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Synestetické asociace a psychopatologické symptomy

Synesthetic associations and psychopathological symptoms

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1. THEORETICAL INTRODUCTION

1.1. SYNESTHESIA

Synesthesia (also synaesthesia, in plural synesthesiae or synaesthesiae) is derived from the ancient Greek words *syn* (union, together) and *aisthesis* (sensation). Synaesthesia is a condition in which stimulation of one sensory modality causes unusual experiences in a different unstimulated modality, for example, hearing a sound may evoke seeing a colour (Hubbard & Ramachandran, 2005; Cytowic, 2002; Day, 2004; Mulvenna & Walsh, 2006; Eagleman & Goodale, 2009; Ward, 2013).

According to reported estimations, prevalence of synesthesia is likely at about 5% or less (Galton, 1883; Cytowic, 1989; Ward, 2013). The most widely cited study to date suggests that synesthesia occurs in at least 1 in 2000 people (Baron-Cohen et al., 1996), although this is now generally regarded as an underestimated. Some other studies suggest that for example prevalence of grapheme-color synesthesia might be between 1 in 200 and 1 in 100 (Ramachandran & Hubbard, 2001b; Mulvenna et al., 2004). Subsequent large-scale studies have suggested the prevalence of synesthesia as high as 1 in 20 across all forms and 1 in 100 for grapheme-color synesthesia (Ramachandran & Hubbard, 2005). This high prevalence argues against the notion that synesthesia is merely a ''benign cognitive variant'' (see Ward & Mattingley, 2005; Ramachandran & Hubbard, 2005; Veen et al., 2014) and instead suggests that it is a widespread phenomenon that may provide novel insights into the neural basis of the mind (Ramachandran & Hubbard, 2001b). Some of this variability is probably due to differences in definitional criteria used by different researchers and its different subtypes (Simner & Hubbard, 2013b).

In this context, synesthesia in general is a phenomenon of intersensory and intrasensory linkage that may be observed in various conditions including artistic creativity and also manifests in conditions of various brain dysfunctions and injuries (Armel & Ramachandran, 1999; Steven & Blakemore, 2004; Grossenbacher & Lovelace, 2001; Hochel & Milan, 2008). In many cases synesthesia also may be influenced by drugs, for example synesthetic hallucinations due to exposition of the lysergic acid diethylamide (LSD), mescaline and ayahuasca (Hartman & Hollister, 1963; Stuckey et al., 2005; Spector & Maurer, 2009) or other psychotropic drugs (Ramachandran & Hubbard, 2001b; Sinke et al., 2012; Brogaard, 2013). In addition, synesthesia has also been reported in healthy individuals between sleep and wakefulness and in a high proportion of medita-

tors (Walsh, 2005), and also it may be influenced by hypnotic suggestions (Fuentes et al., 2007; Terhune et al., 2010). Taken together these findings suggest that synesthesia is a phenomenon on general level based and represented by transmodal associative connections that may represent a continuum from strong synesthetic phenomena to its mild forms that may enable creation of "synesthetic" metaphors.

1.2. TYPOLOGY OF SYNESTHESIA

Synesthesia occurs in various forms and more than 60 different types of synesthesia that connect various sensory modalities have been described (Cytowic & Wood, 1982; Day, 2004; Simner, 2013; Marks, 2011; 2012b; Ward, 2013; Simner & Hubbard, 2013b). Most frequently experienced forms of synesthesia are colored hearing or hearing induced vision and at about 18% of these experiences represent colors induced by auditory stimuli such as music and noise (Day, 2004). Many synesthetes experience colors related to speech but not to other types of auditory stimuli (Sagiv & Ward, 2006) and the color experiences frequently depend on linguistic properties of the stimulus, for example the graphemic composition is more important than acoustic properties, i.e. heard words beginning with the letter ''p'' tend to elicit the same color even the letter may have different pronunciation (e.g., ''psychology,'' ''photo,'' and ''potato'' have the same color) (Baron-Cohen et al., 1993; Baron-Cohen, 1996; Sagiv, Ward 2006).

Frequently occurring form of synesthesia is also based on linking of visual and tactile modalities (for a review see Spence, 2002, Schiltz et al., 1999; Ward, 2013). For example, Armel and Ramachandran (1999) documented an acquired case of synesthesia related to retinal damage in which tactile stimulation of the arms induced color photisms. Synesthesia-like tactile and kinesthetic sensations also have been induced in amputated limbs using mirrors, and interesting findings show that synesthesia-like sensations can be turned on or off depending on the presence or absence of a mirror (Ramachandran & Rogers-Ramachandran, 1996).

Some findings also show a relationship of synesthetic phenomena with emotional activation, for example, experience of mental colours in response to faces, human figures, and visual scenes related to specific emotional contents (Cytowic, 2002; Milan et al., 2007; Ramachandran & Hubbard, 2001b; Ward, 2004). Synesthetic experience per se most frequently is linked to positive emotions but occasionally it may be related also to negative feelings (Hochel & Milan, 2008; Perry & Hanig, 2013; Dael & Sierro & Mohr, 2013).

Several fMRI findings suggest that synesthetes can be divided into two distinct groups: (1) those with perceptually mediated synesthesia expressed in the abnormal activation of visual areas, and (2) those with semantically mediated synesthesia expressed in the abnormal activation

of the parietal lobes (Kadosh et al., 2007b). These data are in agreement with description of two basic forms of synesthetic experience 'lower' (referring to lower perceptual processes) and 'higher' (referring to higher cognitive processes), in whom the different forms of synesthesia represent different stages of brain processing (Ramachandran & Hubbard, 2001a, Pearce, 2006; Hochel & Milan, 2008; Marks, 2011; Ward, 2013; Simner, 2013). With respect to these types of synesthetic mechanisms have been described also two basic subjective forms of synesthetic experience 'out in space' likely corresponding to higher activation of sensory cortices, i.e. projective synesthesia ("projector synesthetes") or associative synesthesia that is not experienced in the outside world like projective synesthesia but 'in the mind's eye' ("associator synesthetes"). For example, in projector synesthetes naming the colour of the ink in which a grapheme was presented induced greater Stroop interference than naming the photism colour, whereas in mind's eye' associator synesthetes the opposite pattern was observed (Dixon et al., 2004; Pearce, 2006; Marks, 2011; Simner, 2013).

In this context, typical differences in neural connectivity between "associator" and "projector" synesthetes have been reported (Rouw & Scholte, 2007), which suggest a hypothesis that synesthesia represents a consequence of specific forms of sensory connectivity (Esterman et al., 2006; Mulvenna & Walsh, 2006; Simner, 2012b, 2013).

1.3. PSYCHOLOGICAL AND NEUROBIOLOGICAL MECHANISMS OF SYNESTHETIC PHENOMENA

Developmental studies based on synesthetes' subjective reports suggest that synesthesia is acquired very early during development and is stable over lifetime (Hochel & Milan, 2008; Simner & Hubbard, 2013b). Other results suggest that the mechanisms underlying synesthesia are related to sensory processes and cannot be explained only by memory associations (Cohen et al., 1993; Ramachandran & Hubbard 2001a; Hubbard et al., 2005; Radvansky et al., 2011; Simner, 2012; Ward, 2013).

1.3.1. SYNESTHETIC BRAIN

Basic neurobiological mechanisms of synesthesia most likely are linked to a balance of synaptic pruning, neuronal inhibition, and connections between sensory cortical areas which in principle might be linked to amplification of normal sensory processes (Spector & Maurer, 2009; Tomson et al., 2013; Simner & Hubbard, 2013b).

Various neural mechanisms likely play a role in these different types of synesthesia that may be linked to local crossactivations and re-entrant feedback mechanisms involving processed modalities in different brain areas that create various associations, as for example word-color, tone-color, grapheme-color and other forms of synesthesia (Smilek et al., 2001; Myles, et al., 2003; Ramachandran & Hubbard, 2005; Hubbard, 2007; Ward, 2013).

For example, a lexical–colour synesthesia characterized by observation of an achromatic grapheme is related to specific neural signals from the retina that arrive to lower visual areas. Subsequently these signals are processed by a shape-processing area (the posterior fusiform gyrus) and finally they are processed in the area that is in charge of the interpretation analysis of the meaning in which the anterior fusiform gyrus plays a significant role (Hochel & Milan, 2008). According to Smilek et al. (2001) activation of photisms in "projector" synesthetes is a result of cyclic feedback communication from shape and meaning processing areas to colour regions V4. According to current data two linked basic mechanisms are local cross-activation and disinhibited feedback that may play a role in the synesthetic experiences (Ramachandran & Hubbard, 2005;

Grossenbacher & Lovelace, 2001; Hochel & Milan, 2008; Neufeld et al., 2012). In addition, according to some data based on research of event-related potentials, synesthetic phenomena likely occur in relatively later stages of sensory processing because differences in brain activity in synesthetes and nonsynesthetes are not observed until 200 milliseconds after stimulus onset (Schiltz et al., 1999; Kadosh et al., 2007; Goller et al., 2009; Volberg et al., 2013).

Based on recent neuroimaging findings and existing theories, basic neuronal mechanisms underlying synasthesia are still poorly understood. In recent years, advanced neuroimaging methods such as functional magnetic resonance imaging (fMRI) have been used to compare brain activities of synesthetes and nonsynesthetes (Simner et al., 2011; Marks, 2011). Most of these studies examined neuronal correlates of grapheme–color synesthesia with controversial results. Some studies suggest that synesthesia is due to anomalous functioning of occipito-temporal areas such as V4/V8 and others found that synesthetic experience is correlated with abnormal activation of the parietal lobes (Kadosh et al., 2007b; Simner, 2012; Ward, 2013; Veen et al., 2014).

