) (Ekman, 1993; Gendron & Barrett, 2009).

Some emotional expressions are so closely linked to emotional states that there exists a consensus among psychologists that a small number of pure emotions can be considered basic states, much like base vectors in a coordinate decomposition of a point in some high-dimensional space. These base states are characterized by specific — and identifiable — facial muscle contractions (Gendron & Barrett, 2009). They are identifiable not only by researchers active in psychological field work, but also by anyone observing these facial expressions in someone else’s face.

This has led to codification of facial muscle movements called FACS (Facial Action Coding System) which is based on so-called Action Units. Each Action Unit is a collection of facial muscle contractions (and releases) that create, through an as yet-to-be-determined synchronization, a particular facial expression (Gendron & Barrett, 2009). The method is used descriptively (in order to analyze the emotional status of an individual) but also prescriptively as a template for the animation of facial expressions (van der Struijk et al., 2018). Animations are routinely used in the computer graphics industry, where the distinction between the facial expressions of pain and of sexual climax is particularly interesting; furthermore, a difference of mental representations of these two emotional expressions could be derived (Chen et al., 2018).

One can, of course, down-regulate the expressiveness and thereby affect the amount of information shared between the experiencing person and the his/her observer (the proverbial *poker face* comes to mind) but there may be limits that apply to extreme experiences. In the context of sexuality, this grimace issue has already been described in the “Kinsey Reports” (1953). Recently, other examples from other social situations have also been observed (Wenzler et al., 2016).

Pain, pleasure and fear are three emotional states suspected to be ambiguous to observers/raters whenever they are not presented within the encompassing context of the communication. Interestingly, the accuracy of

judgement of these emotions can be even lower when actors/actresses are instructed to act the emotion rather than when it is expressed in genuine, real-life settings (Abramson et al., 2017). Thus, BDSM (Bondage-Dominance-Sadistic-Masochistic) sexual acts, performed by professional actors in commercial for-sale videos are a data set we can use to investigate the expressions of these emotions and pain.

Use of BDSM videos of private persons would infringe on their right to privacy and we could not reliably infer which emotion is being expressed (we would have to rely on their statements). In the case of BDSM videos with professionals, on the other hand, we are certain that the displayed emotion is intentionally expressed, perhaps not genuinely. If the intensity is insufficiently displayed, the video, along with the actor/actress, would disappear from the market. We cannot expect the emotions expressed by the actor/actress to be translated into a genuine grimace, but this uncertainty is the leverage point we use for our analysis.

Here, we pursue an image analysis regimen, including AI, to focus on high-intensity states during which the facial muscles are contracted to a grimace, putatively communicating an otherwise difficult-to-identify intensive experience. We quantify the differences in grimaces by using the Euclidean distance between normalized dimension-reduced feature vectors, extracted from the images of the grimaces, to derive the statistics of differences and their significance.

2 MATERIALS

One of the authors (T.H.) scanned ten BDSM videos with professional participants, five of females and five of males. Based on the development of the plot in the video, five frames (one frame of neutrality, one of fear, one of pleasure, one of pain, one with laughter) were chosen from each video. The data base thus consists of 50 images of these five emotions expressed by five actors and five actresses.

3 METHODS

We use AI image recognition software to (a) extract the rectangle containing the face with negligible borders in each of the 50 frames; (b) use a suite of image analysis routines supplied by the software package to align the five faces for each actor/actress in each video; (c) apply a feature extraction function to reduce the five images thus aligned to a 4D feature vector; (d) dimension-reduce the 4D feature vectors to coordinates in a 2D manifold via an auto-encoder neural network with 7 layers; and (e) calculate the Euclidean distance between (normalized) pairs of these feature vectors for each video (Fig. 1 & 2).

We then estimate the ML distribution of these Euclidean distances and calculate the modes as well as the HDI_{95%} uncertainty for the distance between emotion pairs “neutral” □ “fear” and “pain” □ “pleasure”. We then use Wilks lambda to determine whether the ML distributions (and, by implication, their modes) for the emotion pairs “neutral” □ “fear” and “pain” □ “pleasure” are significantly different.

4 RESULTS

For the females, the ML distributions for the emotion pairs “neutral” □ “fear” and “pain” □ “pleasure” are Gamma distributions with modes 1.177 and 0.791, respectively (Fig. 3a); Wilks lambda is 5.985, so the probability that both emotional distances are drawn from the same statistical population is 5.0%. In other words, the two populations of (normed) distances are significantly different. We also observe that the mode of the normed distance “neutral” □ “fear” is greater than the mode of the normed distance “pain” □ “pleasure”. We observe that

the HDI95% uncertainty for the females during the transition “neutral” $\rightarrow$ “fear” is not only least of all four (males and females), but remarkably narrow.

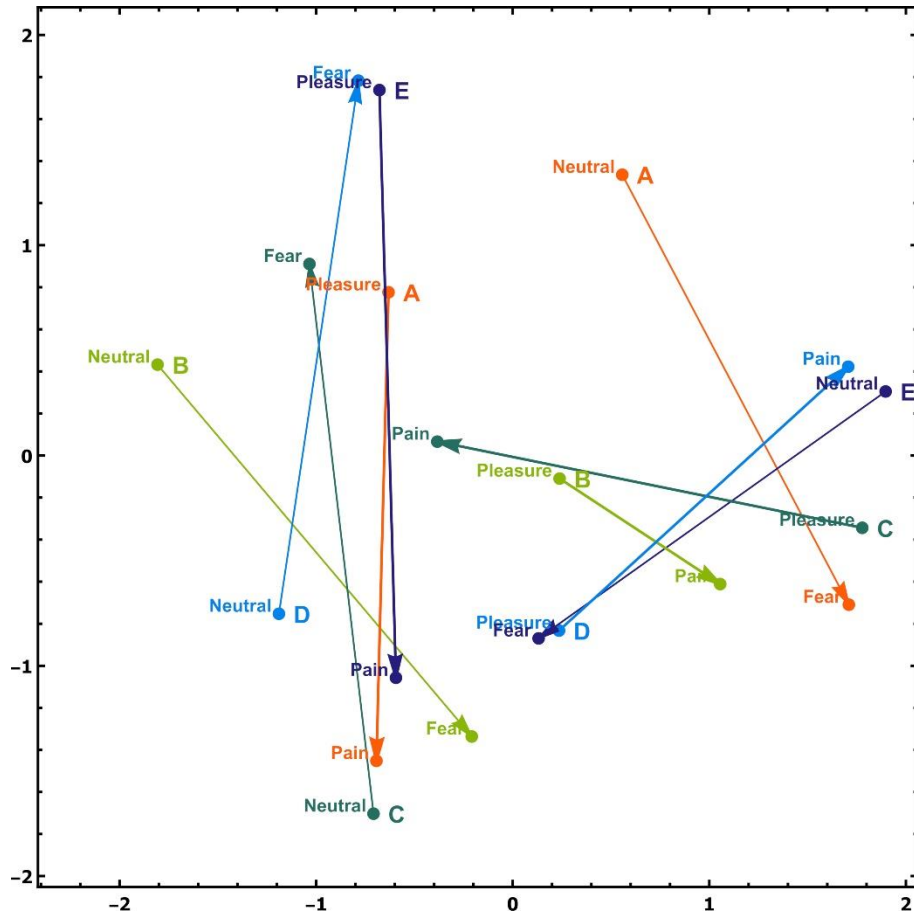


Figure 1: The shifts in emotion manifest in the images of the five females, obtained by dimension-reduction of the feature vectors of the image frames. Color-coding is unique for each female; arrows show the direction we investigate in this study; capital letters identify the females. There are two arrows per female, because we investigate two shifts. We observe that the shifts “neutral” $\rightarrow$ “fear” are oftentimes longer than “pain” $\rightarrow$ “pleasure”.

For the males, the ML distributions for the emotion pairs “neutral” $\rightarrow$ “fear” and “pain” $\rightarrow$ “pleasure” are Gamma distributions with modes 0.801 and 1.158, respectively (Fig. 3b); Wilks lambda is 3.658, so the probability that both distances are drawn from the same statistical population is 16.1%. In other words, the two populations of (normed) distances are insignificantly different (at 5% significance level). We also observe that the mode of the normed distance “neutral” $\rightarrow$ “fear” is less than the mode of the normed distance “pain” $\rightarrow$ “pleasure” — opposite the mode shifts for the females. However, because the different distributions are not significantly different, this inequality is of no consequence.

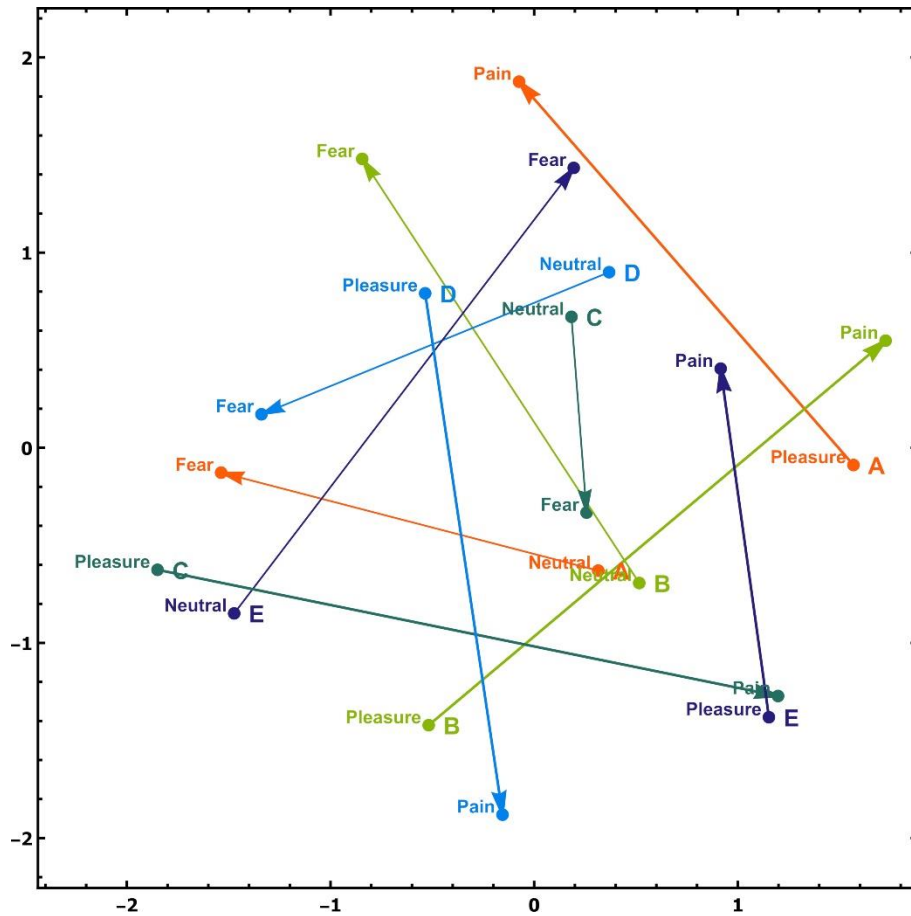


Figure 2: The shifts in emotion manifest in the images of the five males, obtained by dimension-reduction of the feature vectors of the image frames. Color-coding is unique for each male; arrows show the direction we investigate in this study; capital letters identify the males. There are two arrows per male, because we investigate two shifts. We observe that the shifts “neutral” $\rightarrow$ “fear” are not always longer than for “pain” $\rightarrow$ “pleasure”.

5 DISCUSSION

We looked for the five leading ML distributions (from more than a dozen, including mixture distributions) in order to choose one. We used two criteria for our choice: (a) the domain of the distribution has to be positive (thus, the normal distribution must be excluded) and (b) AIC (Akaike’s Information Criterion) must be a minimum and, if there are competing distributions, the ones that agree for both the emotion pairs “neutral” $\rightarrow$ “fear” and “pain” $\rightarrow$ “pleasure”. Using these criteria, we find that all the emotion distances are Gamma distributed (Fig. 3).

To assume that the normed distances are Student t -distributed is fallacious, so a t -test is not possible. Furthermore, because ML methods estimate both ML parameters of the distribution in one sweep, an ANOVA test is doubly useless (ANOVA assumes that the sample points are drawn from a nearly-normal distribution and that the variance estimated from the data is a good estimator of the variance of the distribution).

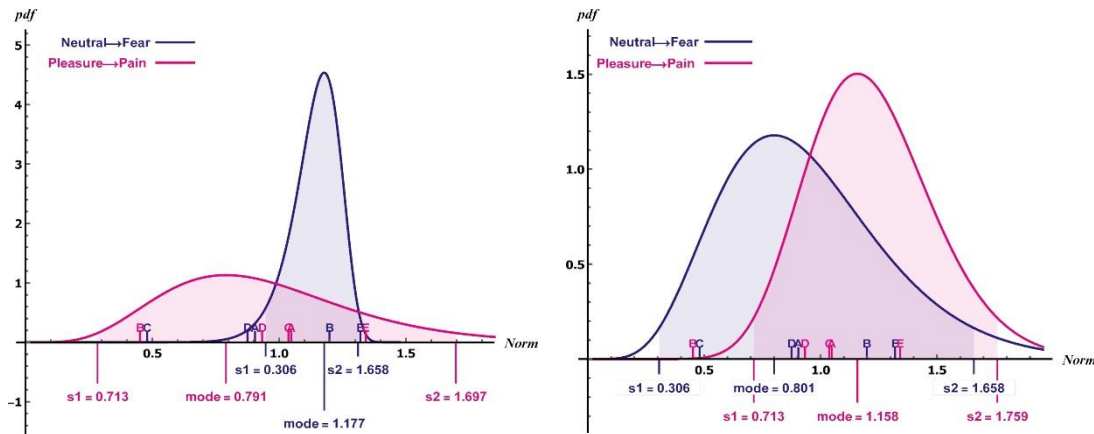


Figure 3: The ML distributions of the shifts “pain” → “pleasure” (dark magenta) and “neutral” → “fear” (dark blue) for the normalized Euclidean distances (females: Fig. 1 and males: Fig. 2) for the females (above left) and the males (above right). The color-coded rug plots in both graphs show the normalized Euclidean distances. All distributions are gamma distributions; the shaded areas (from s_1 to s_2 , respectively) are 0.95 for each distribution; these define the $HDI_{95\%}$ confidence intervals. (The $HDI_{95\%}$ interval is the generalization of the $\pm 1.96s$ interval for the normal distribution, where in this formula s is the point estimator of the standard deviation of the sample. The $HDI_{95\%}$ is derived from the ML distribution, not from the sample.) We observe that the modes of all distributions differ and for both males and females the $HDI_{95\%}$ confidence intervals overlap. However, the two sets of normalized distances for the female shifts are significantly different (at 5 % significance level), while for the males they are not.

Each stimulus/image used in this study was one single frame taken from the video at the moment an intensive affective state was shown/experienced by the actor/actress; we relied on the researcher making the choice, based on his following the plot. The resolution of the extracted image was occasionally as low as 500×550 pixels (because the face was within a BDSM scene); furthermore the orientation of the head was not predetermined. We used an image alignment algorithm to ensure reasonable alignment of the faces via image rotation. The feature extraction software is minimally dependent on the exactitude of the alignment, so we can (and do) assume the results are neither biased by the alignment issue nor the smallness of the image of the face (if the image is not too small). Consequently, the result is remarkable in terms of accuracy, far more so than a result obtainable by some human rater. Evidence: we have previously applied the same method of feature vector extraction of images in short horror-video game clips (Prossinger et al., 2021) where 50 frames (with chosen maximum expression in the 24th frame) were used to successfully distinguish neutral facial expression from expression of joy and fear.

6 CONCLUSION

The differentiation of distinct facial expressions can be further used in the implementation of safety fuses during personal use of horror videos at home as suggested by Binter et al. (2020) but also for maintaining the well-being of smart-city inhabitants (for a review see Muhammad et al., 2017).

The method we present here can potentially be used in the analysis of already existing video materials (typically online) to determine if the depicted individuals are personally endangered or are experiencing discomforting — or worse — situations. Needless to mention, it is important to determine the border between BDSM videos that use actors/actresses and those that use criminal violence. The proof-of-principle we

demonstrate here can be used to keep the market for BDSM videos legal. The method definitely has its limitations if and when the quality of the data set is insufficient.

This novel approach we have presented here demonstrates that the emotional pairs pain and pleasure are easily distinguishable from each other in males and females with surprisingly high accuracy — likewise for the pairs consisting of neutral facial expression and fear. The outcomes bring novel approaches to emotion differentiation applied to semi-naturally occurring videos (depicting interaction of two adult individuals taking part in BDSM activities). Other novel approaches to be developed are the analysis of the highly salient expression of ambiguous emotions by employing AI algorithms contained in MATHEMATICA[®] (Wolfram Technology[®]).

These methods generate numerous implications for emotion research, namely in health care, in on-the-spot diagnostics (such as when a potential witness is being interviewed by a detective), and in applications in the fields of Information and Communication Technologies. The method can be used to not only estimate one's affective state with high accuracy during certain activities and to trigger safety fuses but also to retrospectively evaluate existing visual materials. Importantly, since video-recording is a non-invasive type of data collection and real-time analysis is available, we stress that it should become a method of choice to benefit people.

ACKNOWLEDGMENTS

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The Correlations of BIS/BAS, SIS/SES and SOI Questionnaires in Two Czech Samples: An Implication for Future National Studies

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Keywords: Dual Control Model; Behavioral Inhibition and Activation System; Sociosexuality; Sampling; Self-selection

Abstract

Research of sexuality often times includes individuals who choose to be researched and are willing to undergo the procedure (in case of measures are taken) or filling up a questionnaire. Other motivation may be gaining of credits and fulfilling university duties. In both cases the samples of population (students and self-selected enthusiasts) do not resemble the nation's population structure nor general idea of random human even though the psychological mechanisms researched are thought to be universal. The aim of this study was to investigate the relationship between proximal measures of domain specific and non-specific excitation and inhibition in two (probabilistic and non-probabilistic) samples. We collected approximately 400 individuals from Central European country – Czech Republic – via specialized agency to match the probabilistic sample and a second similarly sized sample via snowball sampling and online advertisements at the same time. The participants were asked to fill in two questionnaires

widely used by sex researchers (Sexual Inhibition and Excitation Scale and Sociosexual Orientation Inventory), and one scale designed to map broader motivations to avoid aversive outcomes and motivation to approach goal-oriented outcomes (Behavioral Inhibition and Activation Scale). Generally, the non-probabilistic sample findings resembled the published results whereas the probabilistic sample differed, especially in men. Furthermore, findings from women were the more consistent of the two sexes when comparing the probabilistic and non-probabilistic sample outcomes. Our results, relying on correlational analyses as majority of studies does, provide a valuable insight to impact of sampling on results. The outcomes should be considered when future national studies are planned.

Introduction

Human behavior can be broadly reduced to a dichotomous motivational system of approach and avoidance. According to Reward Sensitivity Theory (Gray, 1973, McNaughton & Corr, 2008), whilst the former regulates behavior towards something appetitive, the latter regulates behavior away from something aversive. These two systems – excitatory and inhibitory – are thought to be independent; for example, a high level of excitation is not necessarily related to low inhibition (Corr, 2002). The Behavioral Inhibition System and Behavioral Activation System (BIS/BAS) questionnaire was developed to measure an aspect of personality derived from variation in patterns of excitatory and inhibitory responses across non-specific contexts.

Derived from the core system proposed in the BIS/BAS, the Sexual Inhibition System and Sexual Excitation System questionnaire (SIS/SES) was developed to measure the motivational system underlying sexual behavior exclusively. Based on the Dual Control Model (originally developed by Bancroft and Janssen, 2000), a dichotomous division of appetitive and aversive motivations are postulated to influence sexual behavior. The SIS/SES aimed to predict individual differences in behavior arising from the relative patterns of excitatory and inhibitory sexual responses (Graham et al., 2006; Bancroft & Janssen, 2000; Hodgson et al., 2016). While theoretically proximal, SIS/SES shown modest overlap with the BIS/BAS (Janssen et al., 2002). Given the domain specificity, SIS/SES should share a stronger relationship with measures of sexual behavior. For example, there is a relationship between SIS/SES items and scores on the sociosexual inventory (Nolet et al., 2021; Bártová et al., 2021; Janssen et al., 2002). However,

the notion of domain specificity is somewhat equivocal given evidence that both scales contribute to the prediction of sexual and non-sexual behavior (van Lankveld et al., 2015).

Previous studies have shown the SIS/SES to satisfy criteria for establishing psychometric properties (Velten et al., 2018; Nowosielski et al., 2021; Graham et al., 2006; Bloemendaal & Laan, 2015). Application of the SIS/SES scale has also proven useful; evidence of high SES and SIS scores have been linked to sexual dysfunction and pathology (Bancroft et al., 2009; Velten et al., 2018). However, research in the development and assessment of the psychometric properties predominantly utilized non-probabilistic sampling of university students, for example, raising questions about the extent to which results from the questionnaire can be accurately attributed to a broader population. This issue has been raised in social psychology more broadly, where it is estimated that samples ranging from 20-70 % of studies comprise undergraduate students (Rad et al., 2018).

The use of non-probabilistic convenience samples can lead to bias in the research findings: (a) students (regardless of their age) are in close contact with their peer group, which is likely to influence social behavior and strategy (Binter et al., 2012). Furthermore, psychological problems and lower quality of life are more prevalent amongst students (Henning et al., 2012). Another issue pertains to the self-selected sample (Bethlehem, 2010): (b) individuals that participate in a study focused on sensitive topics such as sexuality tend to be more open-minded and experienced; individuals that choose not to participate in such a study tend to be more insecure or conservative (Copas et al., 2020; Wiederman 1999). As such, the narrow focus of participants could lead to less reliable predictions when applied to sexual behavior in the broader population. It is not to say that the sample that is collected as probabilistic is at all not affected by the self-selection. Also part of population that does not use internet is hardly researched in quantitative studies in last decade. Furthermore, those who take part in such studies may have other motivations such as financial reward for participation. Thus, the chances of discovering generalizable phenomena are higher in population that are motivated by different notions than interest in the topic or signing in a subject thought at university.

In addition to acknowledging factors related to sampling, it has long been recognized that the development of psychometrics is subject to cultural bias; estimates indicate that 96 % of research in the social sciences is conducted in western, educated, industrialized, rich, and

democratic (WEIRD; Rad, Martingano, & Ginges, 2018) regions. Furthermore, more than half of the studies are carried out in the United States (Rad, Martingano, & Ginges, 2018). The universal nature of psychological mechanisms is often belied by socio-cultural, political, and linguistic manifestations. The SIS/SES has been translated and applied in several countries including Germany, Italy, Portugal and Poland (Velten et al., 2018; Panzeri et al., 2008; Gomes et al., 2018; Nowosielski et al., 2021). While the results are generally supportive, there are some differences in the comprehension of individual items and variation in the optimum factor structure.

Several studies have indicated gender differences in SIS/SES scores: in comparison to men, women tend towards higher sexual inhibition and lower sexual excitation (Carpenter et al., 2008; Cantarella et al., 2008). Validation of the SIS/SES with women confirmed a similar factor structure although the model fit was less convincing (Carpenter et al., 2008). There were some gender differences in the relevance of items with respect to sexual arousal (Carpenter et al., 2008). Interestingly, it was noted that women's scores correlated more strongly to measures of sexual behavior while men's scores were more closely related to the BIS/BAS (Carpenter et al., 2008). A short version of the scale was developed that incorporated items deemed to have invariant psychometric properties across genders (Carpenter et al., 2011). However, the short form was also developed based on the responses of higher education students.

Previous studies have explored the relationship between BIS/BAS-SIS/SES (Carpenter 2008, 2011; van Lankveld et al., 2015; Janssen et al., 2002) and SIS/SES-SOI (SOI: Sociosexual Orientation Inventory; Carpenter 2008, 2011; Bártová et al., 2021; Janssen et al., 2002). We used these studies to generate hypotheses and extend our study to investigate the relationship between the BIS/BAS and SIS/SES questionnaires together with the SOI using two methods of sampling – non-probabilistic and probabilistic. Both samples were collected in the Czech Republic, a central European country, that arguably does not conform to a typical WEIRD population. The aim of this study was to determine whether predicted relationships between questionnaires were evident when applied to a broader population.

Method

Participants

The probabilistic (representative) sample was collected by a data collection agency (Czech National Panel; narodnipanel.cz). The sample was randomly sampled based on strata including sex, age groups, level of education, and size of inhabited area. The non-probabilistic (non-representative) sample was collected using combination of online advertising on science and life style oriented webpages and snowball sampling (websites pokusnikralici.cz; bezpasaka.cz). Data were collected using Qualtrics online platform, which could be completed on both computer and mobile devices. Both samples were collected simultaneously in the Czech Republic 2021.

The data was part of a larger research project focused on affective state perception (pre-registered <https://osf.io/bhk6m/>). Criteria for inclusion were: (a) age of respondent between 18 and 50 years, and (b) at least minimal reported experience with pornographic materials (due to fact that pseudo-sexual images – facial expressions and vocalizations of individuals experiencing sexual pleasure, but no explicit visual materials – were presented to participants during the study). The exact formulation was as follows: “I declare that I have at least minimal experience with pornographic materials.”

In the probabilistic sample, a total of 417 respondents (aged 18-50, $M_{age} = 33.69$, $SD = 9.72$) completed the questionnaires. We aimed for $N = 400$ but extra 17 individuals filled in the questionnaire). In total 213 women (aged 18-50, $M_{age} = 31.98$, $SD = 9.02$) and 204 men (aged 18-50, $M_{age} = 31.98$, $SD = 9.02$) took part in the study. In the non-probabilistic sample, 485 participants filled in the questionnaire, 313 women ($M_{age} = 30.17$, $SD = 7.77$) and 172 men ($M_{age} = 31.43$, $SD = 8.01$). Further demographic information for both samples are included in Table 1..

Measures

The Institutional Review Board of Faculty of Sciences approved the study protocol (no. 2018/08). Data were handled in compliance with GDPR regulations.

Following an onscreen introduction to the study, participants provided informed consent before completing the demographic information set of questions. The BIS/BAS, SIS/SES, and SOI

questionnaires were translated to Czech and back-translated by experienced researchers and trained psychologists .

The sexual inhibition and inhibition scales (SIS/SES-SF)

The questionnaire is composed of 3 separate types of questions targeting hypothetical situations related to sexual performances, risks related to sexual interaction, and arousal reactivity involving situations. The rating is on 4-point scale (*Very false to me – Very true to me*). SIS1, Inhibition Due to Threat of Performance Failure, consists of 4 questions (i.e., “I cannot get aroused unless I focus exclusively on sexual stimulation”). SIS2, Inhibition Due to Threat of Performance Consequences, consists also of 4 questions (i.e., “If I realized there is a risk of catching a sexually transmitted disease, I am unlikely to stay sexually aroused”). SES, Sexual Excitation, consists of 6 questions (i.e., “When a sexually attractive stranger accidentally touches me, I easily become aroused”).

The questionnaire used is a shorter form (Carpenter et al., 2011) of the original Sexual Inhibition and Sexual Excitation Scales (Janssen et al., 2002). The reason for choosing the short version, apart from time-consumption in an online experiment, is that the version is valid for both sexes. The Czech version (Appendix 1) allows for administration for both sexes with no modification. There are number of studies demonstrating consistency of the short version with the original one (Bancroft et al., 2009, Carpenter et al., 2008, Rettenberger & Briken, 2013, Turner, Briken, Klein, & Rettenberger, 2013).

Behavioral Inhibition System/Behavioral Activation System Scales (BIS/BAS-Scales)

The BIS/BAS-scales consist of 4 separate types of questions targeting motivation to avoid aversive outcomes and motivation to approach goal-oriented outcomes. The rating is realized on a 4-point scale (*Very false to me – Very true to me*). The Behavioral Inhibition (BIS) scale consists of seven questions (i.e., “I worry about making mistakes“, “Criticism or scolding hurts me quite a bit“). Other 13 questions are dedicated to the Behavioral Activation Scales (BAS). Thus, three separate subscales are Fun-Seeking (BAS-FS) which consists of 4 questions (i.e., “I will often do things for no other reason than that they might be fun”), Reward Responsiveness (BAS-RR) consisting of 5 questions (i.e., “When I’m doing well at something, I love to keep at it”), and Drive (BAS-D), also consisting of 4 questions (i.e., “I go out of my way to get things I want”). The Czech version (Appendix 2) allows for administration for both sexes with no

modification. The questionnaire was used in other languages and consistency of the results was successfully demonstrated (Carver & White, 1994; Jorm et al., 1998).

The socio-sexual orientation inventory (SOI-R)

The questionnaire maps individual willingness to engage in uncommitted sexual activity. The questionnaire consists of 9 questions that can be divided to 3 subscales, each consisting of 3 questions: Behavior (i.e., “With how many different partners have you had sex within the past 12 months?”), Attitudes (i.e., “Sex without love is OK.”), and Desires (i.e., “How often do you have fantasies about having sex with someone you are not in a committed romantic relationship with?”). A total score (SOI-TOT) can be obtained by summing (or less commonly averaging) scores from all questions. We used the version that uses 9-point scales that all responses are mapped into. The originally developed scale by (Penke & Asendorf, 2008) is commonly used in Czech language (e.g., Bártová et al., 2020, Bártová et al., 2021) and consistency with the original language has been demonstrated by above mentioned authors.

Hypotheses

Hypotheses were based on previously published results.

H1: Sexual excitation (SES) will positively correlate with the behavioral activation (BAS) dimensions of Drive, Fun-seeking and Reward Responsiveness in women (van Lankveld et al., 2015; Carpenter et al., 2008) and men (van Lankveld et al., 2015; Carpenter et al., 2008, 2011; Janssen et al., 2002).

H2: Sexual inhibition due to threat of performance failure (SIS1) and sexual inhibition due to threat of performance consequences (SIS2) will negatively correlate with the dimension Fun-seeking of behavioral activation (BAS) in men (van Lankveld et al., 2015; Carpenter et al., 2008, 2011; Janssen et al., 2002).

H3: SIS1 and SIS2 in men will positively correlate with behavioral inhibition (BIS; Carpenter et al., 2008, 2011; Janssen et al., 2002; van Lankveld et al., 2015).

H4: Sexual excitation (SES) will positively correlate with the three sociosexual orientation (SOI) subscales (Bártová et al., 2021) and SOI total score in both men and women (Janssen et al., 2002; Carpenter et al., 2008, 2011; Bártová et al., 2021).

H5: Both measure of sexual inhibition (SIS1 and SIS2) will negatively correlate with the three sociosexual orientation (SOI) subscales and SOI total score in men and women (Janssen et al., 2002; Carpenter et al., 2008, 2011; Bártová et al., 2021).

Data analysis

The data analyses were performed using SPSS 26 software package. Data from the probabilistic and non-probabilistic samples were analyzed separately. Cronbach's alpha was calculated to determine the level of internal consistency. The relationship between subscales were analyzed using Pearson's correlations controlled for age. The reason is maximal comparability with existing studies, especially Bártová et al. (2021) conducted on Czech non-probabilistic sample.

Results

Reliability

Analysis of the internal consistency was conducted on data from the probabilistic sample. For the BIS/BAS questionnaire, internal consistency of 0.790 (for women 0.790 and 0.775 for men respectively) was found for the total score. The Behavioral Inhibition (BIS) subscale reached a consistency of 0.753 (for women 0.741 and 0.714 for men respectively); the BAS-FS subscale reached a consistency of 0.673 (for women 0.680 and 0.664 for men respectively); the BAS-RR subscale reached a consistency of 0.688 (for women 0.682 and 0.691 for men respectively); and the BAS-D subscale reached a consistency of 0.680 (for women 0.713 and 0.640 for men respectively).

For the SIS/SES-SF questionnaire, an internal consistency of 0.662 (for women 0.697 and 0.639 for men respectively) was found for the total score. The Sexual Excitation subscale reached a consistency of 0.790 (for women 0.793 and 0.768 for men respectively); the Inhibition Due to Threat of Performance Failure (SIS1) subscale reached a consistency of 0.538 (for women 0.512 and 0.516 for men respectively); and the Inhibition Due to Threat of Performance Consequences (SIS2) subscale reached a consistency of 0.648 (for women 0.656 and 0.618 for men respectively).

For the SOI-R questionnaire, an internal consistency of 0.829 (for women 0.788 and 0.849 for men respectively) was found for the total score. The Behavior subscale reached a consistency

of 0.744 (for women 0.737 and 0.753 for men respectively); the Attitudes subscale reached a consistency of 0.799 (for women 0.741 and 0.836 for men respectively); and the Desire subscale reached a consistency of 0.818 (for women 0.780 and 0.816 for men respectively).

Correlations

The relationship between questionnaires was analyzed separately for men and women in each of the probabilistic and non-probabilistic samples. Controlling for age limits the impact of age differences in the samples and allowing for a direct comparison with the results of Bártova et al. (2021).

Data from the probabilistic sample of women (see Table 2) showed SIS1 and SIS2 were significantly positively correlated. A significant positive correlation was found between SIS1 and SES. A significant positive correlation was found between SES and all three SOI subscales (behavior, attitude and desire) as well as SOI total score. There was a significant negative correlation between SIS1 and BAS reward, while SIS2 showed a significant negative correlation with BIS. A significant negative correlation was found between SES and the three BAS (drive, fun and reward) dimensions as well as between SES and BIS. Significant positive correlations between the three BAS dimensions. There was a significant positive correlation between both BAS Fun, BAS Reward and BIS. In addition, BAS fun was significantly negatively correlated with SOI Behavior, SOI Desire and the SOI total result while for BAS Reward we found negative correlation with SOI Attitude, SOI Desire and SOI total score.

In the non-probabilistic sample of women (see Table 3), correlations with SES were replicated with two exceptions: a significant negative correlation between SIS1 and SES was found in addition to a significant negative correlation between SIS2 and SES. There were significant negative correlations between SIS1 and SOI Attitude, SOI Desire and the SOI total score. SIS2 significantly negatively correlated with the three SOI subscales as well as SOI total score.

In the probabilistic sample of men (see Table 4) a significant positive correlation was found between SIS1 and SIS2. SES significantly positively correlated with SOI, SOI Attitude and SOI Desire. However, no further significant correlations were found between either SIS1 or SIS2 and SOI. There was a significant negative correlation between SIS1 and BIS. A significant

negative correlation was also found between SIS1 and BAS Reward in addition to a significant positive correlation between both SIS1, SIS2 and BAS Fun.

In the non-probabilistic sample of men (see Table 5), the significant positive correlation between SIS1 and SIS2 was replicated. SES was also found to significantly correlate with SIS2. Significant negative correlations were found between SIS1 and SOI Attitude, SOI Desire and SOI total score. Significant negative correlations were found between SIS 2 and SOI Behavior, SOI Attitude, SOI Desire, and SOI total score. Significant positive correlations were also found between SES and SOI Behavior, SOI Attitude, SOI Desire, and SOI total score. The significant relationship between SIS1 and BAS Reward was not replicated in the non-probabilistic sample. Furthermore, a significant positive correlation was found between SIS1 and BAS Fun, with a significant negative correlation between SIS1 and both BAS Reward and BIS. Significant negative correlations were found between SIS2 and both BAS Drive and BAS Fun. There was a significant positive correlation between SIS2 and BIS. A significant negative correlation was also found between SES and BAS Fun.

Discussion

We investigated the relationship between psychometric measures of excitation and inhibition in two (probabilistic and non-probabilistic) samples. Data were collected simultaneously, therefore any discrepancy in between our results and previous research can be reasonably attributed to the sampling process and not differences in time. The correlation analyses also controlled for age to limit the possibility of differences in sexual behavior between samples. For example, it is understood that sexual motivation changes over the lifespan (Bártová *et al.*, 2021, Binter *et al.*, 2012). As such, any difference between samples is likely to stem from demographic aspects such as socioeconomic status or geographic location.

A positive correlation between sexual excitation and the three behavioral activation dimensions was predicted (H1) in both men and women. This relationship was found in women in both samples. In men, sexual excitation was only related to behavioral activation dimensions (with the exception of the dimension Drive) in the non-probabilistic sample. These results validate the sexual excitation construct as a specific domain of the general behavioral activation system theorized by the Reinforcement Sensitivity Theory (Bancroft, 1999). However, the absence of

a relationship in the probabilistic sample indicates that in men, there could be demographic factors that moderate SES or BAS, creating divergence. For example, it is notable that there is no relationship between sexual excitation and sociosexual orientation's behavior in the probabilistic sample that is calculated based on three items including the number of sexual partners. Encompassing broader geographical regions where access to multiple sexual partners is limited or stable monogamous relationships are more prevalent could influence sexual excitation whilst not diminishing individual differences in general activation.

A negative relationship between both SIS1 (sexual inhibition due to threat of performance failure), SIS2 (sexual inhibition due to threat of performance consequences) and BAS Fun was predicted (H2) in men. However, we only found a negative correlation between SIS1 and BAS Fun in the non-probabilistic sample. There was also no negative relationship between either SIS1 or SIS2 and BAS Fun in the women's results. Both SIS1 and SIS2 concern sexual inhibition; specifically, SIS1 concerns performance anxiety and SIS2 concerns fear of performance consequences. As such, inhibition in this context was anticipated to be opposed to proneness to seek novel sensations or excitement. Validation of the SIS/SES scale in Polish also found no significant relationship between SIS and BAS (Nowosielski et al., 2021). Firstly, their study incorporated a sample that had a broad age range, the majority of which had attained secondary level of education and worked blue-collar jobs. Secondly, during factor analysis two items in SIS1 were found to load better on SES. It was suggested that socio-cultural factors might influence the context of sexual encounters (Nowosielski et al., 2016), thus predicting arousal rather than threat of consequences for example.

In men, a positive relationship between both SIS1 and SIS2 and BIS (behavioral inhibition) was predicted (H3). However, only a relationship between SIS1 and BIS was shown in the non-probabilistic sample of men. This is congruent with some previous research that showed a relationship between SIS1 and BIS (Carpenter et al. 2011; van Lankveld et al. 2015) while others found a relationship between SIS2 and BIS (Carpenter et al., 2008, 2011; Janssen et al., 2002). Both BIS and SIS measure inhibitory motivation and as such should at least show some overlapping relationship. We also found no relationship between either SIS1 or SIS2 and BIS in both samples of women. Van Lankveld et al. (2015) suggested that whilst sexual inhibition covaries with domain non-specific inhibition in men, the relationship may only be weak in women.

We predicted (H4) positive correlations between SES and SOI (the three subscales and total score of sociosexual orientation) in both men and women, which was confirmed in both

probabilistic and non-probabilistic samples; except the correlation between SES and SOI behavior in the non-probabilistic sample discussed previously. These relationships in the expected direction validate the SES construct. Individuals with a more casual attitude to sexual relations exhibit greater sexual excitation. Conversely, a negative correlation was predicted (H5) between sexual inhibition measures (SIS1 and SIS2) and SOI (the three subscale and the total score) in men and women. In the non-probabilistic sample, the relationships between SIS1 (Bártová et al., 2021), SIS2 (Janssen et al., 2002; Carpenter et al., 2008, 2011; Bártová et al., 2021) and SOI subscales (with the exception of SOI Behavior) is congruent with previous research. Individuals with a more casual attitude to sexual relations are less likely to be inhibited by the threat of performance failure and consequences. However, there was no relationship between measures of sexual inhibition in the probabilistic samples of men or women. This pattern of results matches research conducted in Poland (Nowosielski et al., 2021); while the relationship between sexual excitation and attitudes appears robust, further research is required to determine the influence of sexual inhibition within the broader population.