Recent studies indicate that neural mechanisms underlying synesthesia most likely are based on different types of neurocognitive processes related to various sensory modalities (Kadosh & Walsh, 2008; Simner, 2013; Ward, 2013). These studies, for example using positron emission tomography, show that synesthetes manifest increased activation of several visual associative areas mainly posterior inferior temporal cortex and parieto-occipital junctions, and also right prefrontal cortex, insula and superior temporal gyrus (Rouw et al., 2011; Hubbard et al., 2011). In this context, also some other data suggest that the right hemisphere functions might have a specific role in synesthesia, because the right hemisphere, more than left, likely plays a role in various interconnections of different brain zones that may create unusual associations (Rotenberg, 2004, 2013; Iturria-Medina et al., 2011). This specific right hemispheric interconnectivity may explain manifestations of synesthesia in certain mental states that create atypical experiences and associations such as meditation, hypnosis or psychedelic experiences, and also higher occurrence of synesthesia in artists (Cytowic, 2002; Ione & Tyler, 2004; Stuckey et al., 2005; Cohen Kadosh et al., 2009; Terhune et al., 2010; Jewanski et al., 2011; Ward, 2013; Voskuil, 2013).

Other studies used functional magnetic resonance imaging (fMRI) and for example Nunn et al. (2002) found that most activated regions by speech in synesthetes represent areas V4 and V8 of the left hemisphere and also overlap of this V4/V8 activation in normal controls in response

to colour has been reported. Some other studies also found that synesthesia is linked to colour processing areas V4 and V8 which are necessary for the generation and experiencing of photisms (Hochel & Milan, 2008; Pearce, 2006; Steven, Hansen & Blakemore, 2006). Interesting case study reported by Pearce (2006) reported increased activity in visual cortical areas specifically related to illusory coloured and spatially located visual percepts in a synesthetic man, who had been completely blind for 10 years (Pearce, 2006).

Although basic neural mechanisms of synesthesia are poorly understood, majority of these neuroimaging studies are in agreement with the two basic concepts of synesthesia, the lower synesthesia, which is characterized by typical crossactivations that may occur between adjacent regions of the fusiform gyrus involved in letter recognition and colour processing, and the higher synesthesia that may arise from cross-activation in the parietal cortex, particularly in the angular gyrus, the ventral intraparietal area and the lateral intraparietal area (Hubbard & Ramachandran, 2005; Pearce, 2006; Marks, 2011). Cross-activation in the region of the parietal lobe in higher synethetes also might explain synesthetic number forms, in which numerical and other ordinal sequences are experienced as having specific locations in space, in addition to colours (Hubbard & Ramachandran, 2005, Dixon et al., 2004; Hubbard et al., 2011). In addition, since graphemes, phonemes, music and colours function are processed in different brain regions, several manifestations of synesthesia likely may have different anatomical neuronal substrates (Ward & Simner, 2006; Pearce, 2006; Simner, 2012; Tomson et al., 2013; Carmichael & Simner, 2013).

In the overall context neurocognitive processing related to synesthesia is linked to large scale communication in the brain whose connectivity is closely associated with basic mechanisms of consciousness that most likely cannot be explained by neuroanatomically defined active connections and various unknown mechanisms related to information transfer may play a role (Baron-Cohen et al., 1993; Hochel & Milan, 2008; Simner, 2012; Tomson et al., 2013).

1.3.2. SYNESTHESIA AND EMOTIONS

Synesthesia, in a broader sense, might be based on continuum based on a great variety of conditions ranging from "lower" synesthesia to more "associative" emotional synesthesia (Hochel & Milan, 2008; Simner et al., 2011; Marks, 2011; Simner, 2012). Most likely these forms of lower projec-

tive synesthesia and associative "emotional" synesthesia (Cytowic, 2002; Milan et al., 2007; Ramachandran and Hubbard, 2001b; Ward, 2004) are related to different neural mechanisms and recent data suggest that "projectors" show stronger structural connectivity in the inferior temporal cortex than "associators" (Rouw & Shoulte, 2007; Simner, 2012b).

For example, Galeyev (2007) considered synesthesia in context of higher associative synesthesia as a specific manifestation of non-verbal thinking based on involuntary or purposeful comparison of the impressions of different modalities, on the basis of structural, semantic and emotional similarity. In this context, synesthesia can be characterized as focused and simultaneous actualization of the "sensuous" modalities in a wide range of manifestation implemented by means of emotions (Galeyev, 2007).

Important aspects of synesthetic phenomena represent emotional reaction in which the spoken form can be transformed into an affective component of a word (or other stimulus) that can directly trigger a synesthetic sensation of colour (Ward, 2004; Moller et al., 2009; Okubo & Ishikawa; Kuhbandner & Pekrun, 2013). For example, Collier (1996) reported that subjects tend to choose the colour blue for "sad," yellow for "cheerful," gold for "proud," and there is some correspondence between emotional valence and hue, i.e. darker and less saturated colours (e.g., brown, black) tend to be associated with negative emotions, and lighter and more saturated colours (e.g., yellow, green, red) tend to be associated with positive emotions (Okubo & Ishikawa, 2011). Similarly, positive emotions tend to be mapped onto rounded forms and negative ones onto angular forms. An extent to which these links between colors and emotions reflect cultural associations is not clear **(**Simner, 2012b; Marks, 2013; Palmer, 2013**)**.

Other forms of synesthesia that reported widely consistent patterns across subjects have also been described. For example, in pitch-colour synesthesia, lower-pitched sounds tend to be darker and higher-pitched sounds tend to be brighter (Marks, 1975). In a series of experiments, Marks has shown that the same pitch brightness may be observed in matching tasks and metaphors produced by nonsynesthetic individuals (e.g. Marks, 1982, Simner et al., 2011; Simner, 2013). This suggests that some forms of synesthesia can be conceptualized as an exaggeration of basic and usually occurring neurophysiological crossmodal mechanisms.

In this context, some researchers suggested that synesthesia may reflect stronger crosswiring or cross-activation of areas in the brain that normally in most usual neurophysiological conditions are less connected

(Baron-Cohen, 1996; Maddock, 1999; Ramachandran & Hubbard, 2001b; Simner, 2012, 2013).

1.4. SYNESTHESIA AND METAPHOR

Metaphor usually can be understood as a form of "mapping" of one domain into another domain as a spontaneous and emergent property of mind (Lakoff, 1993). Synesthesia from this "metaphoric" point of view may be understood as intersensorial links of colors, tones and spatial images representing a typical polysensory form of perception based on crossmodal association mechanisms (Lakoff & Johnson, 1980; Day, 1996; Martino et al. 2001; Galeyev, 2007; Marks, 2011). Those crossmodal association mechanisms due to extensive cross-wiring between brain regions that usually represent abstract concepts, might explain links between creativity, metaphor and synesthesia that typically have higher incidence among artists and poets (Dailey et al., 1997; Ramachandran & Hubbard, 2001b; Marks & Mulvenna, 2013). Similarly, metaphor may be understood as a form of cross-activations of conceptual maps in a manner analogous to cross-activation of perceptual maps in synesthesia" (Ramachandran & Hubbard, 2001b; Simner, 2013; Marks, 2013b). This similarity might explain higher incidence of synesthesia in artists and poets, which likely is based on opportunity of creative mapping related to hyperconnectivity that typically involves sensory- limbic connections (Ramachandran & Hubbard 2001b; Martino et al., 2001; Simner, 2013).

A specific structure that may play significant role in these cross-modal connections is angular gyrus, which is in agreement with its strategic location at the crossroads between the temporal, parietal and occipital lobes. Ramachandran and Hubbard (2001b) suggested that angular gyrus might play a critical role in forming cross-modal associations. In addition this structure might be related to a dynamic interplay between learned and naturally biased constraints on the development of neural structures (Spector & Maurer, 2009). Some research data also show that various crossmodal interactions between synesthetically corresponding dimensions likely play a role in synesthetic associations linked to multisensory integration (Parise & Spence, 2009).

Some authors also suggest that cross-modal interactions in weaker forms of synesthesia follow the same principles of organisation that occur in individuals with specific synesthetic abilities (Kadosh et al., 2007; Kadosh & Walsh, 2008; Simner et al., 2011; Marks, 2011; Marks & Mulvenna, 2013; Simner, 2013). For example, Kadosh et al. (2008) using post-hypnotic suggestion reported induction of a grapheme-colour synesthe-

sia that is usually observed in stronger forms of "developmental" synesthesia. This finding is in agreement with the concept of synesthetic metaphors and suggests that posthypnotic suggestion can induce behavior similar to of congenital synesthetes likely due to hyperconnectivity (Kadosh et al., 2008).

Taken together these findings enable to understand that differences between two typical forms of synesthesia defined as "strong" and "weak" are represented by typical distinguished activations of neural network and not specific differences in neural substrate (Martino and Marks, 2001; Ramachandran and Hubbard, 2001b; Marks, 2011, 2013b; Marks & Mulvenna, 2013). There is also evidence that strong synesthesia is usually characterized by a vivid image in one sensory modality in response to stimulation in another sensory domain (Baron-Cohen et al., 1996; Cytowic, 1989). On the other hand weak (metaphoric) synesthesia usually describes milder forms of cross-sensory connections that are characterized by cross-sensory correspondences expressed through language, perceptual similarity and perceptual interactions during information processing (Martino & Marks, 2001; Marks, 2011).

Typical forms represent cross-modal metaphors that occur in common language (e.g., warm color and sweet smell), in literature (e.g., Baudelaire's poem "Correspondences") and experimental data focused on cross-modal associations in which participants are asked to pair a stimulus from one sensory modality to a stimulus from another sensory domain (Marks, 1978; Martino & Marks, 2001; Moller et al., 2009; Marks & Mulvenna, 2013). For example, given a set of notes varying in pitch and a set of colors varying in lightness, the higher the pitch, the lighter the color paired with it (see Marks, 1978, 2011; Kuhbandner & Pekrun, 2013). Compared to strong synesthesia, in weak synesthesia correspondences are defined by context, which means that the highest pitch is always associated with the lightest color. This enables to define crossmodal correspondences in weak synesthesia as "contextual", whether strong synesthesia have the same manifestations independent of experimental or situational context (Baron-Cohen et al., 1996; Cytowic, 1989, 2002; Martino & Marks, 2001; Fitzgibbon, et al., 2010; Marks, 2013b).

Also other studies suggest basic parallels between synesthesia and cross-modal associations in nonsynesthetes (Simner et al., 2011; Marks & Mulvenna, 2013; Simner, 2013). For example, Ward, Huckstep, and Tsakanikos (2006) demonstrated that associations of sounds to colours in synesthesia showed same patterns of correspondence between luminosity and tone pitch as were observed in cross-modal associations of normal persons. Similarly, Hochel & Milan (2008) suggest that specific regions of

human brain may have an innate capacity to extract common, abstract properties from otherwise unrelated domains that may be less or more "contextual" or "hardwired" in the nervous systems that might be environmentally or genetically influenced (Asher, et al., 2009; Smilek, Dixon, & Merikle, 2005; Hochel & Milan, 2008; Spector & Maurer, 2009).

Within this context, synesthetic phenomena could be conceptualized as more "contextually" enhanced or more neural based ("perceptual" or "developmental") based on cross-activation of brain maps. Similarly, also Ramachandran & Hubbard (2001b) proposed that various levels of extensive cross-wirings between brain regions may represent abstract concepts that might explain also links between creativity, metaphor and synesthesia and their neural correlates. In this context, terms synesthesia and "synesthetic metaphor", most likely have significant overlap with basic mechanisms of crossmodal associations that may help to explain synesthetic and metaphoric phenomena as a continuum of various forms of intersensory experiences related to verbal and emotional memories (Marks, 2011; Simner, 2013; Kuhbandner & Pekrun, 2013).

1.5. CONCLUSION

This review discussed recent findings and specific relationships of synesthesia, cross-modal associations and metaphor. Mainly recent research findings have focused on grapheme-color and tone-color synesthesia that may help to explain basic neural mechanisms of conscious experience and nature of perceptual qualia (Hochel & Milan, 2008). On the other hand, research of strong and weak synesthetic phenomena provide various neuroscientific findings about basic mechanisms involved in perceptual coding and cross-modal information processing (Martino & Marks, 2001; Dael et al., 2013).

More comprehensive understanding of neural mechanisms of synesthesia provides also research in patients with autism-spectrum disorders (Harrison et al., 2004). Important findings show neuropathological studies that reported abnormally increased connectivity in autism and specific alterations of white matter that indicate increased connectivity in synesthesia (Asher, et al., 2009; Brogaard 2013), mainly in some cases of autistic savants that manifest strong forms of synesthesia (Baron-Cohen et al., 2007). Nevertheless future research is needed to elucidate specific relationships between synesthetic phenomena and neuronal connectivity and also certain disinhibitory mechanisms that may underlie hyperconnectivity related to intrasensory and associative links connecting various sensory domains ranging from "lower" synesthesia to more "associative" synesthesias and cross-modal metaphors (Cytowic, 2002; Marks, 1978; Hochel & Milan, 2008; Simner, 2013). In future research study of increased cross-modal connections may explain specific psychopathological phenomena such as hallucinations or delusions and also disturbed forms of imagination that occur in mental disorders as for example in schizophrenia but also in other mental disorders.

2. EMPIRICAL RESEARCH

2.1. SYNESTHETIC ASSOCIATIONS AND PSYCHOPATHOLOGICAL SYMPTOMS: PRELIMINARY EVIDENCE IN YOUNG WOMEN

Introduction

Synesthesia is a neuropsychological condition in which stimulation of one sensory modality or cognitive pathway is associated with unusual experiences in a different unstimulated modality, for example, hearing a sound may evoke seeing a color (Martino & Marks, 2001; Eagleman & Goodale, 2009; Ward, 2013). The first reported case of synesthesia was published in 1812 by Sachs, who documented colored sequences of vowels and music and later Fechner reported colored letter photisms (Jewanski, Day & Ward, 2009; Jewanski et al., 2011). Later research after the Second World War documented growing evidence about synesthetic phenomena and recent findings show that synesthesia is a phenomenon related to various forms of inter-sensory connections from which most frequent form is experience of colored hearing (Martino & Marks, 2001; Nunn et al., 2002; Simner & Hubbard, 2013). For example, it has been documented that higher sounds evoke images of lighter and brighter colors and vice versa (Marks, 1978, 2011; Kuhbandner & Pekrun, 2013).

Recent studies indicate that phenomenon of synesthesia may be also related to various forms of associative connections as for example grapheme-color synesthesia (Marks, 1978; Cohen, 2005, Ward, 2013). In this context it has been reported that lighter colors are more frequently associated with positive emotional meanings (e.g. happy, good) and certain color specific associations were found for red color ("strong" and "angry"), blue ("good"), green ("strong"), purple ("sad") (Dailey et al., 1997; Berman, 1999; Kadosh et al., 2005; Okubo & Ishikawa, 2011).

According to recent findings synesthesia in its mild forms may have relatively high prevalence in population which according to some reported data may be at about 30-50% (Cytowic, 2002; Campen & Froger, 2003; Simner & Hubbard, 2013). In this context a purpose of this study is to assess mild forms of synesthetic experience using novel method of world-color associations which is based on emotional response to words that according to their emotional meaning may be specifically associated with darker of lighter color and quantified on Likert scale. These findings

suggest a hypothesis that darker colors as related to more negative emotions colors in response to certain specific emotional words could be more likely related to psychopathological processes related to depression, anxiety, alexithymia and stress symptoms.

Participants and method

Participants

Group of participants consisted of 43 healthy young women (Mena age=18.25; SD=0.86, age range 17-19) with high school education. All participants signed informed consent and the study was approved by Charles University ethical committee.

Methods

Assessment of color-word associations

The method of color-world associations is based on emotional response to words that according to their emotional meaning may be specifically associated with lighter or darker color and quantified on color scale from 1 to 10 (Figure 1). In the assessment, colors are associated to words that also include a number of critical words which usually have particular psychological significance that may cause association disturbances (Jung, 1910; Kondas, 1989). The critical words are designed to recall previous affective associations that modulate new defensive reactions and lead to significant physiological response (Jung, 1910). During the experiment the standard list of 25 stimulus words plus 3 added words (love, sex, punishment) were presented in the following order (critical words in italic): 1. brook, 2. lion, 3. book, 4. dark, 5. l*ove*, 6. child, 6. *love*, 7. table, 8. head, 9. *death*, 10. boy, 11. *illness*, 12. hand, 13. mountain, 14. *sex*, 15. *crying*, 16. needle, 17. family, 18. cheese, 19. moon, 20. *fear*, 21. window, 22. street, 23. *punishment*, 24. salt, 25. man, 26. *anger*, 27. soldier, 28. doctor. To each stimulus words were associated 3 colors in sequence which describes the word. For scoring is used mean score of 3 colors associated to the word, first associated color and maximum difference between darkest and lightest associated colors.

Beck Depression Inventory (BDI-II)

For the assessment of depressive symptoms was used Czech version of Beck depression inventory (Beck et al., 1996) that represents 21-items

questionnaire for assessing depression (Cronbach's alpha 0.89, test-retest reliability after week 0.85). Subjects indicate degree of their experience of depressive symptoms on 4-point Likert scale. The scale is sensitive to changes of the mental state of the individual in the course of time.

Self-Rating Anxiety Scale (SAS)
Levels of anxiety symptoms were assessed using the Czech version of The Zung Self-Rating Anxiety Scale (Cronbach's alpha 0.89, test-retest reliability after week 0.85) (Zung, 1971). The SAS is 20-item self-reporting questionnaire focused on the most common general anxiety symptoms. Each question is scored on 4-point Likert scale from 1 to 4.

Toronto Alexithymia Scale (TAS-20)
Alexithymia was assessed using the validated Czech version of the 20-item Toronto Alexithymia Scale (Cronbach's alpha 0.81, test-retest reliability after 1 week 0.77) (Bagby et al., 1994). Each question is scored on a five-point Likert scale (1-5) and the TAS total score has range from 20 to 100.

Trauma Symptoms Checklist (TSC-40)
Symptoms of traumatic stress were assessed using Trauma Symptom Checklist (Briere, 1996). TSC-40 is a self-reported questionnaire with 40 items scored on a 4-point Likert scale (total score from 0 to 120). TSC-40 evaluates stress symptoms in adult individuals associated with childhood or adult traumatic experiences and measures aspects of posttraumatic stress and other symptom clusters found in some traumatized individuals. The scale includes subscales for dissociation, anxiety, depression, sexual abuse trauma index (SATI), sleep disturbances and sexual problems. The Czech version of the TSC-40 has high reliability and internal consistency (Cronbach's alpha 0.91, test-retest reliability after one week 0.88).

Statistical methods
Statistical evaluation for the results of color-word associations and other psychometric measures included descriptive statistics and Spearman correlation coefficients. All the methods of statistical evaluation were performed using the software package Statistica version 6.

Results

Results of descriptive statistic indicate a tendency to link level of darkness on scale of colors (from white 0 to black 10) with words generally perceived as negative *Anger* (Mean=8.20), *Punishment* (Mean=7.72), *Fear* (Mean=7.94), *Death* (Mean=7.65), *Disease* (Mean=7.64), *Crying* (Mean=6.97) on the other hand the less "dark" (lighter) scores were for example linked to words *Child* (Mean=4.07) and *Family* (Mean=4.69).