Findings from the non-probabilistic sample were generally similar to results of previous studies (van Lankveld et al., 2015; Carpenter et al., 2008, 2011; Janssen et al., 2002, Bártová et al., 2021). The data indicate that sexual excitation is predictive of casual sexual attitudes across both men and women irrespective of the sample demographic. An overlap between general domain of behavioral activation and specific domain of sexual excitation is consistent in women. However, behavioral activation and sexual excitation tendencies are generally only related in the narrow non-probabilistic sample of men. Czech Republic is considered as part of Central Europe and does not arguably fit in the WEIRD categorization. Despite the different historical and cultural background the findings from our self-selected sample are highly similar to the previous studies conducted in western countries.

The relationship between sexual inhibition and attitudes to sexual behavior appear robust only in the non-probabilistic samples of both men and women. These discrepancies were, however, congruent with studies that utilized a broader sample (i. e., Nowosielski et al., 2021). Furthermore, overlap between general domain of activation/inhibition and sexual inhibition construct appears to be more complex. It is important to clarify that correlation analysis is not the ideal statistical tool to explore the presence of associations between scales, thus used in majority of the studies to evaluate the concurrent validity (van Lankveld et al., 2015). Correlation can only capture the simplest type of association and the presence of subgroups within a sample may create artefacts. Nevertheless, the self-selection of participants can bias

sex research; the most conservative or sexually insecure people are less likely to be included. Furthermore, targeted broad population samples are more likely to influence results. Previous cross-cultural research found gender equality, economic income, and life expectancy, for example, to be related to socio-sexual orientation. While there is an abundance of support for the sexual excitation and inhibition model, the validity of predictions may be less reliable when applied to sections of the population.

Conclusion

The study was designed to evaluate the impact of sample choice on the correlational analyses of concurrent validity. Concretely we have focused on SIS/SES-SF, which is based in Dual Control Model of Sexual Response and BIS/BAS questionnaire which is broader measure of tendency to motivation to avoid aversive outcomes (Behavioral Inhibition System) and motivation to approach goal-oriented outcomes (Behavioral Activation System) based in Reward Sensitivity Theory. As third questionnaire we have included the SOI-R that maps socio-sexual orientation, a tendency and willingness to uncommitted sexual activity. The questionnaire also includes behavioral component focused on amount of partners. As expected, we have found different results in case of the probabilistic and non-probabilistic sample. The results show more consistency in case of women compared to men showing higher impact of sample choice on the result in case of men. We also found that our non-probabilistic sample resembled the outcomes in other western countries whereas the probabilistic sample results deviated from expectations (Table 6 and 7). We find these results to be important for future research design adjustment, namely national surveys and probabilistic sample collections, and interpretation of results involving human sexuality.

Ethics

The Helsinki Convention was adhered to at all times, throughout the presenting of the questionnaire, collection of responses and abiding by the wishes of those who did not agree with the terms and conditions; these were not allowed to proceed with the study. All data were anonymized. The study is part of larger set of projects and has been approved by Institutional Review Board of Faculty of Science, Charles University (#2018/08).

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Sample		
	<i>Probabilistic</i>	<i>Nonprobabilistic</i>
<i>N</i>	417	485
<i>Age, mean (SD)</i>	33.69 (9.7)	30.62 (7.9)
<i>Sex</i>		
Female	213 (51.1%)	313 (64.5%)
Male	204 (48.9%)	172 (35.5%)
<i>Size of inhabited area</i>		
Less than 1000	71 (17%)	49 (10.1%)
1 000 – 4 999	82 (19.7%)	68 (14%)
5 000 – 19 999	82 (19.7%)	53 (10.9%)
20 000 – 99 999	82 (19.7%)	66 (13.6%)
100 000 – 999 999	52 (12.5%)	77 (15.9%)
Above 1 mil. (Prague)	48 (11.5%)	172 (35.5%)
<i>Education</i>		
Primary	80 (19.2%)	9 (1.9%)
Vocational	146 (35%)	179 (36.9%)
Secondary	117 (28.1%)	20 (4.1%)
University degree	74 (17.7%)	277 (57.1%)
<i>Partnership status</i>		
Single	141 (33.8%)	207 (42.7%)
In relationship	112 (26.9%)	147 (30.3%)
Married	128 (30.7%)	98 (20.2%)
Divorced	35 (8.4%)	32 (6.6%)
Widowed	1 (0.2%)	1 (0.2%)

Table 1: demographic data for the stratified (probabilistic) and chance (nonprobabilistic) samples, for each variable, apart for age, is reported the relative frequency and the percentage in the sample.

	BAS-D	BAS-F	BAS-RR	BIS	SOI-B	SOI-A	SOI-D	SOI
SES	.505***	.499***	.494***	.370**	.315*	.311*	.414**	.441**
SIS1	.100	.067	.287*	.218	-.114	-.111	-.197	-.175
SIS2	.027	.041	.239	.294*	.020	-.246	-.096	-.157

Table 2: results correlations for stratified sample of women, * $p < .05$. ** $p < .01$. *** $p < .001$

	BAS-D	BAS-F	BAS-RR	BIS	SOI-B	SOI-A	SOI-D	SOI
SES	.172***	.242***	.332***	.095*	.201***	.291***	.546***	.455***
SIS1	.098*	-.019	.130**	.190***	-.060	-.197***	-.210***	-.213***
SIS2	-.092*	-.123**	-.022	.202***	-.132**	-.245***	-.172***	-.249***

Table 3: results of correlations for chance sample of women, *p < .05. **p < .01. ***p<.001

	BAS-D	BAS-F	BAS-RR	BIS	SOI-B	SOI-A	SOI-D	SOI
SES	-.093	.166	.222	.240	.286	.342*	.378*	.435**
SIS1	.144	.020	.405**	.076	.043	.002	.064	.041
SIS2	.052	-.213	.086	-.085	.056	-.136	.255	.040

Table 4: results of correlations for stratified sample of men, *p < .05. **p < .01. ***p<.001

	BAS-D	BAS-F	BAS-RR	BIS	SOI-B	SOI-A	SOI-D	SOI
SES	.123	.270***	.284***	.130	0.214**	.309***	.585***	.489***
SIS1	.010	-.177*	-.002	.182*	-.087	-.313***	-.187*	-.266***
SIS2	-.257***	-.246**	-.154	.188*	-.196*	-.248**	-.172*	-.269***

Table 5: results of correlations for chance sample of men, *p < .05. **p < .01. ***p<.001

	BAS-D	BAS-F	BAS-RR	BIS	SOI-B	SOI-A	SOI-D	SOI
SES	P N	P N	P N		P N	P N	P N	P N
SIS1						N	N	N
SIS2					N	N	N	N

Table 6: report of significant correlations (p<.05) found between questionnaire's subscales based on the hypotheses –visible non-darkened area - and found in the probabilistic –marked P- and non-probabilistic – marked N – samples of women.

	BAS-D	BAS-F	BAS-RR	BIS	SOI-B	SOI-A	SOI-D	SOI
SES		N	N		N	P N	P N	P N
SIS1		N		N		N	N	N
SIS2		N		N	N	N	N	N

Table 7: report of significant correlations ($p < .05$) found between questionnaire's subscales based on the hypotheses –visible non-darkened area - and found in the probabilistic –marked P- and non-probabilistic –marked N – samples of men.

Appendix 1: Czech translation of SIS/SES-SF questionnaire

1. Když se mě náhodně dotkne pro mě sexuálně přitažlivý neznámý člověk, snadno se sexuálně vzruším.
2. Pravděpodobně nedosáhnou silného vzrušení, když mám sex někde venku na skrytém místě a myslím si, že někdo může být nablízku.
3. Sexuálně se vzruším, když telefonuji s někým, kdo má sexy hlas.
4. Nemohu se sexuálně vzrušit, pokud se nesoustředím výhradně na sexuální dráždění.
5. Když jsem sám/sama a masturbuji, ale uvědomím si, že někdo může každou chvíli vejít do místnosti, mé sexuální vzrušení opadne.
6. Když si uvědomím riziko nákazy sexuálně přenosnou chorobou, je nepravděpodobné, že zůstanu sexuálně vzrušený/á.
7. Pokud by mě při sexuálních aktivitách mohl někdo vidět, je nepravděpodobné, že zůstanu sexuálně vzrušený/á.
8. Je pro mne snadné se vzrušit, když myslím na velmi atraktivní osobu.
9. Pokud dosáhnou sexuálního vzrušení (u mužů - mám erekci), chci co nejdříve pohlavní styk, než moje vzrušení opadne.
10. Když začnu mít sexuální představy, velmi snadno se vzruším.
11. Vidět jiné lidi při sexuálních aktivitách ve mně budí touhu se sexuálními aktivitám věnovat také.
12. Když mám rušivé myšlenky, mé sexuální vzrušení snadno opadne.
13. Když mě vyruší hudba, televize, nebo rozhovor, je nepravděpodobné, že budu i nadále sexuálně vzrušený/á.
14. Když se mnou flirtuje někdo přitažlivý, snadno se sexuálně vzruším.

Appendix 2: Czech translation of 24 item BIS/BAS questionnaire

1. Rodina je pro člověka nejdůležitější součástí života.
2. I když se mi má stát něco zlého, málo kdy zažívám strach nebo nervozitu.
3. Dělán, co můžu, abych dosáhl/a po čem toužím.
4. Když se mi v něčem daří, rád/a v tom pokračuji.
5. Jsem vždy ochotný/á vyzkoušet něco nového, když si myslím, že to bude zábava.
6. Je pro mne důležité, jak se oblékám.
7. Když získám něco, co jsem chtěl/a, cítím se vzrušený/á, nabuzený/á.
8. Když mě někdo zkritizuje nebo napomene, značně se mě to dotkne.
9. Když něco chci, obvykle do toho dám všechno.
10. Často dělám věci jen pro to, že by to mohla být zábava.
11. Je pro mě těžké najít si čas na věci, jako je návštěva holiče/kadeřnice.
12. Když vidím šanci získat něco, co chci, hned se do toho pustím.
13. Cítím se docela ustaraně nebo znepokojeně, když si myslím, nebo vím, že se na mě někdo zlobí.
14. Když vidím příležitost získat něco, co se mi líbí, hned se nadchnu.
15. Často dělám věci z popudu a bez přemýšlení.
16. Když si myslím, že se stane něco nepříjemného, obvykle jsem "jako na trní".
17. Často uvažuji nad tím, proč se lidé chovají tak, jak se chovají.
18. Když se mi stane něco dobrého, silně to prožívám.
19. Když si myslím, že se mi nepovedlo něco důležitého, cítím se ustaraně.
20. Toužím po vzrušení a nových prožitcích.
21. Když o něco usiluji, neohlížím se na pravidla, jdu do toho bez zábran.
22. Ve srovnání s mými přáteli mám jen velmi málo obav.
23. Výhra v soutěži by ve mně vyvolala vzrušení.
24. Mám obavy, že udělám něco špatně.

Multimedia Tools and Applications

Artificial-Intelligence-driven detection of key points and saliency can describe asymmetric distributions of sexual arousal cues of female nudes without using supervised landmarks
--Manuscript Draft--

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Article Type:	Track 3: Biometrics and HCI	
Keywords:	sexual arousal; saliency maps of visual regions of interest; AGAST key points; neural networks; dimension reduction of sexual arousal feature vectors	
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2 **Artificial-Intelligence-driven detection of key points and saliency can**

3

4 **describe asymmetric distributions of sexual arousal cues of female nudes**

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6 **without using supervised landmarks**

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- 28

29 **Keywords:** sexual arousal; saliency maps of visual regions of interest; AGAST key points;

30 neural networks; dimension reduction of sexual arousal feature vectors

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35 **Abstract:** 198 words

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38 **Text:** 4209 words

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41 **Tables:** 1

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44 **Figures:** 7

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47 **Ethics Statement**

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51 This study has been approved by the Ethical Committee of the Faculty of Science, Charles

52 University (Ethics Approval Number 2017/04). All images used in this study are publicly

53 available online. The webpages used offer a direct download function for free.

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58 **Acknowledgments**

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Artificial-Intelligence-driven detection of key points and saliency can describe asymmetric distributions of sexual arousal cues of female nudes without using supervised landmarks

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7 **Artificial-Intelligence-driven detection of key points and saliency can**
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10 **describe asymmetric distributions of sexual arousal cues of female nudes**
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16 **Abstract:** *Background:* Traditionally, specific features of the nude female form were found to
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18 be sexually attractive: overall body shape, as well as breast appearance and culturally-based
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20 modifications (tattoos, piercings, pubic hair removal). *Aim:* We used modern image analysis
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22 algorithms (specifically, neural networks) to challenge this view by extracting features other
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24 than landmarks present in the 2D images of 15 female nudes. *Methods:* We implemented the
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26 AI analysis to find two kinds of features in these images, key points and regions of high
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28 saliency, and their possibly asymmetric distribution. Our choice of these two kinds of features
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30 is based on how humans use gazing and saccades prior to appraising what has been seen.
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35 *Results:* We find that (1) the ten strongest AGAST key points are asymmetrically distributed
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37 in $\sim \frac{2}{3}$ of the nudes; (2) regions of high saliency ('saliency patches') are asymmetrically
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39 distributed among the nudes; (3) several saliency patches were (intentionally) produced by
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41 these women via tattoos, piercings, depilation, etc. *Conclusion:* Saliency patches and AGAST
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43 key points contribute to a woman's visual sexiness beyond her physical attractiveness. The
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45 difference between physical attractiveness and erotic arousal is crucial from an evolutionary
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47 aspect: the latter ensures offspring, while the former may not.
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Introduction

Signaling a potential partner's sexuality, in the sense of arousal, is an important mechanism for reproductive success. Ethologists and evolutionary psychologists have pointed out that one must distinguish between physical attractiveness and 'sexiness' (i.e. being sexually arousing).

While the former may be a first stage in becoming aware of a potential partner, sexiness is necessary for ultimately successful copulation and, in the situation of heterosexual partners, reproductive success. Sexiness, therefore, has a biological quality that must have evolutionary implications. Because it is impossible to test evolutionary processes in a laboratory setting (at least not for macro-animals, such as humans), we attempt to find rigorous, non-speculative features of sexiness that enable inferences relating to the underlying reproductive biology.

Our aim is to apply a suite of modern statistical analysis methods that can detect such visual arousal mechanisms; we present the visually strongest ones (AGAST key points (Mair et al., 2010) and saliency patches — defined below) and their implications for sexual arousal.

We take advantage of the sexual arousal potential offered by the pornographic industry to search for possible ways it is signaled by photographs of (naked) females. Prior to rehearsing action in a porn video scene, candidates pose naked for 'stills' (the technical term used for photographs — as opposed to video clips — in this industry). We use only these photographs for our analyses. We have no further information about the candidates being hired (or not) after their rehearsal. The 'stills' are oftentimes used as cover images on the packaged medium; therefore, the visual sexiness of the nude in the long run contributes to her video market share.

We assume (as does the pornographic industry) that female bodies at first arouse male viewers visually (Chivers & Bailey; 2005). As we show in this paper, females attempt to manipulate their arousal potential by manipulating their nude appearance. A visual perception

1 setting (oftentimes, but not always, accompanied by rating questionnaires) is an established,
2 commonplace part of the ethologists' toolkit, and we, while not analyzing ratings in this
3 paper, use nude pictures presented to male viewers as a starting point. In the pornographic
4 industry, the raw materials are images and viewers; purchase of a video must be interpreted as
5 a positive rating (albeit a preliminary one, because rating occurs prior to viewing parts of the
6 video). We develop a statistical approach in order to analyze what viewers *see*, prior to their
7 rating the visual cues, which would be what they —as raters — *perceive*.
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11 Among the many methods of how images are analyzed, landmark-based methods have
12 become quite popular (Mardia et al., 2000; Slice, 2005). These methods attempt to identify
13 whether viewers can (unconsciously, perhaps) detect biological signals in images. Landmarks
14 are points in the image that are suitably uniquely defined, so that they can be statistically
15 analyzed in a suite of images. One popular application of landmark-based methods is to
16 identify symmetry and asymmetry (Mardia et al., 2000). The coordinates of those identified
17 landmarks that are outside a line/plane of symmetry — called lateral landmarks — are
18 mirrored and relabeled, generating a further set of landmarks. A Procrustes superposition of
19 the lateral landmarks and the relabeled lateral landmarks then define a plane of pseudo-
20 symmetry (Mardia et al., 2000). The sum of the squares of the (Euclidean) distances between
21 landmarks and their corresponding relabeled landmarks is then a measure of asymmetry of the
22 form. Details are described in (Slice, 2005).
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47 However, if one were to investigate whether viewers can detect asymmetry in images of
48 women posing nude, we encounter a serious problem — if we assume that asymmetry is one
49 aspect of sexiness (Thornhill & Gangestad, 1994; Thornhill et al., 1995; Gangestad &
50 Thornhill, 1997). In the conventional landmark-based scenario, the images are the result of
51 considerable preparatory care by the photographer (such as ensuring consistent frontal views,
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1 reasonably uniform lighting, absence of distracting blemishes, etc.). In the world at large,
2 subjects do not pose according to the photographer's and the researcher's regimen (Třebický
3 et al., 2016; Saribay et al., 2018). Here, we specifically deal with images of this world-at-
4 large sort. The females are not posing with, say, their neck vertical and their face in rigorously
5 frontal view, nor are they willing to prevent their head hair from falling asymmetrically over
6 their shoulders; they might even desire to suggest coyness as a sexual signal by choosing how
7 to display their (head) hair (Kerrigan, 1996). Hence we do not (and need not) define
8 landmarks, because we investigate how viewers' vision (which we mimic by AI image
9 processing) is involved in assessing the physical attractiveness and sexiness of the posing
10 nudes.
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25 There exists a considerable body of research that documents how the visual apparatus relies
26 on extracting sexiness via eye movements (smooth gaze and saccades). Saccades are fast
27 movements of the eyes from one fixation point to another (Holland & Komogortsev, 2013)
28 and what we perceive as a smooth gaze in reality consists of rather fast twitches (further
29 details in Hessels et al., 2018). Focusing or gazing rarely relies on landmarks — if at all.
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31 Conventional studies have defined ROI (Regions of Interest — *plural*), an approach critics
32 have found wanting, as ROI are usually defined by researchers. With the advent of AI-based
33 image processing algorithms, ROI need no longer be defined by the researchers, but by
34 regions of high saliency (Karthikeyan & Muneeswaran, 2015). If we are interested in
35 determining how viewers appraise the nudes, we must take into consideration that visual
36 perception via landmarks may not be as strong as that via saliency map regions and key
37 points. Saliency regions and key points drive the human visual apparatus's response to
38 (visual) stimuli. We therefore need not define ROI, but let unsupervised AI-driven image
39 processing detect ROI for us.
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1 Eye-tracking studies have shown that gaze patterns are the same for both hetero- and
2 homosexual males and females (Dixson et al., 2010; Dixson et al., 2011; Garza et al., 2016;
3 Apostolou et al., 2017; Widman et al., 2019).

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7 Analysis of eye-tracking studies that attempted to (separately) evaluate aesthetics and
8 asymmetry show that there exist two different gaze patterns, with the aesthetic evaluation
9 being more uniformly distributed over the whole female form, while the fixation point
10 distribution is highly laterally asymmetric. Not surprisingly, researchers have dealt with the
11 issue of whether some fixation points are likely to be around the areolas (Garza et al., 2016;
12 Pietruski et al., 2019); study outcomes have, however, been inconclusive. This region is also
13 challenging from another aspect, because areola skin coloration changes to darker in many
14 women, the abruptness of the change (mathematically: the change in the derivative of the
15 radial skin tone function) depending on the surrounding skin tone.
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30 It has long been argued that the shape of the female body is of primary sexual interest
31 (Thornhill & Grammer, 1999; Singh et al., 2010; Bovet et al., 2016). However, the issue of
32 ornamentation (in contrast to ornament) has added a new aspect to body shape investigations.
33 Thornhill & Grammer (1999) support their argument that the whole body (front and rear)
34 constitutes an ornament with signaling quality by calculating the correlation between facial
35 and body attractiveness. As we point out in our analysis, correlations of encoded categorical
36 random variables are a statistically unsupported analysis method. An unexpected relationship
37 between facial and body images was found () for the same images used in
38 this paper. found that the facial appearance is more important for the
39 judgement of physical attractiveness, whereas body sections are for sexiness; the body *in toto*
40 is not an ornament *per se*. If so, which sections define ROI? How are these to be found and
41 how great is their signaling strength?
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One approach is to find comparable effects in non-humans, especially in some species of birds, where ornamentation plays a major role in mate attraction (Diamond, 1998). If we concur with Diamond (1998), we will predict that ornamentations of the *labia majora* and the *mons pubis* are such ornamentations. As we show below, we indeed find support for this interpretation of the usefulness of ornamentation to signal sexiness, but not universally; ornamentations are neither the same across all (female) nudes nor the *sole* signal of sexiness.