In addition the data show some significant correlations of means, first associated color (1) and the maximum difference of the lightest and darkest associated color (dif.) with psychopathological symptoms of depression, anxiety, alexithymia and traumatic stress. In statistical analysis following significant relationships were found:

Associated color score to the word *Child* (mean) indicates relatively high negative Spearman correlations with TAS-20 (-0.47; $p<0.01$), BDI-II (-0.33; $p<0.05$) and TSC-40 (-0.36; $p<0.05$), which suggest a link between level of lightness of associated color and symptoms of alexithymia, depression and symptoms of traumatic stress. *Child (1)* manifests negative correlations with TAS-20 (-0.55; $p<0.01$), BDI-II (-0.33; $p<0.05$), SAS (-0.35; $p<0.05$) and TSC-40 (-0.40; $p<0.01$) which also suggest a link between level of lightness of associated color to *child* and the psychopathological symptoms.

First associated color to word *Head* (1) manifests negative correlations with TAS-20 (-0.31; $p<0.05$), SAS (-0.39; $p<0.01$) and TSC-40 (-0.40; $p<0.01$) which also suggest a link between level of lightness of associated colors and the psychopathological symptoms.

Associated colors to word *Boy* (mean) are significantly negatively correlated with TAS-20 ($r=-0.49$; $p<0.01$) and *Boy* (dif) are significantly negatively correlated with TAS-20 ($r=-0.32$; $p<0.05$) and BDI-II (-0.31; $p<0.05$) which suggests that lighter associations to this word are linked to the symptoms. *Hand* (1) also manifests negative correlations with BDI-II ($r= -0.36$; $p<0.05$) and the link between higher lightness level and depressive symptoms is also documented by significant negative correlation between *sex* (1) and BDI-II (-0.32; $p<0.05$). *Salt* (mean) manifests negative correlations with TSC-40 (-0.41; $p<0.01$) and *Salt* (1) that also manifests negative correlations with TSC-40 (-0.33). *Month* (mean) has positive correlation with TAS-20 (0.36; $p<0.05$) and TSC-40 (0.31; $p<0.05$). Other correlations are *Family* (1) with TAS-20 (-0.33; $p<0.05$), *Cheese* (mean) with TSC-40 (-0.30; $p<0.05$) and *Fear* (1) with BDI-II (-0.45; $p<0.01$).

With respect to these results we have found specific words associated with depression [Child (mean), Child (1), Boy (dif), Hand (1), sex (1),

Fear (1)], anxiety [Child (1), Head (1)], alexithymia [Child (mean), Child (1), Head (1), Boy (mean), Boy (dif), Month (mean)- inverse score, Family (1)] and stress symptoms [Child (mean), Child (1), Head (1), Salt (mean), Salt (1), Month (mean)- inverse score, Cheese (mean)]. Sum of scores related to these words provide subscales for quantified projective assessments of these symptoms. Color-word subscale for depression (CWDep) shows highly significant correlation with BDI-II (Spearman R= -0.60, $p<0.01$), Color-word subscale for anxiety (CWAnx) shows highly significant correlation with SAS (-0.44, $p<0.01$), Color-word subscale for alexithymia (CWAlex) shows highly significant correlation with TAS-20 (-0.70, $p<0.01$), and Color-word subscale for symptoms for traumatic stress (CWStress) shows highly significant correlation with TSC-40 (-0.64, $p<0.01$).

Conclusion

The results are in agreement with previous reported studies suggesting that lighter colors are more frequently associated with positive emotional meanings (Dailey et al., 1997; Berman, 1999; Kadosh et al., 2005; Okubo & Ishikawa, 2011). In addition the results indicate significant relationships of color-word associations to some specific words with depression, anxiety, alexithymia and symptoms of traumatic stress. For example, most significant relationship has been found between lighter associations of colors to word "child" with psychopathological symptoms of anxiety, depression, alexithymia and symptoms of traumatic stress. This finding suggests that young women who see child in light colors have higher levels of psychopathological symptoms and on the other hand tendency to see child in darker colors in young women of this age is more associated with mental health. This finding likely corresponds to understanding of early maternity as a negative factor (Fraser et al., 1995; Lewis et al., 2009). Other results of this study also suggest certain specific relationships between the levels of darkness corresponding to higher scores of the color-word scale and some psychopathological manifestations linked to depression, anxiety and alexithymia. These results are in accordance with existing findings in context of the so-called metaphorical synesthesia where significant role might be attributed to color intensity (Galeyev, 2007). In this metaphorical context synesthetic experiences are closely linked to typical patterns of memory functionally and specifically consolidated in the hippocampus and other structures (Ramachandran & Hubbard, 2001; Cytowic, 2002; Simner, 2013).

Altogether results of this study provide promising data for quantification of projective assessments using color-word associations and further research in large age and gender specific samples might be very useful for quantified psychodiagnostic projective assessments.

2.2. DISSOCIATIVE SYMPTOMS AND WORD-COLOR SYNESTHETIC ASSOCIATIONS

Introduction

First scientific discoveries of divided consciousness called dissociation (or splitting) appeared in Janet's research and in Freud's and Breuer's work, who considered secondary consciousness in "Studies in hysteria" (Breuer & Freud, 1895; Janet, 1890; Ellenberger, 1970). In this study, Breuer and Freud developed concept of splitting that explains shifts of mind during the time due to a consciously experienced conflict of opposing mental forces leading to repression (Breuer & Freud, 1895; Ellenberger, 1970). Later findings have shown that a level of conscious integration or disintegration may change due to various conditions related to experimental cognitive manipulations, hypnosis or stressful experiences which may lead to dissociation of consciousness and influence accessibility of various mental contents into the consciousness (Baars, 2002; Diaz & McCarthy, 2007; Melloni et al., 2007). Consequently these alterations may be linked to great and abrupt changes in patterns of neural activity that may dissociate (or split off) certain external and internal information out of awareness, and cause a lack of the self-representation which may lead to a distinct state of divided consciousness (Hilgard, 1986; Crawford, 1994; Rainville et al., 2002; Vermetten & Douglas, 2004; Bob, 2008).

In the historical context the theory of dissociation ("dis-association") was also studied by Jung (Jung, 1910; Ellenberger, 1970; Bob, 2011), who found that associations to specific words are linked to complex mental structures that connect emotional, episodic and semantic memories that also reflect conflict related to dissociated memories. These words include usual words and also critical words that are more likely related to a conflict which cause association disturbances (Jung, 1910; Ellenberger, 1970; Hilgard, 1986; Bob, 2011). Recent studies also indicate that these associative connections may be also related to various forms of synesthetic associations as for example grapheme-color synesthesia (Marks, 1978; Cohen, 2005, Ward, 2013). These findings show that certain colors may have specific associations, for example red color ("strong" and "angry"), blue

("good"), green ("strong"), purple ("sad"), whereas lighter colors are more frequently associated with positive emotional meanings (e.g. happy, good) and (Dailey et al., 1997; Berman, 1999; Kadosh et al., 2005; Okubo & Ishikawa, 2011).

According to recent findings synesthesia is a phenomenon related to various forms of inter-sensory connections (Martino & Marks, 2001; Nunn et al., 2002; Simner & Hubbard, 2013) which in its mild forms may have relatively high prevalence in population which according to some reported data may be at about 30-50% (Cytowic, 2002; Campen & Froger, 2003; Simner & Hubbard, 2013). In this context a purpose of this study is to assess mild forms of synesthetic experience using novel method of world-color associations which is based on emotional response to words that according to their emotional meaning may be specifically associated with darker or lighter color and quantified on Likert scale. These findings suggest a hypothesis that associated colors as related to specific emotions in response to certain specific emotional words that mainly in the cases of words related to cognitive and emotional conflict could be related to dissociative symptoms, symptoms of splitting and other symptoms related to stressful experiences.

Participants and method

Participants

Group of participants consisted of 40 healthy young men (Mean age=26.12; SD=5.16, age range 19-34) with high school education. All participants signed informed consent and the study was approved by Charles University ethical committee.

Methods

Assessment of color-word associations
The method of color-world associations proposed in this study is based on emotional response to words that according to their emotional meaning may be specifically associated with lighter or darker color and quantified on color scale from 1 to 10 (Figure 1). In the assessment, as a response to a stimulus words a participant provides spontaneous association of a color according to the scale on Figure 1. The words include usual words but also critical words which usually have particular psychological significance that may cause association disturbances (Jung, 1910; Kondas, 1989). The critical words are designed to recall previous affective associations that modulate new defensive reactions and lead to significant physiological response (Jung, 1910). During the experiment the standard list of 25 stimulus words plus 3 added words (***love, sex, punishment***) were presented in the following order (critical words in bold italic): 1. brook, 2. lion, 3. book, 4. dark, 5. ***love***, 6. child, 7. table, 8. head, 9. ***death***, 10. boy, 11. ***illness***, 12. hand, 13. mountain, 14. ***sex***, 15. ***crying***, 16. needle, 17. family, 18. cheese, 19. moon, 20. ***fear***, 21. window, 22. street, 23. ***punishment***, 24. salt, 25. man, 26. ***anger***, 27. soldier, 28. doctor. To each stimulus words were associated 3 colors in a sequence which describes the word. For scoring is used mean score of 3 colors associated to the word, first associated color and maximum difference between darkest and lightest associated colors.

Dissociative Experiences Scale

Symptoms of dissociation were assessed using the Dissociative Experiences Scale (Bernstein & Putnam, 1986). The DES is a self-reported scale with 28 items asking respondents to indicate their response on 100-mm scale to what extent they experience typical dissociative phenomena in daily life (Cronbach's alpha 0.92, test-retest reliability after week 0.91). Normative score of the scale defines increased probability for manifestations of dissociative disorders for total scores higher than 30. Dissociative phenomena for example include feelings of depersonalization, derealization, psychogenic amnesia and others. DES as well as other psychometric measures used in this study were translated into Czech language from the English original and then back-translated into English. The resulting documents were compared with the originals by a native English speaker and all the tests have good psychometric properties and equivalent quality to test occurrence of the symptoms as their English originals.