Another possible approach to evaluate sexiness is to use computer-generated models with exact lateral symmetry (Bovet et al., 2016). One interesting finding involving sexuality studies is that the gazing pattern hardly relates to information gained from the viewing pattern (Bovet et al., 2016). Gazes are not laterally symmetric, it was found. For example, there are visual cues that demand attention, such as a mole on the skin, which destroys lateral symmetry (Wei et al., 2016; Qianqian et al., 2016). We pursue this cueing and attention-generating aspect in greater detail in this study.

Our approach involves inventorying those cues and ROI that are available to male viewers while they appraise the sexiness of the female nudes. We replace a pre-specified list of ROI by employing an unsupervised approach: we develop a saliency map and let the image processing algorithms localize regions of high saliency, which we call saliency patches. These saliency patches are the ROI for this study. We also need to find key points in the images; these are (visual) cues. The posing nudes may have, in addition to their body features, tattoos, piercings and varying head (and occasionally body) hair styles. These are intentional, manipulative additions by the posing females: they want to appear uniquely identifiable and sexy. They want to seduce — not necessarily all beholders, but perhaps those they (unconsciously) consider potential consumers of the porn videos they strive to be acting in — or in the case of partnership — the male they want to copulate with. One research question

then focuses on: How effective is each nude's saliency map (by location and number of saliency patches) and key points in order to seduce potential viewers? A follow-up question is: Is there an asymmetry in the distribution of these saliency patches and/or key points?

Materials and Methods

Target stimuli

15 females who participated in a casting for participation in pornographic movies were photographed while they posed standing upright and naked. Based on the recruiting scheme of the video producing company, we know the females posed with the intent of appearing sexually arousing, and therefore did not all have the same upright stance, the same facial orientation, the same tattoos, etc.

AGAST key points

One theme in this paper is the issue which points can be used for assessing arousal morphology and, by extension, which points are needed if landmarks are not available or are not included in the list. In image recognition software, various algorithms are used to detect key points. We use the Adaptive and Generic Corner Detection Based on the Accelerated Segment Test (AGAST) algorithm (Mair et al., 2010) to detect the 10 key points with greatest strength. We know from the literature (Zhou & Yu, 2021) that seven to eight fixations are optimally used by the human visual system. We have added a 25% margin to ensure reliability without introducing noise.

The first step in determining asymmetry using AGAST key points is to tally the ones that are to the right and to the left of the midline. Figure 1 shows an example of AGAST key point distribution of a posing nude.

Saliency maps

Saliencies are regions in an image that have an enhanced signal relative to their surrounding pixels; it is the region in an image or scene that attracts visual attention. There exist several algorithms to detect saliencies; we use the image signature algorithm developed by (Karthikeyan & Muneeswaran, 2015). Figure 2 shows the steps to find saliency patches for one female. We first construct a contour map of the saliency intensity (Figure 2a), then find the output of the image signature algorithm (Figure 2b) and construct patches for likelihoods above threshold (97.5% of $\mathcal{L}_{\max}$) that are within the outer contours of the nude image (Figure 2c). We inventory the distribution of saliency patches over the image of the body for all nudes, each nude separately. As both the nude identification number and the location of the patches are categorical variables, we use correspondence analysis (CA; Greenacre, 2007) to find strongest associations. Because patches on the legs and axial/midline patches contribute predominantly to noise (Figure 5), we restrict ourselves to the patches on head, face, arms and torso.

Bayesian likelihoods and clustering

Bayesian statistical analysis is based on the paradigm that the probability s is a random variable (Kruschke, 2015) and the most likely probability is the mode of the likelihood function of s . If s is the probability of no asymmetry, then the likelihood function for n_1 cases of no asymmetry and n_2 cases of asymmetry is a Beta distribution

$$pdf(Be(n_1 + 1, n_2 + 1), s) = \frac{\Gamma(n_1 + n_2 + 2)}{\Gamma(n_1 + 1)\Gamma(n_2 + 1)} s^{n_1} (1 - s)^{n_2}$$

where $\Gamma(\cdot)$ is the Gamma function (Weisstein, online). To find the uncertainty of the mode (specifically, the 95% confidence interval about the mode), we calculate the highest density interval HDI_{95%} (Kruschke, 2015). If this interval overlaps the probability of randomness ($s = \frac{1}{2}$), then the probability of asymmetry is not significant at this 95% significance level. We note

that a 95% significance level is a very severe measure (in Bayesian statistics) of non-randomness, and therefore, by inference, a very severe measure of asymmetry not due to chance.

We can detect the clustering of the key points of the nudes by applying an AI (artificial intelligence) neural network — in this paper an auto-encoder (Murphy, 2012; Mohri et al., 2018; Kelleher, 2019) to obtain a dimension reduction and then using kernel density estimation (KDE; Murphy, 2012; Hastie et al., 2017; Strang, 2019) to find regions of high likelihood. If the likelihood surface obtained by KDE is multi-modal, then the registrations near each of the modes form a cluster (as in Fig. 3: there are three modes and three clusters).

Correspondence analysis

As pointed out in the Introduction section, correlations cannot be calculated for categorical variables; rather, associations between realizations of categorical variables must be calculated. As there are (only) two random categorical variables (nude number and saliency patch region), correspondence analysis (CA) is a rigorous statistical analysis procedure (Greenacre, 2007; Beh & Lombardo, 2014). CA uses singular value decomposition (SVD) of the (re-normalized) contingency table of the registrations. The associations are detectable by finding a clustering of the scores of one categorical random variable versus those of the other categorical random variable in a 2D or 3D plot. We use the DBSCAN algorithm (Ester et al., 1996) to detect these clusters, because, in addition to other advantageous properties, this algorithm is an unsupervised one (i.e. it also detects how many clusters exist).

We look not only as to whether the nudes are asymmetric, based on salient patch distribution and based on AGAST key points distribution, but also whether specific salient patches inform us as to possible saccadic eye movements that not only may influence how viewers appraise the nudes overall, but may also specifically mislead viewers by (‘eye-catching’) ornaments

that either override or enhance the generation of saliency patches. If we are interested in asymmetry, we look at how asymmetric the full nude ‘stills’ are, both with respect to the AGAST key points and with respect to the saliency patches.

Results

Table 1 shows the probability of an asymmetric distribution of AGAST key points, nude by nude. If we choose to find the significance level using Bayesian likelihood methods, and accept an HDI_{95%} uncertainty interval for a significance measure (Figure 4), then only four nudes (#1, #2, #6, and #8) are significantly asymmetric. If we use Bayesian statistics to infer whether asymmetry of AGAST key points is a likely phenomenon, we obtain the analysis outcome shown in Figure 4. The ML probability that AGAST key points are asymmetrically distributed in the image of a nude is 0.267 and this low probability is significant at 95% significance. In other words: only in $\sim \frac{1}{4}$ of nude images will an asymmetry of AGAST key points be detected. The fact that the HDI_{95%} uncertainty does not overlap $s = \frac{1}{2}$ indicates that the sample size of 15 nudes is *not* too small for this analysis.

The AGAST key points of the nudes are gathered (by the KDE algorithm) into three clusters (Fig. 3). We infer that the nudes in the different clusters present differently distributed fixation points to the viewers. This implies that there are three types of signaling that this casting session has ‘harvested’. We also note that one nude (#13) is an isolate that does not cluster with the other nudes. She may be a further type that could be underrepresented in this casting session.

The prism chart of frequencies of occurrences of saliency patches in different body regions (Fig. 5) shows that in localized regions there is an asymmetry of saliency patch frequencies (such as left versus right torso). We observe, for instance, that, for nudes #2 and #3, there are

no saliency patches on the left head, yet some on the right. Figure 6 shows how these regions of saliency patch asymmetry associate with nudes. We infer that these asymmetrical distributions trigger a different degree of arousal of the viewers (not necessarily a high one for every viewer). We note that the asymmetric distribution of saliency patches is highest in the left arm (for 11 nudes; $\sim \frac{2}{3}$ of the sample). We conclude that saliency patches rigorously specify ROI. Whereas several investigations of saccades and gazing (Bovet et al., 2016) compare the eye movements of different viewers in the ROI defined by other research teams, we use AI-driven detection of saliency patches to identify ROI; we do not *specify* ROI *a priori*. A further result: ROI for different nudes vary; ROI pre-defined by other researchers do not.

An important, unexpected discovery was the observation of how piercings, tattoos, etc. can influence saliency, while AGAST key points do not. In Figure 7, we show how some ornaments ‘create’ saliency patches that would otherwise not exist. We note how effective piercings with jewelry and tattoos can be used (by the female) to *force* ROI thereby defined. We provide evidence by noting that similar body regions *without* such piercings or tattoos are not saliency patches. In an undertaking such as choosing potential nude models for acting in a porn video, this may be an advantage, comparable to a female seducing a potential sexual partner in the world of reproductive biology — dependent on the male viewers’ arousal levels! For practitioners of geometric morphometrics, on the other hand: our discovery of how saliency patches are not consistently distributed among nudes, and the inference that the (saccadic) gazing by viewers contributes to distracting from looking at landmarks, the message is: the assumption of *rating* the organic form based on the (geometric) location of landmarks in order to detect variations of biological forms *can* be fraught with difficulties.

Because the implementation of piercings, tattoos, depilation regions, etc. are intentional ruses employed by the posing nudes, we use AI to elaborate on how these ruses come about. Clearly, a saliency patch of a tattoo (Fig. 7; Nudes #1 and #6) or a piercing (Fig. 7; Nudes #1, #3, and #12) is detected by the image signature (saliency) algorithm. All saliency patches shown in Figure 7 possess the expected strong image signature (outputted by the algorithm we use to detect saliency patch contours; Fig. 2), namely, that the local contrast in brightness, color gradient, etc. is high. When piercings involve sparkling jewelry (Fig. 7; Nudes #1, #3, and #12), then the effect of forcing a visual fixation is easily achieved. Likewise, a tattoo of black ink on a whitish skin is also effective (Fig. 7; Nude #6). It is important to point out that the described contrast is predominantly possible for females of Caucasian ethnicity (as is our sample), or, more generally, lighter-skinned individuals; other techniques may be needed in the case of darker skinned individuals (Grimes, 2008). But visual fixation can also be generated by a sharp contrast of whitish *labia majora* against the backdrop of an almost black entrance to the vulva (Fig. 7; Nude #12). If this contrast between outer labia and vulva entrance is not high enough (as in Fig. 7; Nude #1 and #6), the outer labia do not generate a saliency patch. (This is one reason why it is not uncommon for nude actresses in pornography videos to bleach the roots of their pubic hairs —after, of course, having depilated their *mons pubis*.) Only in one image (Fig. 7; Nude #12) does one areola generate a saliency patch (out of a total of 30 areolas — 3%; the claim by Pietruski et al. (2019) is not supported by our findings). We dwell on this topic of artificially added or naturally occurring ornamentations because, we argue, they strongly influence the fixation of the viewers and they are much more effective arousal mechanisms than any landmark perception.

Discussion

1 The current analysis does not compare the eye movements with the saliency patches nor with
2 the AGAST key points — we do not imply they are independent. In this paper, we focus on
3 showing which algorithms detect which (possibly asymmetric) features that are to be found in
4 an image of a nude posing for a ‘still’. While the nudes were certainly intentionally posing
5 provocatively (in the sexually arousing sense), the saliency patches and the AGAST key
6 points did not detect many significant asymmetries. This implication of significance does not,
7 of course, imply a significant lack of asymmetry if landmarks were used. It does imply that
8 saliency patches need not be asymmetrically distributed, but perhaps within certain regions of
9 the body they are.

10
11 Detecting AGAST key points is a powerful algorithm that successfully mimics the human
12 visual system, and saliency patch identification algorithms even more so. The latter are part of
13 automated, unsupervised image recognition search techniques used, for example, to detect
14 partially hidden or lost humans, etc. in remote or difficult-to-access geographies. Here, we
15 document why tattoos and piercings are powerful fixation strategies that females use to
16 augment their visual sexiness; we infer that not only nudes casting for participation in
17 pornographic movies employ them. In the world at large, potential brides hoping to ultimately
18 become mothers most certainly do. Our discoveries elucidate the limitations of arguing the
19 whole female body is an ornament.

20
21 However, consider this question: “Why not combine the saliency patch distributions with the
22 AGAST key points distribution, nude by nude?” If we were to do so, we would be adopting a
23 misleading procedure. Modern image processing software that attempts to recognize faces,
24 bodies or other organic forms executes a considerably large suite of image analysis algorithms
25 and combines their outputs (often in proprietary software packages). We don’t consider the
26 use of only these two image processing algorithms to adequately simulate proprietary

software packages. We do demonstrate that the use of landmarks need not be included in a visual perception study. Statistical analysis of distributions of saliency patches and of AGAST key points suffice to present the mechanisms of males' perceptions of sexiness.

The question that is central to evolutionary approaches is whether the ornamentation supplies a benefit to the female beyond visual sexiness; concretely, whether (biological) fitness can be positively enhanced. The hypothesis of the human body surface as a canvas postulates that there is an association between high fitness and the presence of body modifications (Lynn et al., 2019). This question has been rarely asked in the case of women; in traditional cultures — mostly, but not solely — men were shown to gain status by having permanent and semi-permanent body modifications which serve as an extremely costly yet honest signal of good immunity and pathogen resistance, due to the dangerous techniques used (Buss, 2015). In studies about body modifications of women in 'Western' cultures, the tattoo is considered a norm violation. It could be positively evaluated by those who search for it — such as porn viewers — and the signal will be considered a positive one within such a community (Swami & Furnham, 2007). Molloy and Wagstaff (2021) hypothesize that in both sexes the tattoo can also serve the purpose of intrasexual competition. It can therefore also be considered a visual feature when competing for attention via visual cues (Drenten et al., 2020) — an aspect consistent with our findings, most notably because the posing nudes compete with one another for being hired to act in a porn video.

Conclusions

If we maintain that sexual arousal is part of the repertoire employed by females to seduce (in contrast to attract; more specifically, *after attracting*) a male partner of her choice, then signaling sexiness is a method that must have been the outcome of an evolutionary selection process for human females — in a reversal of the iconic peacock's tail. We emphasize that

1 this arousal mechanism is a prerequisite for reproductive success. Our detection of saliency
2 patches and AGAST key points and their distribution among nude images can be seen as
3
4 contributing to the rhetoric of human sexual ethology — and having an evolutionary
5
6 psychology basis, not a culturally constructed one. The biology of (uncontrollable) eye
7
8 movement is, arguably, difficult to reconcile with the notion of a social construct. We provide
9
10 artificial intelligence analysis to show some possible mechanisms in human visual appraisal
11
12 of a female’s nude appearance (specifically: response to feature signaling), thus building a
13
14 bridge between what the eye sees and the brain perceives on the one hand versus the biology
15
16 of human sexual arousal that is not culturally constructed on the other. Females primarily rely
17
18 on the visual cues that saliency patches and AGAST key points produce to evaluate potential
19
20 advantages over competing rivals. Curiously, these signals also arouse females themselves
21
22 sexually — evidenced by them preferentially watching heterosexual pornographic videos
23
24 (Ogas & Gaddam, 2011). Males are aroused by images of nude females with those saliency
25
26 patches and AGAST key points that match *their* (the males’) criteria of a desirable sexual
27
28 partner — criteria that vary among males. We have also found (via algorithms) the
29
30 effectiveness of ornamentations in defining and generating visual fixation points — an issue
31
32 that, as far as we can ascertain, has not been adequately, rigorously statistically analyzed in
33
34 previous publications. Defining ROI with saliency patches prior to statistical analyses is a
35
36 more advanced approach than meta-analyzing published studies that rely on ROI predefined
37
38 by researchers. By using AI to find ROI, we extract biological cues that would remain
39
40 undetected in studies that compare predefined ROI.
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51 **Ethics Statement**

52 [BLINDED]
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58 **Acknowledgments**

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Disclosure Statement

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Conflicts of interest/Competing interests (include appropriate disclosures)

The authors declare no conflict of interest.

Availability of data and material (data transparency).

Since the pictures of nude women may be found disturbing by some readers, we will provide the files upon request (please contact the authors).

Code availability (software application or custom code)

We have used Wolfram Mathematica and their proprietary codes to analyze the data, more details on specific decisions can be found in method section.

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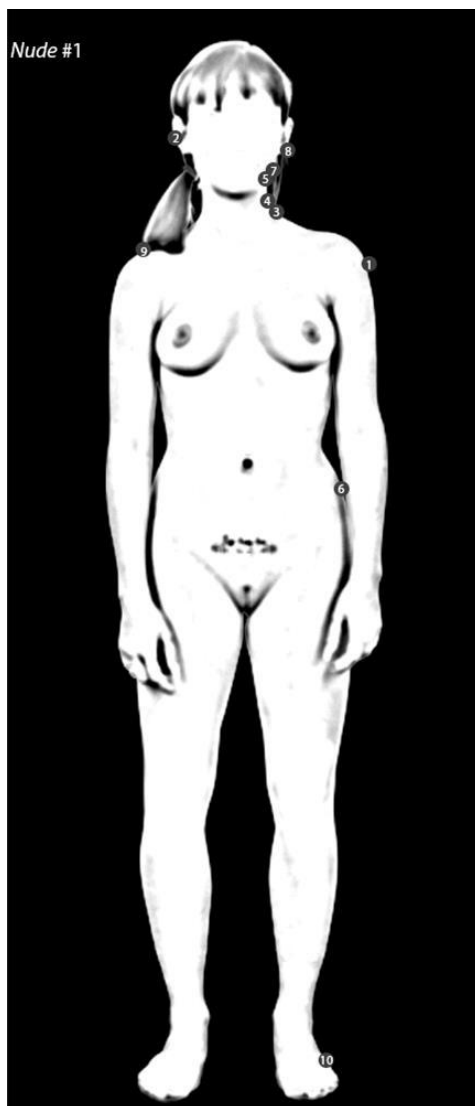
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Table 1 The modes and level HDI_{95%} uncertainties of the likelihood function of the (Bayesian) probability s of right asymmetry distribution of the ten highest strength AGAST key points, nude by nude.

Nude #	SML	s_1 to s_2
1*	0.200	0.0406–0.484
2*	0.800	0.516–0.960
3	0.500	0.212–0.788
4	0.500	0.234–0.766
5	0.400	0.159–0.682
6*	0.800	0.516–0.960
7	0.667	0.367–0.893
8*	0.100	0.00630–0.368
9	0.700	0.412–0.907
10	0.700	0.412–0.907
11	0.600	0.318–0.841
12	0.400	0.159–0.682
13	0.600	0.318–0.841
14	0.556	0.268–0.818
15	0.667	0.367–0.893

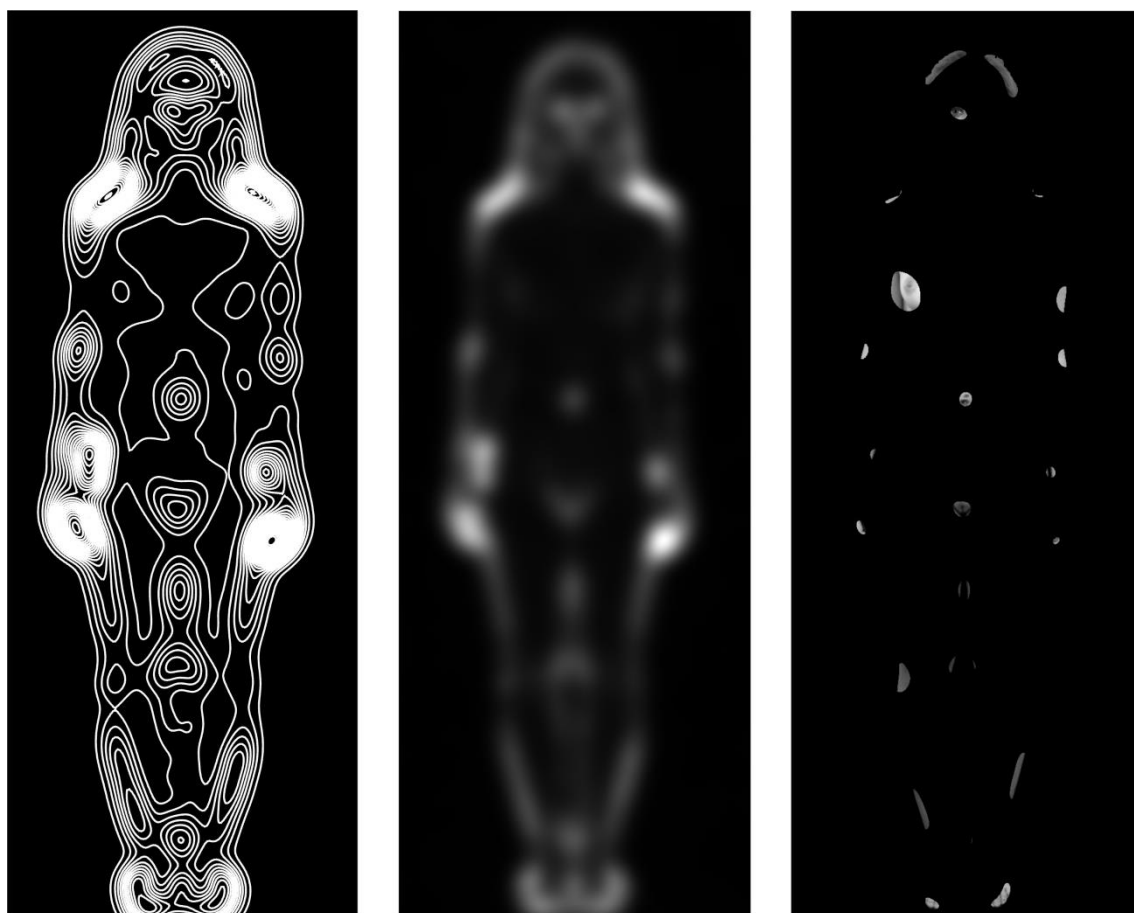
The medial key points are excluded in the tallying. The significance level (HDI_{95%}) for the uncertainties in the maximum likelihood is 95%. For four nudes marked with an asterisk (#1, #2, #6, and #8) the mode does not overlap $s = \frac{1}{2}$; the distribution of their 10 strongest AGAST key points is therefore significantly asymmetric.

Figure 1. The 10 strongest AGAST key points of Nude #1, superimposed on her (darkened) image.



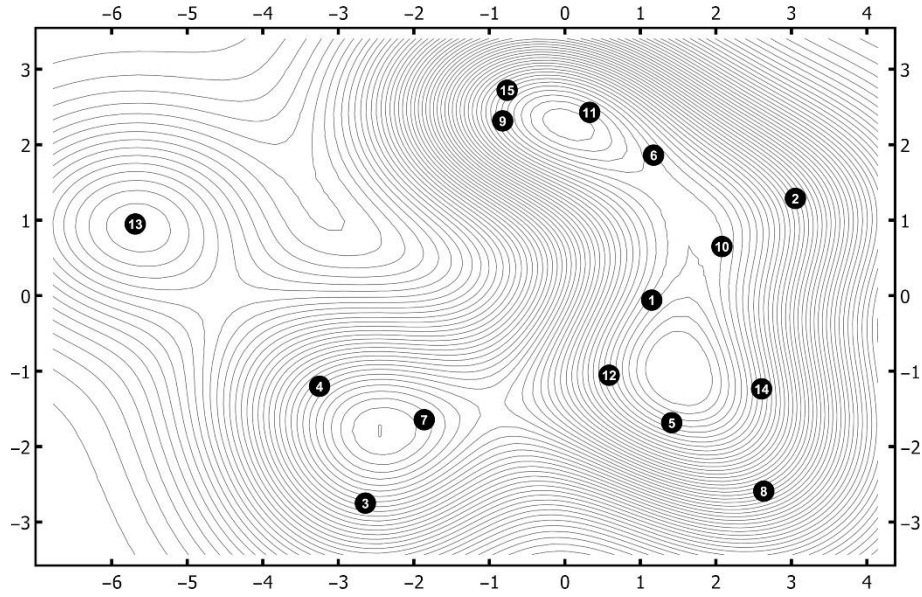
These AGAST key points are all on the outline: eight on the left outline and only two on the right outline; the AGAST key points distribution is asymmetric. No AGAST key points had been detected in the region(s) of the face that was made invisible to ensure anonymity of the model – the facial feature deletion was performed after the visual analysis.

Figure 2. The image processing steps that detect the saliency patches in the images of the nudes.



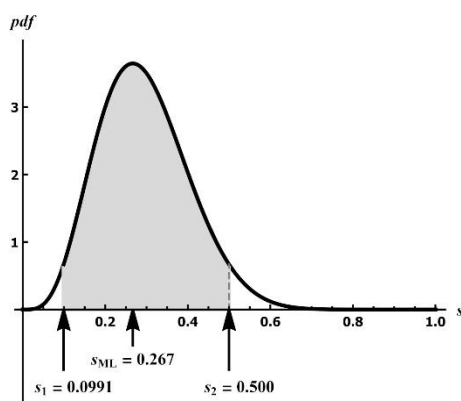
The sequence shown here is for Nude #12. Left: The contour plot of saliency density of the image. Middle: The saliency on an image-adjusted 16-bit grayscale. Right: The overlay of the $\mathcal{L} \geq 0.975\mathcal{L}_{\max}$ patch with the (grayscale) image. The contour plot shows asymmetry — as does the saliency map. For this nude, the right eye has a significant saliency, while the left eye does not. Two patches are along the ‘symmetry’ midline: (i) the navel patch and (ii) the outer labia patch (both details are shown in Figure 7).

Figure 3. The contour plot of the likelihood function for the distribution of the 10 strongest AGAST key points per nude.



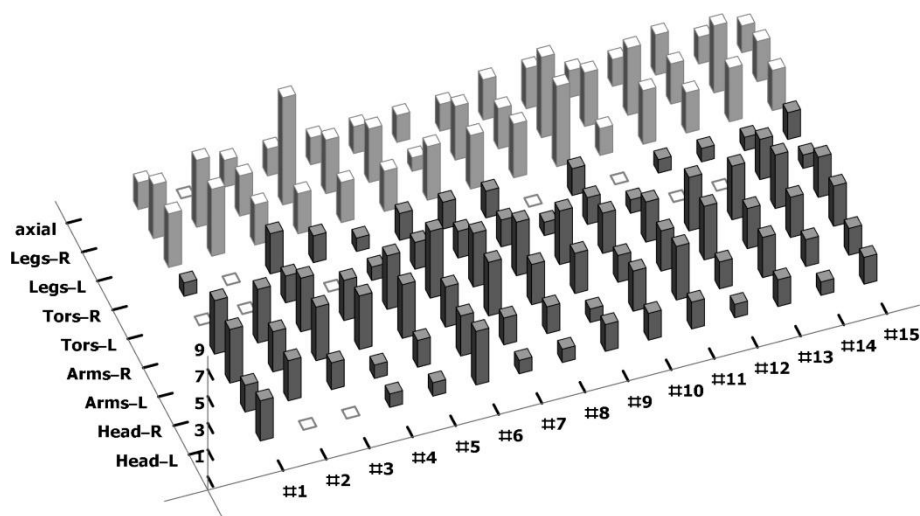
Locations (derived by using an auto-encoder to reduce the dimensions to 2D) of the nudes are labelled in white on a black disc. Black contours are lines of constant likelihood, obtained by using a kernel density estimation (KDE). There exist three clusters of nudes (#3, #4, #7; #1, #5, #10, #12, #14; #6, #9, #11, #15), based on their 10 strongest AGAST key points, and one isolate (Nude #13). The clusters differ in extent and likelihood. Nudes #8 and #2 can be associated with clusters, but with a low likelihood. Five nudes are in the largest cluster.

Figure 4. The likelihood function of the (Bayesian) probability s for observing asymmetry in any of the 15 nudes in this data set.



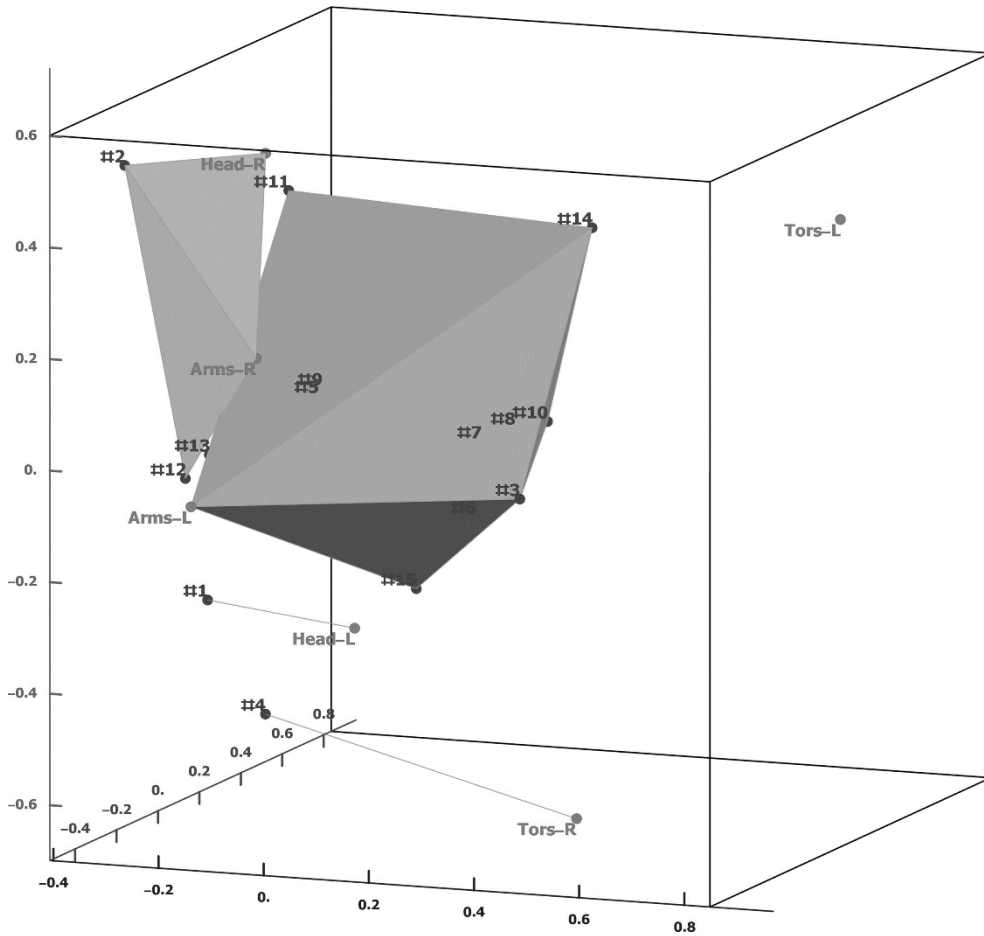
The HDI_{95%} uncertainty interval (Kruschke, 2015) [29] just ‘touches’ the randomness probability $s = \frac{1}{2}$, so the observation of asymmetry of AGAST key points for some nudes (four in our data set; Table 1) is significant; the likelihood function with these parameters also infers that the sample size is large enough to find a significant (Bayesian) effect.

Figure 5. The frequencies of saliency patches in the specified regions of the nudes, dependent on nude identification number and nude image region.



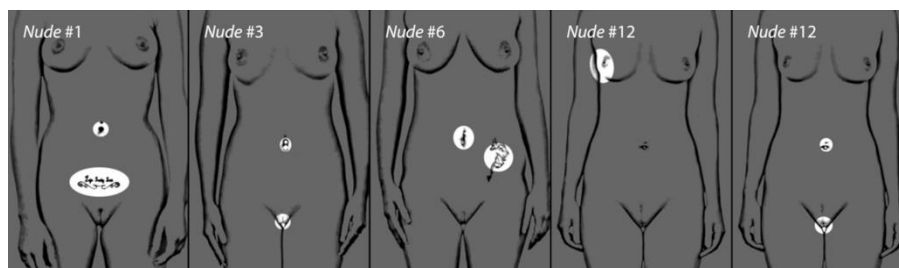
We use the patches in the category regions shown as dark gray prisms for the correspondence analysis (left/right torso, left/right head, and left/right arms). The regions (prisms in light gray) left leg and right leg (including feet) contribute primarily to noise in the correspondence analysis (not shown).

Figure 6. Associations of asymmetric saliency patches for the 15 nudes obtained via correspondence analysis.



The convex hulls show which nudes have the strongest association with the specified body part asymmetries. For example, Nudes #2 and #12 most strongly associate with an asymmetrical head. Whenever only one body region associates strongly with only one nude, then the convex hull degenerates into a line. We observe that the asymmetry of saliency patches of the left arm asymmetry associates with the largest fraction of nudes (namely, $\sim \frac{2}{3}$). The saliency patches of the left torso associate with none of the nudes.

Figure 7. Details of the saliency patches of a few selected nudes.



These images show the effects of (1) using tattoos (Nude #1 and #6); (2) navel piercings (Nude #1, #3, and #12); (3) clitoral piercing (Nude #3); (4) a marked contrast between areola and surrounding mammary skin (Nude #12); (5) the contrast between the outer labia and the smooth, depilated, light-skinned *mons pubis* (Nude #12). Nude #3 has a dark-skinned pubic region, so the jewel on the piercing between the outer labia (most likely a clitoral hood piercing) does indeed trigger a saliency patch, and, by inference, an involuntary saccadic eye movement response by the viewer. The nude images have been darkened and schematized (post-analysis) using image processing software, so the saliency patches appear starkly as white patches; the (human) visual system does not need to rely on such software enhancement.

Machine Learning Detects Pairwise Associations between SOI and BIS/BAS Subscales, making Correlation Analyses Obsolete

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ABSTRACT

We use AI techniques to statistically rigorously analyze combinations of query responses of two personality-related questionnaires. One questionnaire probes aspects of a participant's character (SOI) and the other avoidance of aversive outcomes together with approaches to goal orientated outcomes (BIS/BAS). We use

one-hot encoding, dimension reduction with a neural network (a seven-layer auto-encoder) and two clustering algorithms to detect associations between the twelve combinations of SOI and BIS/BAS groups. We discover that for most combinations more than one association exists. Traditional, fallacious statistical methods cannot find these outcomes.

Keywords: One-hot Encoding, Autoencoder, Neural Networks, DBSCAN Clustering, Spectral Clustering, BIS/BAS, SOI, Heat Maps

INTRODUCTION

In the fields of psychology, sociology and medicine it is common to use questionnaires to evaluate manifestations of certain traits or states. To do so, researchers habitually rely on aggregations of multiple Likert-type questions to compute an index. Because all responses are categorical/ordinal variables, it is fallacious to convert these to cardinal (computable) integers in a trivial linear mapping. We are thus challenged to analyze the responses in a statistically rigorous manner.

We use two questionnaires:

- (a) “Revised Socio-Sexual Orientation (Index)” (SOI-R; Penke, & Asendorpf, 2008). This questionnaire probes aspects of each participant’s tendencies for uncommitted sexual behavior. It has three groups of queries, ‘Attitude’, ‘Behavior’, and ‘Desire’. There are five options for each query (Table 1). (In this paper, we use the shortened label SOI for SOI-R.)
- (b) “Behavioral Inhibition and Behavioral Activation Scale” (BIS/BAS; Carver & White, 1994). There are four groups of questions, one probing motivation to avoid aversive outcomes (‘Inhibition’) and three probing the approach to goal-oriented outcomes (‘Fun’ Seeking, ‘Reward’ Responsiveness, and ‘Drive’). Not all groups have the same number of queries. There are four options for each query (Table 1).

Since a linear trivial mapping is not valid, we can neither compute indices nor correlations. Even though these assumptions are violated, correlations are often accepted by reviewers and editors, despite warnings (Hoekstra et al., 2012). We present one modern, rigorous statistical method in the context of our field — sexuality research — that reveals the associations between inhibition, activation and tendency for uncommitted sexual activity.

MATERIALS AND METHODS

891 participants aged 18–50 responded to all queries in the survey. First: for each query, we convert each response to a vector via one-hot encoding (Murphy, 2012). The vectors of the many responses are then concatenated to form a feature vector.

Each respondent, therefore, has an associated feature vector of length determined by the total number of options for all the queries in the group combination.

The feature vectors have a (very) high dimension (namely, between 31 and 43, depending on the number of queries in the questionnaire section), so a conventional analysis using SEM or some other model will be invalid because of the ‘curse of dimensionality’. Components for each participant’s feature vectors are not linearly independent, and the feature vectors of all participants have (nonlinear) interdependencies among one another as well. It is these two interdependencies we are interested in.

Table 1: Listing of the response options for each BIS/BAS category and each SOI category.