Somatoform Dissociation Questionnaire

Somatoform dissociative symptoms were measured using 20-items self-reported Somatoform Dissociation Questionnaire (SDQ-20) (Nijenhuis, 1996). Normative score of the scale defines significant occurrence of somatoform dissociative symptoms for scores higher than 30. Somatoform dissociative symptoms represent alterations in sensations of pain (analgesia, kinesthetic anesthesia), alterations of perception, loss of motor control, gastrointestinal symptoms, etc. Subjects indicate the degree of their experience on 5-point Likert scale (Cronbach's alpha 0.91, test-retest reliability after week 0.90).

Splitting Index

The symptoms of splitting were measured using self-reported Splitting index (SI) (Gould et al. 1996) that has been proposed to test defense mechanisms as described by Kernberg (1975). Splitting Index is 24-items self-reported questionnaire assessed on 5-point Likert scale from 1 to 5 (Cronbach's alfa 0.92, test-retest reliability after one week 0.82). Using factor analysis three clusters of items have been identified that enable to describe the splitting process. These three factors represent the self factor (splitting of the self image), the family factor (splitting of images of family members), and the factor of others which pertains to people outside the family.

Trauma Symptoms Checklist (TSC-40)
Symptoms of traumatic stress were assessed using Trauma Symptom Checklist (Briere, 1996). TSC-40 is a self-reported questionnaire with 40 items scored on a 4-point Likert scale (total score from 0 to 120). TSC-40 evaluates stress symptoms in adult individuals associated with childhood or adult traumatic experiences and measures aspects of posttraumatic stress and other symptom clusters found in some traumatized individuals. The scale includes subscales for dissociation, anxiety, depression, sexual abuse trauma index (SATI), sleep disturbances and sexual problems. The Czech version of the TSC-40 has high reliability and internal consistency (Cronbach's alpha 0.91, test-retest reliability after one week 0.88).

Statistical methods

Statistical evaluation of the results of the color-word associations and other psychometric measures included descriptive statistics and Spearman correlation coefficients. All the methods of statistical evaluation were performed using the software package Statistica version 6.

Results

Results of descriptive statistic indicate a tendency to link level of darkness on scale of colors (from white 0 to black 10) with words generally perceived as negative ***Anger*** (Mean=7.44), ***Punishment*** (Mean=7.31), ***Fear*** (Mean=7.21), ***Death*** (Mean=7.01), ***Illness*** (Mean=6.53), ***Crying*** (Mean=6.20) on the other hand the less "dark" (lighter) scores were for example linked to words *Child* (Mean=3.68) and *Family* (Mean=4.98).

In addition the data show some significant correlations of means, first associated color (1) and the maximum difference of the lightest and darkest associated color (dif.) with psychopathological symptoms of depression, anxiety, alexithymia and traumatic stress. In statistical analysis following significant relationships were found:

Associated color score to the word *Street* (dif) indicates relatively high negative Spearman correlations with DES (-0.44; $p<0.01$), SDQ-20 (-0.49; $p<0.01$), SI (-0.35; $p<0.05$) and TSC-40 (-0.32; $p<0.05$), which suggest a link between the maximum difference of the lightest and darkest associated color and dissociative symptoms, symptoms of splitting and symptoms of traumatic stress.

Associated color score to the word *Family* (mean) indicates relatively high positive Spearman correlations with SI (0.49; $p<0.01$) and TSC-40 (0.35; $p<0.05$) and *Family* (1) with SI (0.46; $p<0.01$) and TSC-40 (0.39; $p<0.05$) which suggest a link between level of darkness of the associated color and symptoms of splitting and symptoms of traumatic stress.

Month (mean) manifests negative correlations with DES (-0.35; $p<0.05$) and TSC-40 (-0.34; $p<0.05$), which suggest a link between level of lightness of associated color to *Month* (mean) with dissociative symptoms and symptoms of traumatic stress. *Month* (1.) manifests negative correlations with DES (-0.32; $p<0.05$), which also suggest a link between level of lightness of associated color to *Month* (1.) and dissociative symptoms.

Associated colors to word: *Lion* (mean) are significantly positively correlated with TSC-40 ($r=0.38$; $p<0.05$), *Head* (mean) with TSC-40 ($r=0.37$; $p<0.05$), ***Illness*** (1.) with SI ($r=0.35$; $p<0.05$), *Cheese* (1.) with SDQ-20 ($r=0.41$; $p<0.01$), *Window* (1.) with SI ($r=0.41$; $p<0.01$). Associated colors to word: ***Punishment*** (mean) are significantly negatively correlated with SI ($r=-0.35$; $p<0.05$), *Boy* (mean) with SI ($r=-0.34$; $p<0.05$) and *Hand* (1.) with DES ($r=-0.34$; $p<0.05$).

With respect to these results we have found specific words associated with DES [Hand (1) - inverse score, Month (mean) - inverse score, Month (1.) - inverse score, Street (dif) - inverse score], with SDQ-20 [Cheese (1.), Street (dif) - inverse score], with SI [Boy (mean) - inverse score, Illness (1.), Family (mean), Family (1), Window (1.), Street (dif) - inverse score, Punishment (mean) - inverse score] and with TSC-40 [Lion (mean), Head (mean), Family (mean), Family (1), Month (mean) - inverse score, Street (dif) - inverse score].

Sum of scores related to these words provide subscales for quantified projective assessments of these symptoms. Color-word subscale for dissociation (CWDis) shows highly significant correlation with DES (Spearman $R= 0.56$, $p<0.01$), Color-word subscale for somatoform dissociation (CWSomDis) shows highly significant correlation with SDQ-20 (0.56, $p<0.01$), Color-word subscale for splitting (CWSplit) shows highly significant correlation with SI (0.69, $p<0.01$), and Color-word subscale for symptoms for traumatic stress (CWStress) shows highly significant correlation with TSC-40 (0.58, $p<0.01$).

Conclusion

Recent and historical findings about dissociation are in agreement with neuroscientific evidence that perceptual information may be processed and included in various contextual frameworks and that awareness requires access to that information by other parts of the mind/brain (Brown, 1984; Baars, 1988, 2002; Bunge et al., 2001; Shevrin, 2001; Bob, 2011). Recent findings indicate that association processes directly link various contextual frameworks that in a case of conflict and dissociation (or split) of mental contents lead to association disturbances (Jung, 1910; Ellenberger, 1970; Hilgard, 1986; Nadel & Jacobs, 1998; Lavenex & Amaral, 2000; Bob, 2011).

In this context, results of this study suggest that color associations may reflect various mental contents and specifically indicate stimulus words related to dissociated states that manifest as response to conflicting contextual frameworks and stressful experiences. This crossmodal association process likely is linked to process of synesthesia as a neuropsychological condition in which stimulation of one sensory modality or cognitive pathway is associated with unusual experiences in a different unstimulated modality (Martino & Marks, 2001; Eagleman & Goodale, 2009; Ward, 2013). Mainly these results are in accordance with existing findings in context of the so-called metaphorical synesthesia (Galeyev, 2007) and in agreement with previously reported data suggesting that lighter colors are more frequently associated with positive emotional meanings (Dailey et al., 1997; Berman, 1999; Kadosh et al., 2005; Okubo & Ishikawa, 2011). In this metaphorical process synesthetic experiences are closely associated to typical patterns of memory functionally and specifically consolidated in the hippocampus and other structures that create various contextual frameworks (Ramachandran & Hubbard, 2001; Cytowic, 2002; Simner, 2013) that are specifically influenced by stressful conditions (Bunge et al., 2001; Diaz & McCarthy, 2007; Ellenberger, 1970; Nadel & Jacobs, 1998; Vermetten & Douglas, 2004; Bob, 2011).

These findings about metaphoric synesthetic associations may play a specific role in symbolic imagination, where various colors and their levels of lightness or darkness may characterize their association or dissociation ("dis-association") with predominant contextual framework and reflect unconscious mental processes. Nevertheless qualitative or symbolic meanings of these color associations to specific words and their re-

lationship to symptoms of stress and dissociation were not included in this study and will need further research.

In summary, results of this study indicate that associated colors in response to certain specific emotional words associated with cognitive and emotional conflict are related to dissociative symptoms, symptoms of splitting and other stress related symptoms. These results seem to be useful for quantification of dissociative and stress symptoms using projective testing of color-word associations that need to be replicated in further research in large age and gender specific samples.

2.3. SYNESTHETIC ASSOCIATIONS AND PSYCHOSENSORY SYMPTOMS OF TEMPORAL EPILEPSY

Introduction

Temporal lobe epilepsy represents neurological pathological condition which is also related to a wide spectrum of psychopathological symptoms that manifest as various sensory distortions, hallucinatory experiences, depersonalization, derealization and other psychosensory and affective symptoms usually reported in patients with temporal lobe epilepsy (Teicher et al., 1993; Teicher et al., 2003; Teicher et al., 2006; Roberts et al., 1992). Recent research indicates that these symptoms may occur as a continuum of complex partial seizure-like symptoms also in patients with mental disorders and in normal population (Teicher et al., 1993; Roberts et al., 1992). Some data also show that these symptoms may be related to stressful and traumatic experiences that may influence inhibitory functions and neural excitability mainly in the limbic system (Teicher et al., 1993; Teicher et al., 2003; Teicher et al., 2006). Several findings also show that temporal lobe seizures or seizure-like conditions may manifest in various unusual cross-sensory links and unusual associative connections that may cause synesthetic phenomena (Ramachandran & Hubbard, 2001; Terhune et al., 2006). Synesthesia is a phenomenon related to various forms of inter-sensory connections for example, hearing a sound may evoke seeing a color (Ramachandran & Hubbard, 2001; Cytowic, 2002; Martino & Marks, 2001).