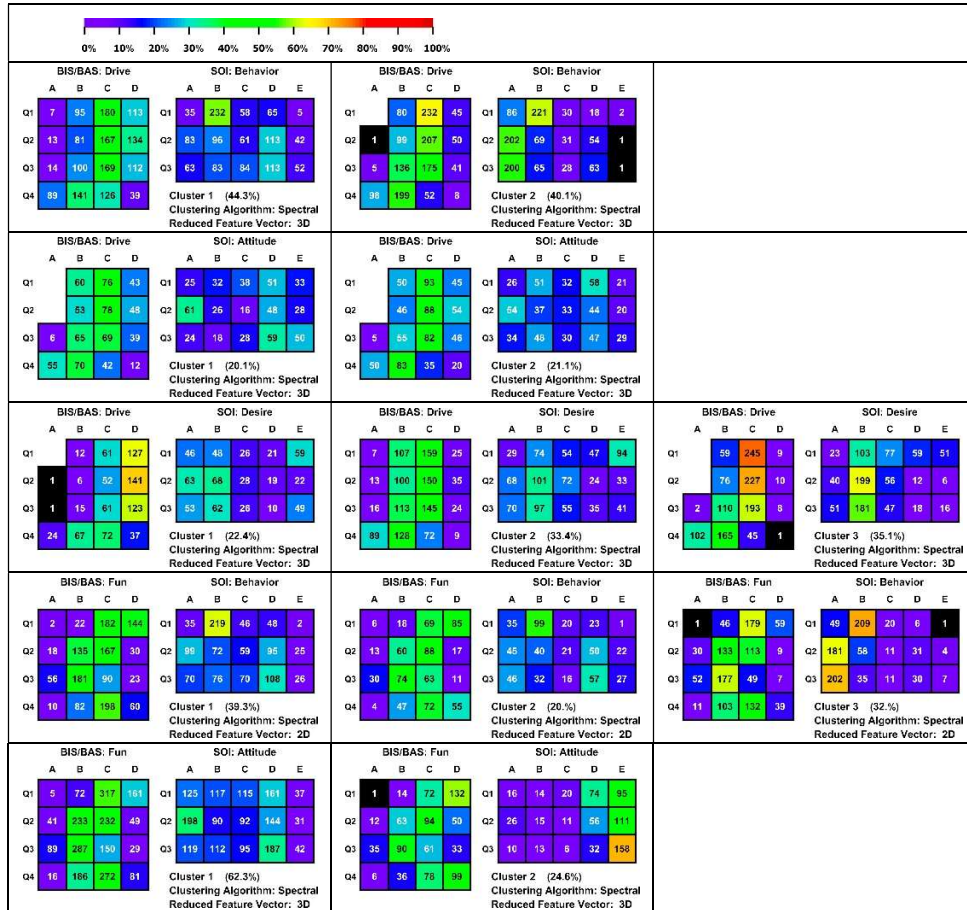
Probe	Ordinal Categories	Response		
		Behavior	Attitude	Desire
SOI	A	Zero	Strongly disagree	Never
	B	One	Disagree	Very seldom
	C	Two to three	Neutral	About once a month
	D	Four to seven	Agree	About once a day
	E	Eight or more	Strongly agree	Nearly every day
BIS/BAS	A	Very false for me		
	B	Somewhat false for me		
	C	Somewhat true for me		
	D	Very true for me		

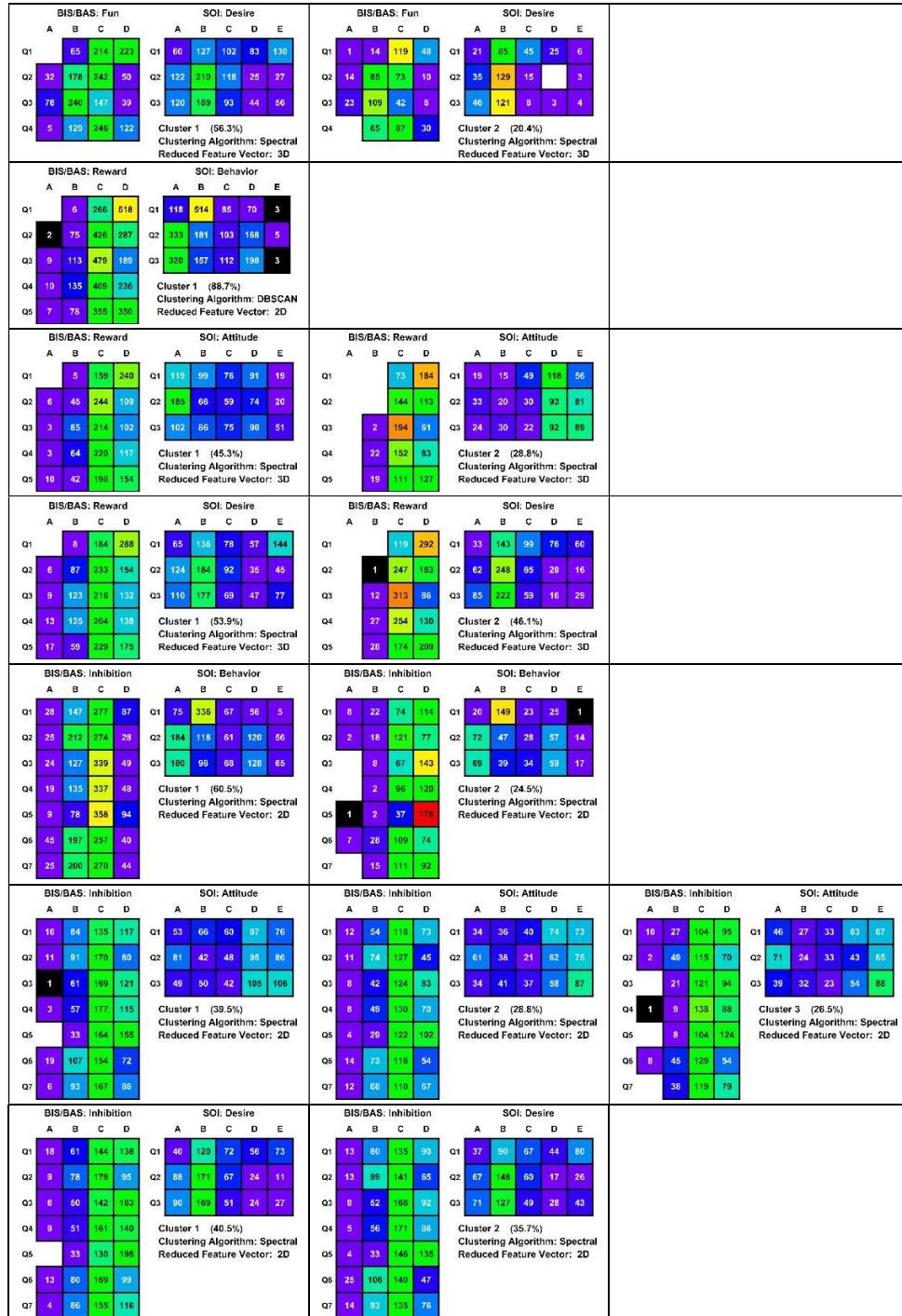
We generate dimension-reduced feature vectors by applying a neural network (specifically: an autoencoder (Goodfellow, 2016) with seven layers), to each combination of SOI and BIS/BAS groups. For every SOI and BIS/BAS combination: (a) We search for clusters in the dimension-reduced feature vector space, using the unsupervised Spectral (Ng et al., 2002) and DBSCAN (Ester et al., 1996) clustering algorithms. We thus have 4 cluster spectra for each combination (each clustering algorithm is applied in 2D and 3D). (b) We determine meaningful associations by choosing membership probabilities above 20% in the clusters of each combination. (c) We “backtrack” for positions of cluster membership to feature vector positions. (d) We construct heat maps of membership percentages in the chosen clusters.

RESULTS

We discover that, for most SOI with BIS/BAS combinations, more than one cluster (and thus more than one association) was detected (Table 2). For each association between a BIS/BAS and SOI combination, cluster membership varies between 41.2% and 100%. Most associations contain 80% to 90% membership (Fig. 1).

Table 2: The heat maps for each association cluster of BIS/BAS responses with SOI responses. Cluster number, probability of the cluster membership, clustering algorithm, and reduced feature vector dimension are listed. Percentage scaling is shown; the colors of the squares in the heat maps are the percentages of the responses for each query separately. The numbers within the squares are the frequencies of members.





We determine the probability of cluster membership by calculating the fractions of member numbers in a cluster relative to the total number of survey participants (891). Because the sample size is large, using the Laplace paradigm for these probability calculations is justified.

Only one combination has only one cluster; it is also the only cluster that was detected using the (unsupervised) DBSCAN clustering algorithm (Ester et al., 1996). All other associations were found with the (unsupervised) Spectral clustering algorithm (Ng et al., 2002). Not all clusters were in three-dimensional reduced feature vector space (Table 2).

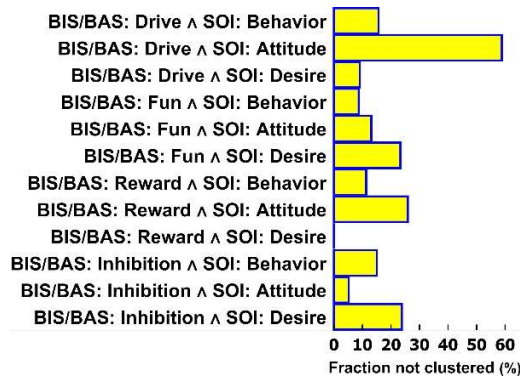


Figure 1. The fractions of membership that are *not* clustered. For one association, all members are in one cluster only ('Reward' vs. 'Behavior', Table 2). For one association ('Reward' vs. 'Desire', Table 2), no members are not clustered. For the combination 'Drive' vs. 'Attitude', membership in any cluster is least.

For some BIS/BAS with SOI combinations, associations occurred with high probability (Table 2). This implies that, for some combinations of BIS/BAS and SOI, associations were very pronounced. Because only one association was limited to only one cluster, we point out that for all the other 11 combinations, more than one association occurred.

Because of space limitations in this paper, we highlight cluster comparisons for only three BIS/BAS and SOI combinations. We specifically avoid psychological interpretations and implications of the highlighting, and focus on comparisons of how responses are skewed in one or both clusters, as discovered by AI.

In the 'Inhibition' vs. 'Behavior' combination, Cluster 1 has predominantly 'C' responses (with a mild contribution of 'B') for 'Inhibition', while Cluster 2 has predominantly 'D' responses for 'Inhibition' (especially for query 'Q5'). In both clusters, the distribution of responses for 'Behavior' is close to equal. We conclude that the responses to 'Inhibition' queries drive the segmentation of the clusters.

In 'Fun' vs. 'Attitude', the responses to 'Fun' queries in both clusters are close to equal, while the responses to 'Attitude' are not. In Cluster 1, responses to SOI queries

are skewed towards ‘A’ and ‘B’; in Cluster 2, responses for all three SOI queries are almost exclusively ‘E’. We conclude that the responses to ‘Attitude’ queries drive the segmentation of the clusters.

In ‘Reward’ vs. ‘Attitude’, the responses to ‘Attitude’ queries in both clusters are both skewed to responses ‘C’ and ‘D’, but in Cluster 2 more strongly. The responses to ‘Attitude’ are oppositely skewed: in Cluster 1, towards responses ‘A’, while in Cluster 2 strongly towards ‘D’ and ‘E’. In this BIS/BAS and SOI combination, segmentation between the two clusters is due to a different skewing in both ‘Reward’ and ‘Attitude’.

DISCUSSION

There exist major problems when attempting to make sense of the data obtained from questionnaires that are so often used in sociological, psychological, and medical fields; using correlational analysis is the ‘culprit’. Many experience-oriented sciences are “cursed” (let’s introduce the idiom *curse of psychology*) by the researchers trying to grasp the experiences perceived in others and convert those into queries that (by introducing a further mistake) describe members of a population on a linear scale after creating an index (to aggravate the problem even further, although this mistake had been pointed out 62 years ago; Blalock, 1960). 10 years ago, it was pointed out to psychologists that violating assumptions lead to false conclusions (Hoekstra, 2012). Our approach using AI remedies this.

We avoid the “curse of dimensionality” that occurs when including a large number of queries in questionnaires but not dimension-reducing the response vectors. If not, modeling noise is the result. Higher-dimensional spaces have properties that are counterintuitive and do not allow for easy understanding of the questionnaire outcome. Remarkably, dimension reduction not only prevents modeling noise, but has the fortunate extra feature of offering easier interpretation(s).

Furthermore, by using one-hot encoding, we have avoided the listed mistakes. We reiterate: one-hot encoding (a) does not fallaciously assign cardinal numbers to categorical variables via a linear mapping (Blalock, 1960); (b) ensures that the response vectors for each single question/statement are mutually independent (orthonormal); (c) introduces no a-priori metric; (d) allows for the detection of interdependencies (including nonlinear ones) among the components of the feature vectors; (e) allows for the detection of interdependencies among the feature vectors from the different respondents.

Fallaciously calculating the correlation between any BIS/BAS and SOI combination would yield only one value. It is impossible, therefore, to detect the existence of clusters, which provide evidence that more than one association between a BIS/BAS and SOI combination can exist. The heat maps of the clusters display the characteristics of members of the clusters (such as high frequencies for certain responses to some queries). By taking advantage of AI clustering algorithms, we are able to characterize the fact that more than one association can exist (and does in 11 out of 12 cases; Table 2) within each BIS/BAS and SOI combination.

CONCLUSIONS

By avoiding the fallacies of converting ordinal query responses to computable integers and then using a linear mapping to calculate correlations between combinations of BIS/BAS and SOI combinations, we discover that more than one association can exist between these combinations. (Fallacious calculations cannot discover this, because only one correlation exists for each combination.)

In addition, we discovered that association probabilities are usually high, and, furthermore, that only one combination ('Reward' vs. 'Behavior') has one and only one association, albeit with a high probability.

Detection of more than one association for each combination radically changes the insights regarding personality types that relate character and motivation to each participant's sexuality.

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ETHICS STATEMENT

The Helsinki Convention was adhered to at all times, throughout the presenting of the questionnaire, and during the collection of responses. We abided by the wishes of those who did not agree with the terms and conditions (these were not allowed to proceed with the study). All data were anonymized. The study is part of a set of projects and has been approved by Institutional Review Board of the Faculty of Science, Charles University, Prague (#2018/08).

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Lack of enhanced Pavlovian-to-Instrumental Transfer (PIT) in men engaging in frequent online sexual behaviour: Implications for Compulsive Sexual Behaviour Disorder

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Abstract:	Reward based learning is broadly acknowledged to underpin the development and maintenance of addictive behaviour although the mechanism in sexual compulsivity is less understood. Using a Pavlovian-to-Instrumental Transfer (PIT) task we tested whether the motivational aspect of conditioned Pavlovian conditioned stimulus invigorated instrumental responding in relation to specific compatible monetary rewards. Performance on the task was analysed between two groups of males based on Low (N = 38) and High (N = 41) self-report online sexual behaviour (OSB). Psychometric tests including sexual compulsivity scale and behavioural activation/behavioural inhibition (BIS/BAS) were also administered to determine the relationship between OSB and general reward sensitivity. We show clear evidence of acquisition in the Pavlovian and instrumental conditioning phases. Specific transfer effect was greater in the High-OSB group although the difference compared to the Low-OSB group was non-significant. OSB negatively correlated with both BIS and BAS indicative of introversion and low reward sensitivity. OSB positively correlated with sexual compulsivity although it is unclear whether individuals in the High-OSB group considered their behaviour either excessive or problematic. These findings contribute to the ongoing debate regarding the nature of problematic OSB. Fundamental differences in motivational characteristics and mechanism contributing to compulsive behaviour in relation to high-OSB might indicate incompatibility with behavioural addiction models. PIT was not enhanced in high-OSB by appetitive conditioning, although problematic OSB could stem from failure to inhibit actions. Further research should investigate whether aversive conditioning differentially affects responding in high-OSB individuals, potentially explaining perseverant behaviour despite negative consequences.
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Lack of enhanced Pavlovian-to-Instrumental Transfer (PIT) in
men engaging in frequent online sexual behaviour: Implications
for Compulsive Sexual Behaviour Disorder

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Abstract

Reward based learning is broadly acknowledged to underpin the development and maintenance of addictive behaviour although the mechanism in sexual compulsivity is less understood. Using a Pavlovian-to-Instrumental Transfer (PIT) task we tested whether the motivational aspect of conditioned Pavlovian conditioned stimulus invigorated instrumental responding in relation to specific compatible monetary rewards. Performance on the task was analysed between two groups of males based on Low (N = 38) and High (N = 41) self-report online sexual behaviour (OSB). Psychometric tests including sexual compulsivity scale and behavioural activation/behavioural inhibition (BIS/BAS) were also administered to determine the relationship between OSB and general reward sensitivity. We show clear evidence of acquisition in the Pavlovian and instrumental conditioning phases. Specific transfer effect was greater in the High-OSB group although the difference compared to the Low-OSB group was non-significant. OSB negatively correlated with both BIS and BAS indicative of introversion and low reward sensitivity. OSB positively correlated with sexual compulsivity although it is unclear whether individuals in the High-OSB group considered their behaviour either excessive or problematic. These findings contribute to the ongoing debate regarding the nature of problematic OSB. Fundamental differences in motivational characteristics and mechanism contributing to compulsive behaviour in relation to high-OSB might indicate incompatibility with behavioural addiction models. PIT was not enhanced in high-OSB by appetitive conditioning, although problematic OSB could stem from failure to inhibit actions. Further research should investigate whether aversive conditioning differentially affects responding in high-OSB individuals, potentially explaining perseverant behaviour despite negative consequences.

Introduction

There is currently a vociferous debate about the nature of compulsive sexual behaviour as it relates to “problematic” internet pornography use. Despite positive effects associated with online sexual behaviour (OSB) and the viewing of visual sexual stimuli [1,2] excessive use can become problematic and detrimentally affect an individual’s personal life and relationships [3-5]. Excessive pornography use is currently classified under the definition of compulsive sexual behaviour disorder (CSBD) in the International Classification of Diseases (ICD-11) [6]. The reinforcing nature of sexual stimuli is often cited as a motivational factor driving such behaviour (see [7]). However, the mechanism underlying perseverant problematic OSB is equivocal. The primary aim of the present study was to test whether men who scored highly for OSB (e.g., risky cybersex and risky internet pornography use) translate reward predicting cues into goal-directed actions more readily than men who do not score highly for risky OSB.

Evidence from neurobiological studies suggest augmented responses to visual sexual stimuli in attentional and reward-related brain structures (e.g., nucleus accumbens, NAc; [8-11]. This is in line with similar activations observed for substance abuse [12,13], gambling [14], and food related disorders [8,15], and suggests that some individuals are more sensitive to reward-related cues as drivers of behaviour. These individuals may therefore form obsessive and compulsive behaviours around those cues more readily than others. However, alternative explanations suggest that compulsive masturbation develops with pornography as means to stimulate sexual arousal [16]. If individuals struggle with this, or have guilt associated with engaging in such behaviour [17], then the development of augmented sensitization may be due to reward prediction errors or reward uncertainty [18,19]. This would be especially potent if viewing internet pornography and masturbation was engaged intermittently (e.g., on a partial reinforcement schedule) and/or if individuals were in a more continuous refractory period following excessive masturbation to several ejaculations (a

state that some self-identified internet pornography “addicts” call Porn-Induced Erectile Dysfunction, or PIED) [20].

Men that have a greater frequency of pornography consumption per week are actually better able to achieve erection to visual sexual stimuli in laboratory situations relative to men with a lower frequency of pornography consumption [21]. However, men with frequent but problematic pornography consumption who also have high sexual desire show a blunted processing of visual sexual cues [22], suggesting some attempt at active inhibition. It is also possible that individuals that consume more pornography generally have attentional and reward-related brain systems that are driven naturally toward highly valued incentives. It follows that such individuals would display enhanced sign-tracking of high reward value goals.

Pavlovian reward predictive cues can become imbued with motivational salience that promotes the likelihood of repeated exposure [23]. In addition, positively reinforced instrumental responding increases the likelihood of repeating an action. Pavlovian Instrumental Transfer (PIT) allows these two paradigmatic elements to interact when the motivational aspect of a Pavlovian conditioned stimulus is transferred, resulting in an increase in the learned Instrumental behaviour in the presence of the cue (for a recent review see [24]. PIT is a naturally adaptive process through which individuals learn to forage for resources, for example, to sate natural impulses such as hunger and thirst. Bray et al. [25] found increased specific PIT responding in a group of typical individuals using soft drinks and concluded that transfer effects relating to reward predicting cues were not the sole preserve of problematic behaviour. Lehner et al. [26] showed that food, money, and social rewards facilitate increased instrumental responding; postulating that the strength of PIT is modulated by subjective value rather than type of associative reward. Nevertheless, PIT has proven effective describing the maladaptive process that can facilitate the development and maintenance of substance addiction [27]. Drug related cues induce craving

and invigorate instrumental responding [28-31]; an effect that is more pronounced in dependent individuals [28,30].

The propensity for sexual imagery to bias behaviour has been leveraged for some time in advertising. Male and female models are often employed to associate products with an unconditioned arousal response. Sexually explicit material accounts for an enormous proportion of internet traffic [4,32]. With the advent of targeted advertisements and pop ups, individuals are regularly exposed to unsolicited sexual content; moreover, interacting with such content can result in algorithmic changes that provide the user with further content. However, not all individuals succumb to temptation [33] and only a small proportion may develop a compulsive habit of viewing sexual stimuli as a means of generating sexual arousal for masturbation [3,34].

Individual differences in reward sensitivity may occur by the interaction of two motivational systems [35], behavioural activation and behavioural inhibition. These dual control systems for any motivated behaviour provide it with a beginning, middle, and end, and for sexual behaviour that can be seen in the models of Moll [36], Masters and Johnson [37], Bancroft and Janssen [38], and Toates [39]. The behavioural activation system (BAS) regulates appetitive rewards and the motives to instigate approach behaviour. BAS comprises three discrete dimensions: drive (reward-focused in pursuit of goals) fun-seeking (engages in spontaneous, novel, and potentially rewarding sensations), and reward-responsiveness (anticipates and responds positively to rewarding outcomes). The behavioural inhibition system (BIS) influences the end of responding along with a shifting of attention to other rewards, non-rewards, or aversive cues, and accordingly abrogates behaviour. Individual differences in dimensions of BAS sensitivity, in particular, have been associated with addictive behaviour [40,41]. Moreover, general reward responsiveness has been found to correlate positively with responses to sexually explicit visual stimuli [42]. As such, a positive correlation between BAS dimensions and OSB scores was expected.

The present study aimed to elucidate if a general mechanism of reward sensitivity might exist to reinforce OSB. Accordingly, we investigated the relationship between OSB and behavioural activation/inhibition. Furthermore, differences in performance on a PIT task were determined based on self-report measure of OSB use that allowed us to divide participants into low and high use groups. We chose not to use sexually explicit stimuli to test the general effect and to limit sexually explicit stimuli exposure to participants. Indeed, the effects of sexual conditioning also tend to be weak in adults [43] possibly owing to already formed preferences and their heterogeneity [44]. However, individuals that exhibit heightened reactivity to drug related cues also showed greater reward responsiveness to non-drug related reinforcement [45,46]. As such, a difference in general reward mechanism was expected. Specifically, we anticipated that individuals with higher OSB scores would transfer more strongly than those with lower OSB scores.

Method

Ethics statement

Ethical approval for the study was granted by the National Institute of Mental Health Research Ethics Committee (No: 53/16). All individuals provided informed written consent to participate.

Design

In the PIT task, prior to the transfer phase, baseline Pavlovian conditioning was established in phase 1, measured as post-conditioning increases in pleasantness ratings (-5 to +5) for conditioned Pavlovian stimuli, and baseline instrumental conditioning was established in phase 2, measured as the percentage (%) of trials where rewarding outcomes were selected over the neutral outcome. Each used a within-groups experimental design to establish post-

conditioning learning. A two-sample between-groups experimental design was used to compare the magnitude of the transfer effect, measured as percentage (%) responses in the transfer phase (phase 3) of the PIT task, in low- and high- (problematic) online sexual behaviour (OSB) groups. In addition, three behavioural control groups were included in phase 3 of the PIT; Pavlovian reward, Pavlovian neutral and neutral choice controls, which were likewise measured as percentage (%) responses.

Low- and high-OSB groups were determined psychometrically, using the Internet Sex Screening Test online sexual behaviours subscale (ISST-OSB) [47], and exploratory between-groups comparisons were made of scores on the Sexual Compulsivity Scale (SCS) [48] and the Behavioural Inhibition System and Behavioural Activation System (BIS/BAS) [35] scales (see *Table 1*). In addition, the scores from the ISST-OSB, along with the aforementioned psychometric measures were used to perform exploratory correlational analyses.

Participants

Czech participants ($N = 89$) were recruited through Czech language advertisements placed on social media pages associated with the Sexology and Psychopathology Research Group at the National Institute of Mental Health (NIMH, Klecany, Czech Republic) and the Human Ethology Department at Charles University in Prague (Czech Republic). Prior to the study, participants were screened for drug and alcohol misuse with the Drug Abuse Screening Test (DAST-10) [49] and short version of the Michigan Alcohol Screen Test (sMAST) [50] since co-morbid substance use can confound conditioning effects [51]. Data from eight individuals were excluded for exceeding drug and alcohol cut-off scores. Data from two further participants were excluded owing to incomplete questionnaires. Remaining participants comprised 79 males that were separated into low ($N = 41$) and high ($N = 38$) OSB – see *Table 1*.

178

179 Table 1. Participant characteristics and descriptive statistics for psychometric measures in
 180 low- and high-OSB experimental group

	Low-OSB		High-OSB	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age	25.4	4.9	25.58	4.7
DAST-10	1.63	1.35	1.82	1.43
sMAST	.85	.63	1.0	1.04
ISST-OSB	5.88	1.78	11.82*	2.8
SCS	14.98	4.04	18.82*	5.54
BIS	16.9	1.95	15.82*	2.08
BAS Drive	8.85	1.71	8.23	1.32
BAS Fun	9.61	1.96	8.53*	1.9
BAS Reward	12.39	2.06	10.97*	1.81

181 Low-OSB (lower risk for problematic online sexual behaviours); High-OSB (higher risk for
 182 problematic online sexual behaviours); DAST-10 (Drug Abuse Screening Test, 10-item form);
 183 sMAST (Michigan Alcohol Screening Test, short form); ISST-OSB (Internet Sex Screening Test-
 184 Online Sexual Behaviours subscale); SCS (Sexual Compulsivity Scale); BIS (Behavioural Inhibition
 185 System); BAS (Behavioural Activation System). Asterisks indicate significant differences between
 186 low- and high-OSB groups at $p < 0.05$.

187

188 Psychometric measures

189 A professional academic and scientific translation agency was employed to undertake the
 190 translation of psychometric scales into Czech language. This process also included
 191 backwards translation of the Czech version into English to ensure scale items had not lost or
 192 altered meanings during this process. At each stage, academics from the Sex Research

Group at NIMH (CZ) with the first language of Czech or English discussed and approved the final translations as accurate versions of the English language originals.

Drug Abuse Screening Test (DAST-10): The DAST-10 [49] was used to measure problematic drug use/dependency. This unitary 10-item scale measures yes/no responses; scores of four or more indicate a 'moderate' level problematic drug use/dependence. The DAST demonstrates good reliability and validity [52].

Michigan Alcohol Screen Test, short form (sMAST): The sMAST [50] was used to measure problematic alcohol use/dependency. A 13-item unitary scale is used to measure yes/no responses which vary from zero to 13; scores of three or more indicate problematic alcohol use/dependence. The sMAST demonstrates good reliability and validity [50].

Internet Sex Screening Test - Online Sexual Behaviours (ISST-OSB): ISST-OSB [47] is a 34-item true/false scale comprising two subscales. The first, ISST-OSB, which measures variation in online sexual behaviours (OSB), primarily risky cybersex and use of online sexual content (25 items, total scores vary from zero to 25, with scores >9 indicative of problems such as excessive use of/spending on pornography or online sexual services, often in isolation, with negative consequences for relationships, finances, employment etc. [47]. The cut-off of 9 was used to determine experimental groups (low- versus high OSB) for the analysis of the PIT data (Table 1). ISST-OSB captures dimensions including time spent in isolation consuming sexual materials online, degree of interest in sexual materials and activities online, money spent in the pursuit of such materials and activities, as well as participation or online consumption with other parties. The ISST has been widely used with clinical samples, however limited information about its reliability and validity has been published. The second subscale, the Abbreviated Sexual Addiction Screening Test (ASAST: nine items, scores vary from zero to nine) measures general sexual addiction and compulsivity [47]. The scale was administered in full, however only responses to the 25-item

ISST subscale were included in analyses, since sexual compulsivity was measured using the more widely used measure, the SCS [48].

Sexual Compulsivity Scale (SCS): SCS [48] includes a series of 10 statements concerning sexual thoughts and feelings of control. Responses (level of agreement from 1 - not at all like me to 4 - very much like me) are summed providing possible overall scores between 10 and 40. The SCS was administered to facilitate differentiation between effects of compulsivity and conditioning on choice behaviour in the PIT task.

Behavioural Inhibition System and Behavioural Activation System (BIS/BAS): BIS/BAS [35] measures competing approach/avoidance tendencies resulting from underlying motivational systems that are geared to activate or inhibit behaviours to obtain appetitive outcomes and avoid aversive consequences or harm. The scale includes 24 statements, with responses indicated agreement from 1 – very true for me, to 4 – very false for me. Scores are calculated separately for the BIS subscale and three BAS dimensions; BAS Drive, BAS Fun-seeking and BAS Reward-responsiveness, which concern the motivation to pursue goals, seek novel or spontaneous sensations, and savour positive experiences, respectively.

Behaviour: Pavlovian-to-Instrumental Transfer Task (PIT)

The behavioural task was adapted from a PIT variant used in humans by Bray et al. [25]. The task was administered using *E-prime* 2.0 (Psychology Software Tools, Pittsburgh, PA) experimental presentation software. Participants were initially instructed to pay attention to the relationship between cue-outcome and action-outcome associations throughout the entire experiment. The PIT task variant that was implemented comprised three phases: phase 1 – Pavlovian conditioning; phase 2 – instrumental conditioning; and phase 3 – Pavlovian-to-instrumental transfer (the transfer phase). Fig 1 shows a visual representation

of the three phases and Table 2 provides specifics on the reinforcement schedule and outcomes.

<<Fig 1.tif>>

Fig 1. The Pavlovian-to-instrumental transfer (PIT) task.

Exemplar stimulus slides for each of the three experimental phases are shown (A) phase 1, Pavlovian conditioning; (B) phase 2, instrumental conditioning; and (C) phase 3, Pavlovian-to-instrumental transfer. Within each experimental phase, time (ms) is represented from top-to-bottom, with timings for stimulus slide presentation shown on the left. The struck banknote in the transfer phase denotes that no monetary or neutral outcome was delivered in this phase.

Phase 1- Pavlovian conditioning: Four unique Pavlovian stimuli were created using varying configurations of a red rectangle, triangle and circle. To control for baseline preferences for the Pavlovian stimuli, these configurations were designed to contain identically sized and coloured components, and to be meaningless; however, in pilot testing, we found that participants found it difficult to learn the associations. The same identical shapes were reconfigured so that their aggregates could be verbalised by participants as something meaningful e.g., 'church with sun', which improved performance in this phase.

During Pavlovian conditioning, stimuli were presented in the centre of the screen for 1750 ms before an outcome screen for 3000 ms (Fig 1A). Each stimulus was paired with a monetary reward of different denominations (100, 500, and 1000 Kc banknotes) of currency or with a well-known brand of toy money at its lowest denomination as the neutral outcome (Table 2). Pavlovian stimuli were followed by monetary reward at a 3:2 (reward/no-reward) ratio. Each trial was separated with a blank 'wait' screen (which varied randomly between 1000 and 3000 ms). Each stimulus was presented 6 times in a randomised order, yielding a total of 24 trials.

Table 2. Trial composition during conditioning and transfer phases of the Pavlovian-to-instrumental transfer task.

Phase	Trials	Cues			Outcome	
		Pavlovian	Instrumental			
1	24	S1	-	-	100 Kc	
		S2	-	-	200 Kc	
		S3	-	-	500 Kc	
		S4	-	-	Neutral	
2	36	-	R1	R2	100 Kc	200 Kc
		-	R1	R3	100 Kc	Neutral
		-	R1	R4	100 Kc	Neutral
		-	R2	R3	200 Kc	Neutral
		-	R2	R4	200 Kc	Neutral
		-	R3	R4	Neutral	Neutral
3	60	S1	R1	R2	-	-
		S2	R1	R2	-	-
		S3	R1	R2	-	-
		S4	R1	R2	-	-
		S4	R3	R4	-	-

Phase 1 (24 trials) was Pavlovian conditioning, phase 2 (36 trials) was instrumental conditioning, and phase 3 (60 trials) was the transfer test phase. There were four Pavlovian stimuli, and there were four possible instrumental responses (button options). Outcomes during phases 1 and 2 were images of 100, 500 or 1000 kc banknotes, or a toy banknote as the neutral outcome. No outcome was presented in phase 3. S1 (Pavlovian stimulus 1); S2 (Pavlovian stimulus 2); S3 (Pavlovian stimulus 3); S4 (Pavlovian stimulus 4); R1 (response button option 1); R2 (response button option 2); R3 (response button option 3); R4 (response button option 4).

To assess Pavlovian conditioning, cue evaluation involved participants rating the pleasantness of Pavlovian cues both pre- and post-conditioning phase. Visual cues were

presented on screen for 1750 ms followed by a visual scale from -5 (unpleasant) to 5+ (pleasant). The ARROW keys could be used to move up and down the scale whilst pressing ENTER to confirm a highlighted number selected. Stimuli were presented in a randomised order.

Phase 2- Instrumental conditioning: During Instrumental conditioning (Fig 1B), participants were required to choose between two button options. A row of four blank squares appeared in the lower third of the screen of the screen which corresponded to four adjacent keys on a keyboard, in the same spatial arrangement. Each of the four responses was associated with a specific outcome (Table 2). Unlike during Pavlovian conditioning, here only two responses were associated with monetary values whilst two related to the same neutral outcome (toy money). In each trial, two of the blank squares were replaced with coloured images denoting the two responses available for selection. Instrumental cues were presented on screen for 1750 *ms* before an outcome screen for 3000 *ms*. Response-outcome pairings were partially reinforced on a 2:3 ratio. Each trial was separated with a blank 'wait' screen (which varied randomly between 1000 and 3000 *ms*). There were six configurations of response-outcome pairings, which were each presented six times in a randomised order yielding a total 36 trials.

Phase 3-Pavlovian-to-instrumental transfer: Bray et al. [25] conducted an additional training phase that comprised mixed Pavlovian and instrumental trials in order to consolidate learning prior to the transfer phase. A pilot showed that mixing trials created confusion and resulted in poor transfer performance. As a result, here instrumental conditioning was followed immediately by the transfer phase. Participants were instructed to provide a response during the simultaneous presentation of Pavlovian and instrumental cues. Unlike earlier conditioning phases, no monetary or neutral outcomes occurred during transfer trials constituting extinction (Table 2). Cues were presented on screen for 1750 *ms* before a blank outcome screen for 3000 *ms* (Fig 1C). Each trial was separated with a blank 'wait' screen

(which varied randomly between 1000 and 3000 *ms*). There were five conditions in the transfer phase that were each presented 12 times in a randomised order over a total of 60 trials.

Outcome-specific transfer occurred when Pavlovian cues biased participants towards the instrumental response corresponding with the common conditioned outcome(s). With specific compatible transfer, Pavlovian cue S1 was only associated with the same outcome as instrumental response R1; and Pavlovian cue S2 was only associated with the same outcome as instrumental response R2. With specific incompatible transfer, participants could also choose the incompatible reward response, for example, by selecting response R1 despite previously established associations with Pavlovian cue S2 or by selecting response R2 despite previously established associations with Pavlovian cue S1.

In the Pavlovian reward control condition, participants chose between the two rewarding instrumental response options (R1 and R2) whilst the Pavlovian cue S3 was associated with an outcome seen during Pavlovian conditioning, but that was absent during the instrumental conditioning phase; thus, neither response option was compatible. In the Pavlovian neutral control, participants chose between the two rewarding instrumental response options (R1 and R2) whilst the Pavlovian cue S4 was associated with a neutral outcome (toy money). Again, neither instrumental response was compatible. Finally, in the neutral choice control, Pavlovian cue (S4) was associated with the same neutral outcome as both instrumental response options (R3 and R4).

Data analyses

All analyses were conducted in PASW(SPSS)® ver. 22 (IBM). All statistical tests had the alpha criterion of .05, two-tailed (unless otherwise stated).

A mixed 4 x 2 x 2 ANOVA was used to evaluate the effectiveness of Pavlovian conditioning in phase 1; incorporating repeated measures in pleasantness ratings for each of the four cues pre- and post-conditioning and a test of difference between OSB groups. If the Pavlovian cues had been associated successfully with 'rewarding' monetary outcomes, then pleasantness ratings should be higher post-conditioning, and we expect a stepped pattern in line with increasing monetary value.

A mixed 2 x 2 ANOVA was used to evaluate the effectiveness of instrumental conditioning in phase 2; incorporating repeated measures (the pooled number of choices a reward compatible or neutral outcome option was selected) and a test of difference in responses between OSB groups. A significantly higher percentage of reward-compatible responses compared with reward-incompatible responses was expected, indicating successful instrumental conditioning.

The magnitude of transfer effects in the transfer phase (phase 3) was established as follows. Outcome-specific responses in phase 3 were pooled, calculating a percentage of trials where participants selected the two rewards compatible with their respective Pavlovian cues. Furthermore, the percentage of outcome specific responses were also calculated for selections of the two rewards incompatible with their respective Pavlovian cues. A 2 x 2 mixed ANOVA was used to analyse the difference between outcome-specific responses in low- and high-OSB groups. A higher percentage of compatible transfer-specific effects were anticipated in the high-OSB group.

In phase 3 control conditions, both instrumental response options were incompatible with the Pavlovian cue in reward control and neutral control conditions. Conversely, both instrumental response options were compatible with the Pavlovian cue in neutral choice condition. Behavioural data relating to the control conditions was not presented in Bray et al. [25] which would allow informed predictions to be made. To speculate, participants might be expected

to spread instrumental responses across the two available options in each control condition. A 3 x 2 mixed ANOVA was used to analyse the difference between the proportionally highest options selected across the three control conditions and between low- and high-OSB groups. Between-groups *t*-tests were used to compare low- and high-OSB groups across each of the psychometric measures administered. Pearson's correlations were used to explore relationships between psychometric measures.

Results

Pavlovian-to-instrumental transfer (PIT) task

Pavlovian conditioning in phase 1; increases in ratings for cues post-conditioning provide evidence of successful Pavlovian conditioning. A 4 x 2 x 2 ANOVA analysed the pleasantness ratings of Pavlovian cues pre- and post-conditioning between high and low OSB groups. There was a significant main within measures effects for cues (Greenhouse-Geisser corrected; $F(2.6, 169.8) = 24.31, p < .001, \eta^2 = .24$) and time ($F(1, 77) = 24.34, p < .001, \eta^2 = .24$) and a significant cue x time interaction (Greenhouse-Geisser corrected; $F(2.8, 212.7) = 11.13, p < .001, \eta^2 = .13$). There was no significant between measures main effect of OSB (Greenhouse-Geisser corrected; $F(1, 77) = 1.2, p = .28, \eta^2 = .02$) and no significant interactions between OSB and either cues (Greenhouse-Geisser corrected; $F(2.6, 169.8) = 24.31, p = .55, \eta^2 = .01$) or time ($F(1, 77) = .03, p = .86, \eta^2 < .01$). Post-hoc analyses show increased ratings (Fig 2A) for the cue paired with 100kc (pre: $M = .23, SD = 1.86$; post: $M = .72, SD = 1.65; t(78) = -1.874, p = .03, \eta^2 = .04$, one-tailed) did not reach significance with Bonferroni corrections; increased ratings for cues paired with 500 Kc (pre: $M = .18, SD = 1.81$; post: $M = 1.15, SD = 2.17; t(78) = -3.77, p < .001, \eta^2 < .15$) and 1000kc (pre: $M = .43, SD = 2.05$; post: $M = 2.34, SD = 2.47; t(78) = -5.96, p < .001, \eta^2 = .31$) monetary values were significant. There was no significant difference between pre- and

post-conditioning ratings for the cue paired with the neutral outcome (pre: $M = -.41$, $SD = 1.68$; post: $M = -.32$, $SD = 1.93$; $t(78) = -.403$, $p = .69$, $\eta^2 < .01$).

Instrumental conditioning in phase 2; the relative response selections provide evidence of response-outcome acquisition. A 2 x 2 ANOVA analysed the proportionate responses related to reward versus neutral outcomes between high and low OSB groups. There was a significant main within measures effect of response selected ($F(1,77) = 42.89$, $p < .001$, $\eta^2 = .36$). There was no significant main between measures effect of OSB ($F(1,77) = .01$, $p = .94$, $\eta^2 < .01$) and no significant interaction between response selected and OSB ($F(1,77) = .03$, $p = .96$, $\eta^2 < .01$). Participants chose (Fig 2B) the response paired with a reward ($M = .65$, $SD = .19$) significantly more often when the alternative associated with a neutral outcome ($M = .35$, $SD = .19$).

Pavlovian to instrumental transfer in phase 3; the specific transfer conditions were aggregated across two trial types and were thus analysed separately to the control conditions. A higher percentage of compatible responses provide evidence of a specific transfer effect. The difference in compatible and incompatible transfer responding between high and low OSB groups was determined using a 2 x 2 ANOVA. There was a significant main within measures effect of transfer type ($F(1,77) = 27.85$, $p < .001$, $\eta^2 = .27$). Both the high-OSB ($M = .68$, $SD = .26$) group and low-OSB group ($M = .58$, $SD = .26$) chose the specific compatible responses (Fig 2C) more often than the specific incompatible responses (low-OSB: $M = .37$, $SD = .26$; high-OSB: $M = .29$, $SD = .26$). However, no significant main between measures effect was found for OSB group ($F(1,77) = .48$, $p = .48$, $\eta^2 = .01$) and there was no significant interaction between transfer type and OSB group ($F(1,77) = 2.82$, $p = .1$, $\eta^2 = .04$).