According to recent findings synesthesia in its mild forms may have relatively high prevalence in population which according to some reported data may be at about 30-50% (Cytowic, 2002; Simner, 2013). Recent studies indicate that phenomenon of the so called "soft synesthesia" may be related to various forms of associative connections as for example grapheme-color synesthesia or sound-color synesthesia where higher sounds evoke images of lighter and brighter colors and vice versa (Marks, 1978; Cohen et al., 2005; Kuhbandner & Pekrun, 2013). Several studies documented that lighter colors are more frequently associated with positive emotional meanings (e.g. happy, good) and certain color specific associations were found for red color ("strong" and "angry"),

blue (“good”), green (“strong”), purple (“sad”) (Cohen et al., 2005; Okubo & Ishikawa, 2011).

In this context, a purpose of this study is to assess relationships between mild forms of temporal lobe psychosensory symptoms and word-color synesthetic experience using a novel method of world-color associations. This method is based on emotional response to words that according to their emotional meaning may be specifically associated with darker of lighter color and quantified on Likert scale. These findings suggest a hypothesis that colors related to emotions in response to certain specific words could be more associated with actual presence of psychosensory symptoms related to temporal lobe epilepsy than with other psychopathological symptoms. For the purpose to test the hypothesis we have compared two subgroups of participants selected from general population. The first subgroup of participants who had higher level of psychosensory and affective symptoms related to temporal epilepsy was compared with healthy control subgroup of participants who had only minor level of these symptoms.

Participants and method

Participants

The sample included 71 participants (Mean age=25.23; SD=7.21, age range 18-39) selected by advertising for general population and consisted of 41 women and 30 men predominantly with high school education. The whole sample included two subgroups according to levels of psychosensory and affective symptoms related to temporal epilepsy measured by Limbic System Checklist (LSCL-33). The first subgroup (N=31) included participants with LSCL-33 score 28 or more and the second subgroup (N=40) included participants with LSCL-33 score less than 10. All participants signed informed consent and the study was approved by Charles University ethical committee.

Methods

Symptoms similar to ictal temporal lobe epilepsy such as somatic, sensory, behavioral and memory symptoms linked to temporal lobe epileptiform activity were assessed by Limbic System Checklist LSCL-33 (Teicher et al., 2003). LSCL-33 is designed to measure temporo-limbic activity in the form of somatic, sensory, behavioral and memory symptoms known to be associated with phenomena of ictal temporal lobe epilepsy. These symptoms may be generally described as brief hallucinations, paroxysmal somatic disturbances, automatisms and dissociative disturbances. Czech version of LSCL-33 as well as the original English version shows well psychometric properties and internal consistency Cronbach's alpha 0.90 with test-retest reliability r=0.91.

Trauma Symptoms Checklist (TSC-40)

Symptoms of traumatic stress were assessed using Trauma Symptom Checklist (Briere, 1996). TSC-40 is a self-reported questionnaire with 40 items scored on a 4-point Likert scale (total score from 0 to 120). TSC-40 evaluates stress symptoms in adult individuals associated with childhood or adult traumatic experiences and measures aspects of posttraumatic stress and other symptom clusters found in some traumatized individuals. The Czech version of the TSC-40 has high reliability and inter-

nal consistency (Cronbach's alpha 0.91, test-retest reliability after one week 0.88).

Beck Depression Inventory (BDI-II)

For the assessment of depressive symptoms was used Czech version of Beck depression inventory (Beck at al., 1996) that represents 21-items questionnaire for assessing depression (Cronbach's alpha 0.89, test-retest reliability after week 0.85). Subjects indicate degree of their experience of depressive symptoms on 4-point Likert scale. The scale is sensitive to changes of the mental state of the individual in the course of time.

Assessment of color-word associations

The method of color-world associations is based on emotional response to words that according to their emotional meaning may be specifically associated with lighter or darker color and quantified on color scale from 1 to 10 (Figure 1). In the assessment, colors are associated to words that also include a number of critical words which usually have particular psychological significance that may cause association disturbances (Jung, 1910, Kondas, 1989). The critical words are designed to recall previous affective associations that modulate new defensive reactions and lead to significant physiological response (Jung, 1910). During the experiment the standard list of 25 stimulus words plus 3 added words (love, sex, punishment) were presented in the following order (critical words in italic): 1. brook, 2. lion, 3. book, 4. dark, 5. l*ove*, 6. child, 7. table, 8. head, 9. *death*, 10. boy, 11. *illness*, 12. hand, 13. mountain, 14. *sex*, 15. *crying*, 16. needle, 17. family, 18. cheese, 19. moon, 20. *fear*, 21. window, 22. street, 23. *punishment*, 24. salt, 25. man, 26. *anger*, 27. soldier, 28. doctor. To each stimulus words were associated 3 colors in sequence which describes the word. For scoring is used mean score of 3 colors associated to the word, first associated color (1) and maximum difference (dif.) between darkest and lightest associated colors.

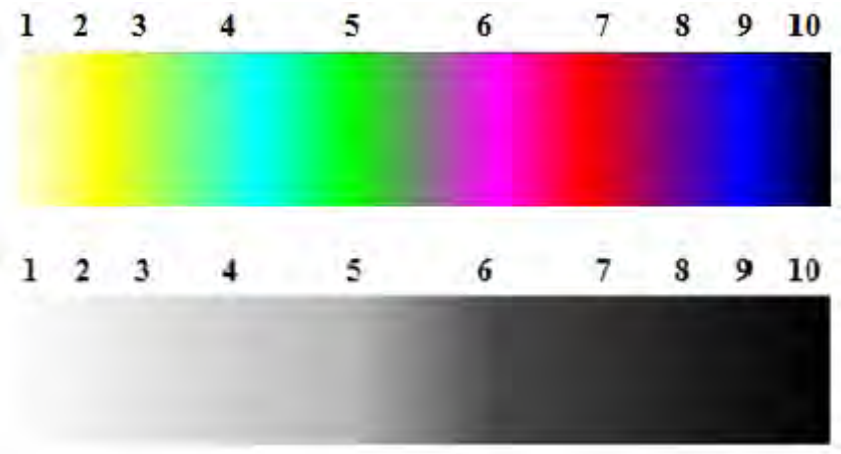


Figure 1. Color scale used for measurement of color associations in response to word stimuli, which in black-white projection provides gray continuous Likert scale from white to black (1-10).

Statistical methods

Statistical evaluation for the results of color-word associations and other psychometric measures included descriptive statistics and Spearman correlation coefficients. All the methods of statistical evaluation were performed using the software package Statistica version 6.

Results

Results of descriptive statistics for all included participants indicate a tendency to link level of darkness on the scale of colors (from white 0 to black 10) with words generally perceived as negative *Anger* (Mean=7.89), *Punishment* (Mean=7.68), *Fear* (Mean=7.65), *Death* (Mean=7.56), *Disease* (Mean=7.09), *Crying* (Mean=6.61) on the other hand the less "dark" (lighter) scores were for example linked to words *Child* (Mean=4.04) and *Family* (Mean=4.67).

In addition the data show specific differences between both subgroups with related to occurrences of significant correlations of means, first associated color (1) and the maximum difference of the lightest and darkest associated color (dif.) with psychopathological symptoms of temporal lobe epilepsy (LSCL-33), depression (BDI-II) and traumatic stress (TSC-40).

The results in both subgroups indicate specific words correlated with scores of psychopathological symptoms measured by LSCL-33, BDI-II and TSC-40. In the first subgroup of participants with high LSCL-33 were significant Spearman correlations of scores related to associated colors with LSCL-33 [Brook (mean) Spearman R=0.36, $p<0.05$; Love (1) -0.48, $p<0.01$; Child (1) -0.42, $p<0.01$; Cheese (mean) 0.41, $p<0.01$; Fear (mean) -0.39, $p<0.05$] with TSC-40 [Table (mean) -0.43, $p<0.05$; Table (1) -0.52, $p<0.01$; Death (1) -0.47, $p<0.01$; Hand (1) -0.40, $p<0.01$; Cheese (dif) 0.45, $p<0.01$; Moon (mean) 0.36, $p<0.05$; Punishment (1) -0.43, $p<0.05$; Doctor (1) -0.42, $p<0.05$] and BDI-II [Book (mean) 0.40, $p<0.05$; Hand (1) -0.51, $p<0.01$; Mountain (1) -0.46, $p<0.05$; Moon (mean) 0.45, $p<0.01$; Street (1) 0.42, $p<0.05$; Man (1) -0.42, $p<0.05$].

In the second subgroup of healthy controls were significant correlations of scores related to associated colors with LSCL-33 [Book (mean) -0.34, $p<0.05$; Book (1) -0.44, $p<0.01$; Child (dif) -0.45, $p<0.01$; Sex (dif) 0.33, $p<0.05$; Family (mean) 0.36, $p<0.05$; Moon (mean) -0.40, $p<0.05$; Moon (dif) -0.46, $p<0.01$; Fear (1) -0.38, $p<0.01$; Street (dif) -0.33, $p<0.05$; Punishment (1) -0.41, $p<0.01$] with TSC-40 [Hand (1) -0.32, $p<0.05$; Street (1) -0.36, $p<0.05$; Punishment (1) -0.34, $p<0.05$; Soldier (mean) 0.37, $p<0.05$; Doctor (1) 0.40, $p<0.05$]. No significant correlations related to scores of associated colors with and BDI-II have been found.

It is important to note that we refer to these significant correlations based on single tests and due to multiple comparisons the Bonferroni

correction should be considered. Nevertheless results of the correlations of color-words associations with psychometric measures have non-random pattern. In order to avoid the type II errors due to taking assessed correlations as independent we refer to uncorrected statistical significance.

Discussion

The results of descriptive statistics are congruent with previously reported studies which suggest that positive emotional meanings are more frequently associated with lighter colors (Cohen et al., 2005; Okubo & Ishikawa, 2011). These findings are in agreement with data that spoken words influence activations in brain visual areas (Nunn et al., 2002). The results show specific differences between both subgroups with related to occurrences of significant correlations of means, first associated color (1) and the maximum difference of the lightest and darkest associated color (dif.) with psychopathological symptoms indicating that the subgroup with higher level of temporal lobe seizure-like symptoms measured by LSCL-33 has higher ability to represent emotional meaning of words by associated colors.