A 3 x 2 ANOVA analysed the highest proportional response in each of the control conditions between high and low OSB groups. There was no significant main within measures effect of

condition (Greenhouse-Geisser corrected; $F(1.94, 149.24) = 2.85$, $p = .06$, $\eta^2 = .04$), no significant main between measures effect of OSB group ($F(1, 77) = 1.16$, $p = .29$, $\eta^2 = .02$) and no significant interaction (Greenhouse-Geisser corrected; $F(1.94, 149.24) = .16$, $p = .85$, $\eta^2 < .01$). The highest proportional response (Fig 2C) in the reward control condition was R2 for both low- ($M = .54$, $SD = .4$) and high- OSB ($M = .55$, $SD = .41$) groups, whereas in the neutral control condition, the highest proportional response was R1 for both low- ($M = .53$, $SD = .31$) and high-OSB ($M = .59$, $SD = .369$) groups. Participants in both low- ($M = .64$, $SD = .28$) and high-OSB ($M = .69$, $SD = .27$) groups exhibited a preference for selecting R3 over R4 in the neutral choice control where both responses were associated with the same action-outcome pairing.

<<<Fig 2.tif>>>

Fig 2. Results of the Pavlovian-to-instrumental transfer task.

(A) Phase 1, Pavlovian conditioning. Data shows mean pre- and post-conditioning pleasantness ratings of Pavlovian cues paired with monetary or neutral rewards; (B) Phase 2, instrumental conditioning. Data show mean percentage of trials where the rewarding outcome was selected over the neutral outcome; (C) Phase 3, Transfer phase. Data show mean percentage of responses $\pm 1 SE$ in each transfer and control condition.

Pair-wise comparisons of psychometric measures

Between-groups t -tests were used to compare low- and high-OSB groups across each of the psychometric measures administered (See Table 1.). There was a significant difference between self-report online sexual behaviour between groups ($t(61.85) = -11.159$, $p < .001$). The high online sexual behaviour group scored significantly higher on measures of sexual compulsivity ($t(67.33) = -3.497$, $p = .001$) compared to the low online sexual behaviour group. BAS fun ($t(77) = 2.491$, $p = .015$), BAS reward ($t(77) = 3.237$, $p = .002$), and BIS ($t(77) = 2.4$, $p = .019$) were all found to be significantly lower in the high online sexual

behaviour group. There was no significant difference in BAS drive between groups ($t(77) = 1.78, p = .079$).

Correlations

Correlational analysis revealed a significant positive correlation between ISST-OSB and SCS scores (Table 3). There were significant negative correlations between ISST-OSB with BAS drive and with BAS reward responsiveness. Significant negative correlations were also found between SCS and BAS fun-seeking and BAS reward responsiveness. ISST-OSB and SCS each showed a significant negative correlation with BIS scores. There was no evidence of a significant relationship between ISST-OSB and DAST-10 or sMAST scores.

Table 3. Pearson's correlations between psychometric measures.

	SCS	DAST-10	sMAST	BAS Drive	BAS Fun	BAS Reward	BIS
ISST-OSB	.38**	.1	.05	-.24*	-.2	-.27*	-.33**
SCS		-.02	.12	-.1	-.31**	-.28*	-.27*
DAST-10			.2	-.1	-.02	.12	.12
sMAST				.01	.15	.01	.18
BAS Drive					.15	.46**	.09
BAS Fun						.53**	.51**
BAS Reward							.56**

ISST-OSB (Internet Sex Screening Test-Online Sexual Behaviours subscale); SCS (Sexual Compulsivity Scale); DAST-10 (Drug Abuse Screening Test, 10-item form); sMAST (Michigan Alcohol Screening Test, short form); BIS (Behavioural Inhibition System); BAS (Behavioural Activation System). Asterisks denote significance at $p < .05^*$ or $p < .01^{**}$

Discussion

The present study was designed to assess whether men who engage in frequent online sexual behaviours differ in their susceptibility to cue-enhanced PIT relative to men who engage in occasional or non-frequent online sexual behaviour. Men in the High-OSB group scored significantly higher than men in the Low-OSB group in the online sexual behaviour subscale of the ISST and in subjective sexual compulsivity. They also scored significantly lower in behaviour inhibition and behaviour activation for fun and reward. Despite these subjective differences, no significant differences were observed between groups in the PIT task, indicating that men in the High-OSB group had no greater susceptibility to cue-induced operant responding than men in the Low-OSB group. Indeed, men in both groups displayed greater pleasantness ratings post-conditioning to cues associated with greater monetary reward relative to neutral cues in Phase 1, and both groups responded significantly above chance for the specific-compatible and neutral cues, and significantly below chance for the specific-incompatible cues. This pattern of results indicates that men in the High-OSB group were not more susceptible to cue-stimulated reward responding than men in the Low-OSB group, providing further evidence that abnormal reward perception *per se* is not likely to be the cause of higher frequency online sexual behaviours.

It is not known whether men in the High-OSB considered their online sexual behaviour to be problematic. Indeed, viewing pornography online has become part of the normal sexual repertoire [17] and is used predominantly to induce arousal for solitary masturbation and/or sexual encounters with others (see [17]). However, both the use of pornography and sexual compulsivity share comparable negative associations with BIS. High BIS sensitivity provokes feelings of anxiety [53,54] leading to the abrogation of behaviour to avoid non-rewarding or conflicting outcomes. Low BIS then could indicate low aversion to risky or harmful outcomes [55]. There is some evidence of low BIS in relation to addictive behaviours [41], thus the findings have proven inconsistent [56,57].

497

498 Dimensions of BAS sensitivity have been more robustly associated with substance abuse
 499 and problem drinking [40,41]. It is generally accepted that addiction is synonymous with a
 500 strong reward focus, sensation seeking, and impulsive decision making. Interestingly, in the
 501 present study both high OSB and sexual compulsivity associated with low BAS reward
 502 responsiveness. Moreover, OSB was negatively related to BAS drive. Low BAS sensitivity is
 503 associated with introversion [35,58] whereas low BAS drive and reward responsiveness are
 504 typically predictors of depression [35,59]. Levels of self-esteem have previously been
 505 highlighted as risk factors in the development of problematic internet use [60]. Taken
 506 together, the self-report measure of reward sensitivity suggests that men with high online
 507 sexual behaviours (and presumably high pornography consumption) may be characterised
 508 differently, such that when this behaviour becomes problematic, it may be more associated
 509 with social withdrawal in individuals that exhibit lower levels of reward sensitivity.

510

511 The data from training phases provide evidence of successful conditioning. The
 512 pleasantness ratings of cues were generally low. However, ratings of Pavlovian associated
 513 cues post-conditioning were proportionally higher with respect to the associated monetary
 514 value. The differential ratings were similar to cues associated with soft drinks used in Bray
 515 et al. [25] and congruent with research indicating the rewarding nature of monetary values
 516 [61]. Furthermore, we showed proportional selection of reward associated Instrumental
 517 responses. Similar to Bray et al. [25], participants chose the rewarding option more often
 518 when the alternative response was associated with a neutral outcome.

519 Bray et al. [25] found no specific brain regions associated with response in the control
 520 condition although behavioural results were not published with which we can draw
 521 comparison. Our findings indicate no group differences in responses during the reward
 522 control and neutral control conditions. However, it is notable that the highest proportional
 523 responses in both groups were for the left and right options respectively. Although the
 524 Pavlovian associated cues were incompatible, this could be viewed as an attempt to select

the best match (neutral closest to 100kc than 500kc; 1000kc closest to 500kc than 100kc). Interestingly, both groups were more likely to select the left response in the neutral choice condition despite both options being equally predicted by the cue-outcome association.

Appetitive Pavlovian cues have previously been shown to influence Instrumental responding [26]. Bray et al. [25] found that cue-outcome pairings modulated responding relative to action-outcome pairings with specific compatible rewards. Although previous research has shown heightened cue reactivity to stimuli associated with compulsive or addictive behaviour (substance, [62]; non-substance, [63]); the present data do not support the idea that high OSB individuals are similarly compulsive. Increased transfer effects related to OSB would have suggested a general mechanism of reward sensitivity beyond sex related cues. However, this is inconsistent with the finding that high frequency OSB was associated with low BAS sensitivity.

Enhanced PIT effects have previously been shown in relation to individuals with alcohol use disorder [28]. Functional activation of the NAcc predicted the strength of transfer effects and proneness to relapse, highlighting the importance of reward-based learning in addiction [28]. However, PIT has also been demonstrated in a study that failed to show enhanced effects in the high alcohol consumption group [29]. It was noted that participant scores on the alcohol scale were limited in the mid-range and unlikely to have captured individuals exhibiting dependency. Similarly, one possible explanation for lack of transfer effects between OSB groups in our study could be the sample characteristics. While groups used in our study differed in OSB and included individuals in the high OSB group at risk of problematic behaviour, scores on the sexual compulsivity scale were not high; which might explain the apparent lack of difference in transfer effects.

Another study of alcohol dependency found that individuals in the patient group were more likely to suppress a positively reinforced action paired with a negatively valenced cue whilst

553 choosing a negatively reinforced instrumental response when paired with a positively
554 valenced cue [30]. Moreover, PIT effects in this study correlated with measure of trait
555 impulsivity. Failure to suppress a behavioural response owing to the strength of contextual
556 associative cues highlights the dysfunctional choice process through which addicted
557 individuals persist despite negative consequences. While our study found no evidence of
558 transfer effects between OSB groups in relation to appetitive conditioning, further research
559 could investigate negatively valenced associative cues on choice behaviour using PIT. The
560 relationship between PIT and impulsiveness is posited to be driven by reward sensitivity [30].
561 Moreover, high BAS drive has been shown to impair appetitive conditioning while high BIS
562 was found to impair aversive (non-reward) conditioning in a conditioned inhibition task [64].
563 Given that BIS/BAS sensitivity negatively correlated with OSB, we might not expect
564 associative cues to impact response inhibition in the same way as alcohol dependency.
565
566 Impaired decision making and sensation seeking are believed to perpetuate addictive
567 behaviours [65,66] and have been suggested to play a role in compulsive internet
568 pornography use and sexual behaviour [67,68] although see [69]. Although sensitivity to
569 reward positively correlates with sexually explicit stimuli [42], there is some evidence that
570 problematic users exhibit faster neural habituation to sexual cues [22]. This is congruent with
571 our findings that indicate lower reward sensitivity in the high OSB group. However, an
572 alternative hypothesis is that the high online sexual behaviour group had a mix of individuals
573 with naturally high sexual functioning who may use online pornography for arousal during
574 more frequent episodes of masturbation, relative to the low OSB group, along with other
575 individuals who may do this more compulsively. This raises a challenge for clinicians
576 diagnosing CSBD. It is easy to conceive of high OSB as being indicative of impaired impulse
577 control and decision making, especially when it seems excessive to the individual and/or the
578 individual's partner(s) based on cultural norms and relationship expectations.
579

Frequent use of online pornography has been taken de-facto as evidence of so-called “sex addiction” by some clinicians [70]. However, Kraus et al. [71] have cautioned against over-pathologizing high levels of sexual interest and behaviour in individuals who do not exhibit impaired control over their sexual behaviour and significant distress or impairment in functioning. Clearly, the frequency of viewing pornography online, for example, with or without masturbation, is not itself predicative of problematic sexual functioning. Further research needs to clarify the relationship between reward sensitivity, interpersonal variables (e.g., introversion, sexual self-esteem, perceived impulse control, positive versus negative attitudes about masturbation, etc.), and online sexual behaviour that is truly compulsive and problematic.

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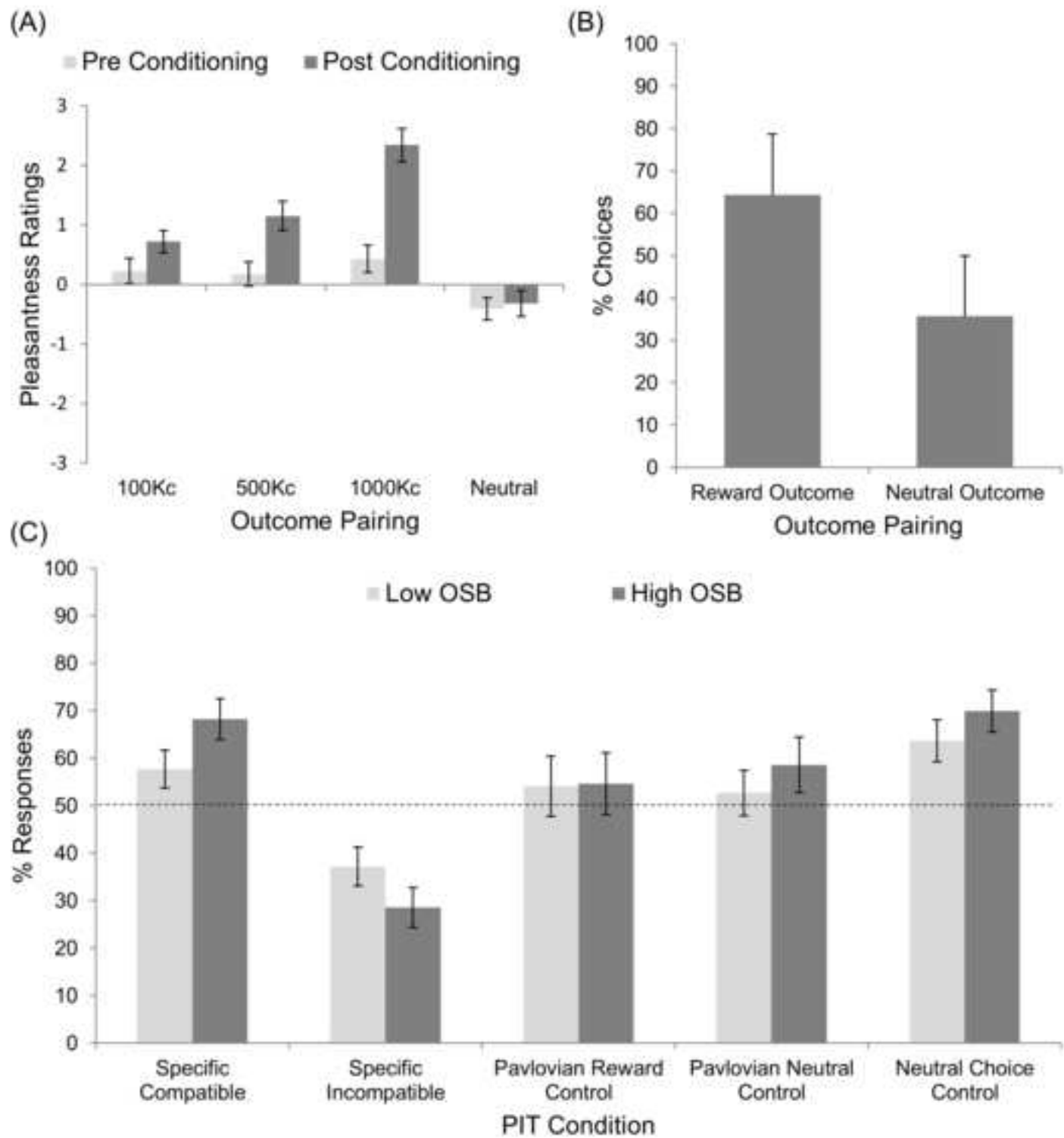
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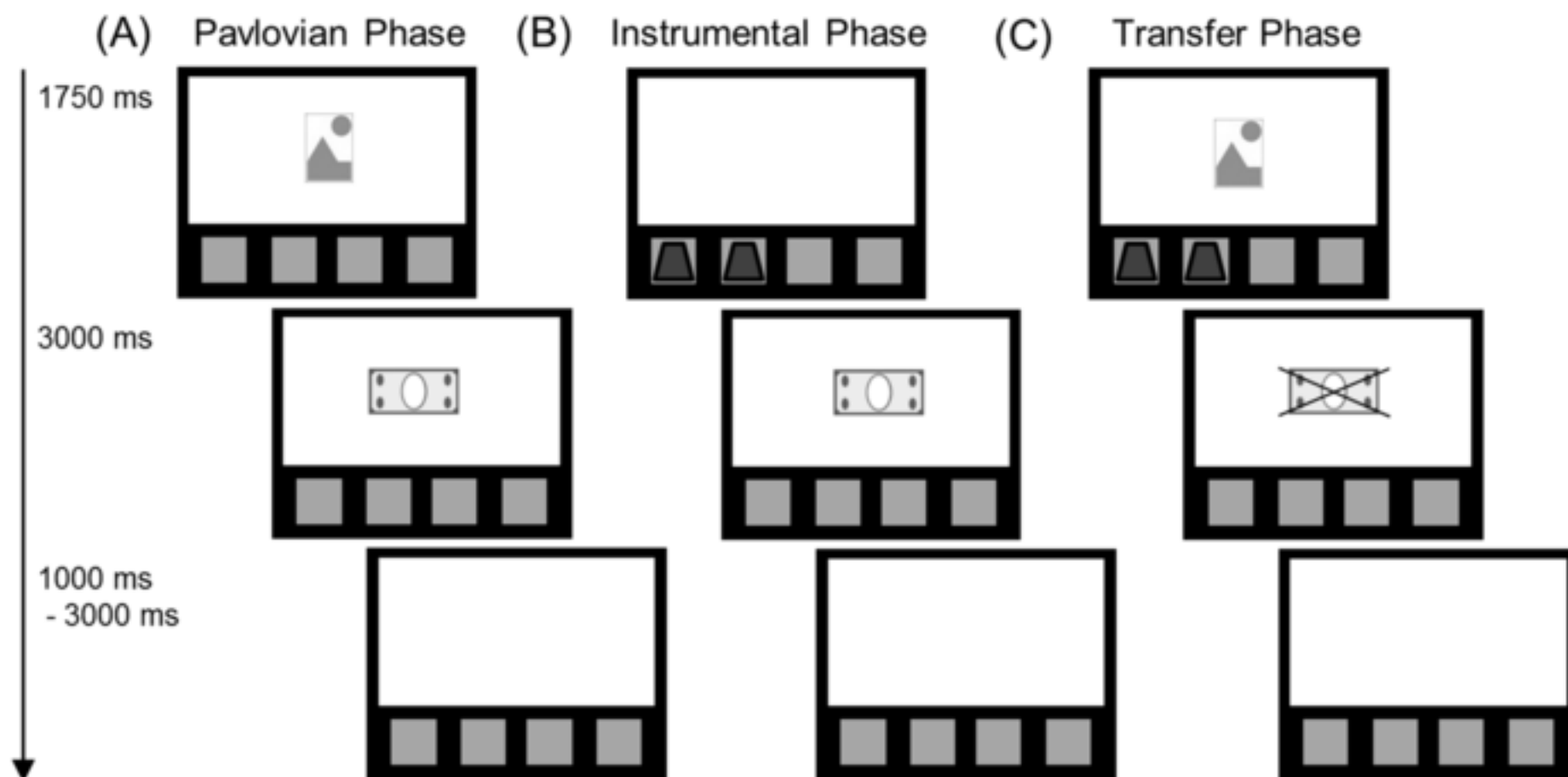
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As supervisor I hereby declare that my doctoral student, Mgr. Jakub Binter, PhD., participated on creation of following publications and confirm for each of the publications his proportion of work. To do so I will use CRediT (Contributor Roles Taxonomy; <https://credit.niso.org/>).

Wells, T.J., Krejčová, L., Binter, J., Pfaus, J.G., & Horsley, R.R. (2022). Lack of enhanced Pavlovian-to-Instrumental Transfer (PIT) in men engaging in frequent online sexual behaviour: Implications for Compulsive Sexual Behaviour Disorder. *PLOS ONE*, X-X.

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Participation in the project also included translation of two questionnaires (*Perceived Vulnerability to Disease*, Duncan et al, 2009, <https://osf.io/taj7u/>; and *Identification With All Humanity*, McFarland et al., 2012, <https://osf.io/9uktr/>) to Czech language in cooperation with Mgr. Ondra Pešout, Ph.D.

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