In this context, Terhune et al. (2006) reported that increased excitability in the primary visual cortex using transcranial direct current stimulation (TDCS) applied in five volunteers who usually and spontaneously have synesthetic experiences led to a stronger experience of colors connected with words or numbers. Similar findings about increased cortical excitability and synesthesia reported also Bolognini et al. (2013). These results are also documented by some case studies as for example reported data about Vincent van Gogh, who most likely had synesthetic experiences related to temporal lobe seizures (Voskuil, 2013).

Taken together these data support the hypothesis that the associated colors manifest much stronger relationship with LSCL-33 than with symptoms of traumatic stress and depressive symptoms. This relationship is likely due to seizure-like conditions and increased excitability reflected by symptoms of limbic irritability (LSCL-33) that may cause increased association connectivity.

Conclusion

The results indicate specific synesthetic-like mechanism in association processes that reflects psychopathological symptoms related to increased temporo-limbic excitability. Although results of this study provide promising data for quantification of projective assessments using color-word associations, further research in large samples with specific age and gender is warranted. This future detailed research could enable to find quantified psychodiagnostic projective assessments of cognitive and affective symptoms related to temporal lobe epilepsy in psychiatric patients. This projective synesthetic-like assessment altogether with LSCL-33 could be helpful for diagnostic consideration of anticonvulsant treatment in patients who have not abnormal EEG but might positively respond to antiepileptic medication.

3. CONCLUSIONS

Synesthesia in general is a phenomenon of intersensory and intrasensory linkage that may be observed in various conditions including artistic creativity and also manifests in conditions of various brain dysfunctions and injuries (Armel & Ramachandran, 1999; Steven & Blakemore, 2004; Grossenbacher & Lovelace, 2001; Hochel & Milan, 2008). In many cases synesthesia also may be influenced by drugs, for example synesthetic hallucinations due to exposition of the lysergic acid diethylamide (LSD), mescaline and ayahuasca (Hartman & Hollister, 1963; Stuckey et al., 2005; Spector and Maurer, 2009) or other psychotropic drugs (Ramachandran & Hubbard, 2001b; Sinke et al., 2012; Brogaard, 2013). In addition, synesthesia has also been reported in healthy individuals between sleep and wakefulness and in a high proportion of meditators (Walsh, 2005), and also it may be influenced by hypnotic suggestions (Fuentes, Cohen-Kadosh, & Catena, 2007; Terhune et al., 2010). Taken together these findings suggest that synesthesia is a phenomenon on general level based and represented by transmodal associative connections that may represent a continuum from strong synesthetic phenomena to its mild forms that may enable creation of "synesthetic" metaphors. Altogether results of this study provide promising data for quantification of projective assessments using color-word associations and further research in large age and gender specific samples might be very useful for quantified psychodiagnostics. The results are in agreement with previous reported studies suggesting that lighter colors are more frequently associated with positive emotional meanings (Dailey et al., 1997; Berman, 1999; Kadosh et al., 2005; Okubo & Ishikawa, 2011).

In addition the results indicate significant relationships of color-word associations to some specific words with depression, anxiety, alexithymia and symptoms of traumatic stress. For example, most significant relationship has been found between lighter associations of colors to word "child" with psychopathological symptoms of anxiety, depression, alexithymia and symptoms of traumatic stress. This finding suggests that young women who see child in light colors have higher levels of psychopathological symptoms and on the other hand tendency to see child in

darker colors in young women of this age is more associated with mental health. This finding likely corresponds to understanding of early maternity as a negative factor (Fraser et al., 1995; Lewis et al., 2009).

Other results of this study also suggest certain specific relationships between the levels of darkness corresponding to higher scores of the color-word scale and some psychopathological manifestations linked to depression, anxiety and alexithymia. These results are in accordance with existing findings in context of the so-called metaphorical synesthesia where significant role might be attributed to color intensity (Galeyev, 2007). In this metaphorical context synesthetic experiences are closely linked to typical patterns of memory, functionally and specifically consolidated in the hippocampus and other structures (Ramachandran & Hubbard, 2001; Cytowic, 2002; Simner, 2013).

Further results show that in agreement with neuroscientific evidence and recent findings about dissociation perceptual informations may be processed and included in various contextual frameworks and that awareness requires access to that information by other parts of the mind/brain (Brown, 1984; Baars, 1988, 2002; Bunge et al., 2001; Shevrin, 2001; Bob, 2011). Recent findings indicate that association processes directly link various contextual frameworks that in a case of conflict and dissociation (or split) of mental contents lead to association disturbances (Jung, 1910; Ellenberger, 1970; Hilgard, 1986; Nadel & Jacobs, 1998; Lavenex & Amaral, 2000; Bob, 2011).

In this context, results of this study suggest that color associations may reflect various mental contents and specifically indicate stimulus words related to dissociated states that manifest as response to conflicting contextual frameworks and stressful experiences. This crossmodal association process likely is linked to process of synesthesia as a neuropsychological condition in which stimulation of one sensory modality or cognitive pathway is associated with unusual experiences in a different unstimulated modality (Martino & Marks, 2001; Eagleman & Goodale, 2009; Ward, 2013). Mainly these results are in accordance with existing findings in context of the so-called metaphorical synesthesia (Galeyev, 2007; Dailey et al., 1997; Berman, 1999; Kadosh et al., 2005; Okubo & Ishikawa, 2011). In this metaphorical process synesthetic experiences are closely associated to typical patterns of memory functionally and specifically consolidated in the hippocampus and other structures that create various contextual frameworks (Ramachandran & Hubbard, 2001; Cytowic, 2002; Simner, 2013) that are specifically influenced by stressful conditions (Bunge et al., 2001; Diaz & McCarthy, 2007; Ellenberger, 1970; Nadel & Jacobs, 1998; Vermetten & Douglas, 2004; Bob, 2011).

These findings about metaphoric synesthetic associations may play a specific role in symbolic imagination, where various colors and their levels of lightness or darkness may characterize their association or dissociation ("dis-association") with predominant contextual framework and reflect unconscious mental processes. Nevertheless qualitative or symbolic meanings of these color associations to specific words and their relationship to symptoms of stress and dissociation were not included in this study and will need further research. In summary, the results indicate that associated colors in response to certain specific emotional words associated with cognitive and emotional conflict are related to dissociative symptoms, symptoms of splitting and other stress related symptoms. These results seem to be useful for quantification of dissociative and stress symptoms using projective testing of color-word associations that need to be replicated in further research in large age and gender specific samples. In this context, Terhune et al. (2006) reported that increased excitability in the primary visual cortex using transcranial direct current stimulation (TDCS) applied in five volunteers who usually and spontaneously have synesthetic experiences led to a stronger experience of colors connected with words or numbers. Similar findings about increased cortical excitability and synesthesia reported also Bolognini et al. (2013). These results are also documented by some case studies as for example reported data about Vincent van Gogh, who most likely had synesthetic experiences related to temporal lobe seizures (Voskuil, 2013).

Taken together these data support the hypothesis that the associated colors manifest much stronger relationship with symptoms of limbic irritability (LSCL-33) than with symptoms of traumatic stress and depressive symptoms. This relationship is likely due to seizure-like conditions and increased excitability reflected by symptoms of limbic irritability (LSCL-33) that may cause increased association connectivity. The results indicate specific synesthetic-like mechanism in association processes that reflects psychopathological symptoms related to increased temporolimbic excitability. Although results of this study provide promising data for quantification of projective assessments using color-word associations, further research in large samples with specific age and gender is warranted. This future detailed research could enable to find quantified psychodiagnostic projective assessments of cognitive and affective symptoms related to temporal lobe epilepsy in psychiatric patients. This projective synesthetic-like assessment altogether with LSCL-33 could be helpful for diagnostic consideration of anticonvulsant treatment in patients who have not abnormal EEG but might positively respond to antiepileptic medication.

4. APPENDIX- PSYCHOMETRIC MEASURES

4.1. SPLITTING INDEX- SI

SI

Jméno a příjmení..... Rodinný stav..... Věk .....

Zaměstnání..... Vzdělání.....

Odpověď znázorněte na škále od 1 (vůbec tomu tak není) do 5 (velmi dobře to odpovídá).

1. Cítím sám(a) sebe odlišně, když jsem s jinými lidmi.	1	2	3	4	5
2. Moje matka má své chyby, ale nikdy jsem nepochyboval(a) o její lásce ke mně.	1	2	3	4	5
3. Být schopen si udržet přátele, je pro mne jednou z nejdůležitějších věcí.	1	2	3	4	5
4. Moji rodiče vždy pečovali o mé potřeby.	1	2	3	4	5
5. Moje cítění sebe sama se dramaticky mění.	1	2	3	4	5
6. Je nemožné mé rodiče vždy milovat.	1	2	3	4	5
7. Odlišné části mé osobnosti je obtížné složit dohromady.	1	2	3	4	5
8. Moje pocity o mé matce se mění ze dne na den.	1	2	3	4	5
9. Moji rodiče pro mne udělali to nejlepší co mohli.	1	2	3	4	5
10. Mám pochybnosti o mých nejbližších přátelích.	1	2	3	4	5
11. Občas si nejsem jist kdo jsem.	1	2	3	4	5
12. Moje pocity o sobě jsou velmi silné, ale mohou se měnit od jednoho okamžiku k druhému.	1	2	3	4	5
13. Mé přátelské vztahy jsou téměř vždy uspokojivé.	1	2	3	4	5
14. Moje pocity o sobě se neměni snadno.	1	2	3	4	5
15. Měl jsem mnoho dlouhodobých přátelství.	1	2	3	4	5
16. Občas se cítím rozdělen(a) mými pocity o sobě.	1	2	3	4	5
17. Mé vztahy s rodinou jsou pevné.	1	2	3	4	5
18. Mé vztahy vůči mým blízkým zůstávají neměnné.	1	2	3	4	5
19. Byl(a) jsem si vždycky vědom(a), že moji blízcí přátelé se o mne opravdu starali.	1	2	3	4	5
20. Mé mínění o mých přátelích se zřídka mění.	1	2	3	4	5
21. Téměř vždy pociťuji jako dobré ty, kteří jsou mi blízcí.	1	2	3	4	5
22. Mám extrémně smíšené pocity o moji matce.	1	2	3	4	5
23. Má rodina mne často zraňovala.	1	2	3	4	5
24. Kdo jsem záleží na tom jak se cítím.	1	2	3	4	5

4.2. DISSOCIATIVE EXPERIENCE SCALE- DES

DES

Jméno a příjmení..... Rodinný stav..... Věk.....

Zaměstnání..... Vzdělání.....

Pokyny:
Tento dotazník obsahuje 28 otázek, jež se týkají zkušeností, které se mohou vyskytovat ve vašem každodenním životě. Zajímá nás, jak často se Vám tyto události stávají. Je však důležité, aby Vaše odpovědi ukázaly, jak často tyto zkušenosti prožíváte, aniž jste pod vlivem alkoholu nebo drog. K tomu, abyste mohli odpovědět na otázku, je nutné, abyste vyjádřili odpovídající stupeň zkušenosti vyjádřené v otázce ve vztahu k sobě a vyznačili jej vertikální čarou na příslušném místě, jak je ukázáno na příkladu.
Příklad:
0% |——————————/——————————| 100%

1. Někteří lidé mají zkušenost, že si při řízení auta náhle uvědomí, že si nemohou vzpomenout na to, co se událo v průběhu celého výletu nebo jeho části. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————| 100%
2. Někteří lidé občas shledají, že si při poslechu něčí řeči náhle uvědomí, že neslyšeli část nebo vůbec nic z toho, co bylo řečeno. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————| 100%
3. Někteří lidé mají zkušenost v tom, že shledají sebe sama na nějakém místě a nevědí, jak se tam dostali . Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————| 100%
4. Někteří lidé mají zkušenost s tím, že naleznou sebe sama oblečené v oděvu a nevzpomínají si, že se oblékali. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————| 100%
5. Někteří lidé mají zkušenost, že naleznou nové věci mezi těmi jež vlastní a nemohou si vzpomenout, že je kupovali. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————| 100%
6. Někteří lidé občas shledají, že se setkají s lidmi, které neznají a kteří je nazývají jiným jménem a trvají na tom, že se spolu již setkali. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————| 100%
7. Někteří lidé mají občas zkušenost, že cítí, jakoby stáli vedle někoho, nebo hledíce na sebe sama něco dělají a vidí sebe sama, jakoby hleděli na jinou osobu. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————| 100%
8. Někteří lidé říkají, že občas nepoznávají přátele nebo členy rodiny. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————| 100%
9. Někteří lidé někdy shledají, že si nevzpomínají na důležité události ve svém životě [například svatba, promoce, maturita a podobně].Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————| 100%
10.Někteří lidé mají zkušenost s tím, že jsou obviňováni ze lhaní, aniž by lhali. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————| 100%
11. Někteří lidé mají zkušenost, že hledí do zrcadla a nepoznávají sami sebe. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————| 100%
12. Někteří lidé mají občas zkušenost s tím, že cítí, že jiní lidé, věci nebo svět kolem nich nejsou reálné. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————| 100%

13. Někteří lidé mají občas zkušenost s tím, že cítí, jakoby jim jejich tělo nenáleželo. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%
14. Někteří lidé mají zkušenost, že si občas vzpomenou na nějakou minulou událost, tak živě, že cítí, jakoby tuto událost znovu prožili.Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%
15. Někteří lidé mají zkušenost s tím, že si nejsou jisti, zda události, na něž si vzpomínají, se opravdu staly, nebo si je jen vysnili.Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%
16. Někteří lidé mají zkušenost s tím, že se octnou na známém místě, které jim připadá zvláštní a neznámé.
Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%
17. Některým lidem se stává, že když hledí na televizi nebo film, jsou tak pohlceni příběhem, že si nejsou vědomi ostatních událostí kolem nich.Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%
18. Některým lidem se občas stává, že jsou tak pohlceni fantazií nebo denním snem, že pociťují, jakoby se jim to opravdu stalo. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%
19. Některým lidem se stává, že jsou občas schopni ignorovat bolest. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%
20. Některým lidem se stává, že občas sedí a upřeně hledí před sebe, o ničem nepřemýšlí a nejsou si vědomi uplynulého času. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%
21. Některým lidem se občas stává, že když jsou sami, hovoří nahlas sami se sebou.
Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%
22. Někteří lidé shledávají, že v některé situaci jednají tak odlišně ve srovnání s jinou, že se cítí téměř tak, jakoby byli dvěma různými lidmi. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%
23. Některým lidem se občas stává, že v některých situacích jsou schopni vykonávat věci, které jsou pro ně obvykle obtížné s úžasnou lehkostí a spontaneitou [například sport, práce, sociální situace]. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%

24. Někteří lidé si občas nemohou vzpomenout, zda-li něco udělali, neboť mají jen myšlenku o tom, že tu věc udělali [například nevědí, zda-li poslali dopis, nebo si jen myslí, že jej poslali]. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%
25. Někteří lidé někdy shledají, že udělali věci, na něž si nemohou vzpomenout, že je dělali. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%
26. Někteří lidé občas naleznou zápisky, kresby, nebo poznámky, mezi těmi jež jim náleží, které museli sami učinit, ale nemohou si vzpomenout kdy.Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%
27. Některým lidem se občas stává, že slyší hlasy uvnitř své hlavy, které jim říkají co mají dělat, nebo komentují to, co dělají. Vyznačte čarou, v jakém procentu času se to stává Vám
0% |——————————————————————————————| 100%
28. Někteří lidé občas pociťují, jako když hledí na svět skrze mlhu, takže lidé a objekty se jim jeví být vzdálenými a nejasnými. Vyznačte čarou, v jakém procentu času se to stává Vám.
0% |——————————————————————————————| 100%

4.4. TRAUMA SYMPTOMS CHECKLIST- TSC-40

TSC-40

Jméno a příjmení..... Rodinný stav.....

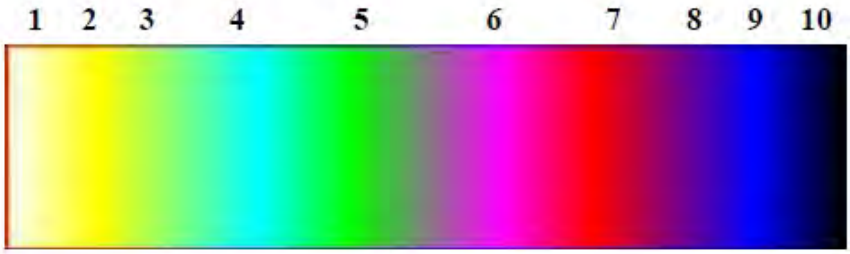
Zaměstnání..... Vzdělání.....

Jak často jste zažil[a] každou z následujících položek v posledních dvou měsících

	Nikdy			Často
1. Bolesti hlavy.	0	1	2	3
2. Nespavost [problém s usnutím].	0	1	2	3
3. Ztráta váhy [bez diety].	0	1	2	3
4. Žaludeční problémy.	0	1	2	3
5. Sexuální problémy.	0	1	2	3
6. Pocit izolovanosti od ostatních.	0	1	2	3
7. "Retrospektivy" [náhlé, živé zneklidňující vzpomínky].	0	1	2	3
8. Neklidný spánek.	0	1	2	3
9. Snížený zájem o sex.	0	1	2	3
10. Záchvaty úzkosti.	0	1	2	3
11. Zvýšený sexuální zájem.	0	1	2	3
12. Pocit osamělosti.	0	1	2	3
13. Noční můry.	0	1	2	3
14. "Úlety" [úniky ve vaší mysli].	0	1	2	3
15. Smutek.	0	1	2	3
16. Závrať.	0	1	2	3
17. Nespokojenost se sexuálním životem.	0	1	2	3
18. Obtížná kontrola nálady.	0	1	2	3
19. Probouzení se brzy ráno a nemožnost opět usnout.	0	1	2	3
20. Nekontrolovatelný pláč.	0	1	2	3
21. Strach z mužů.	0	1	2	3
22. Rána bez pocitů odpočinku.	0	1	2	3
23. Máte sex, který Vás netěší.	0	1	2	3
24. Potíže ve vycházení s druhými.	0	1	2	3
25. Problémy s pamětí.	0	1	2	3
26. Zájem o sebepoškozování.	0	1	2	3
27. Strach ze žen.	0	1	2	3
28. Probouzení o půlnoci.	0	1	2	3
29. Špatné myšlenky nebo pocity v průběhu sexu.	0	1	2	3
30. Odchody někam.	0	1	2	3
31. Pocity, že věci jsou "nereálné".	0	1	2	3
32. Nadbytečné nebo příliš časté mytí.	0	1	2	3
33. Pocity ponížení.	0	1	2	3
34. Trvalé pocity napětí.	0	1	2	3
35. Zmatenost pokud jde o pocity související se sexualitou.	0	1	2	3
36. Přání fyzicky poškozovat druhé.	0	1	2	3
37. Pocity viny.	0	1	2	3
38. Pocity, že nejste vždy ve vašem těle.	0	1	2	3
39. Máte potíže s dýcháním.	0	1	2	3
40. Sexuální pocity tam, kde si je nepřejete mít.	0	1	2	3

4.5. COLOR-WORD ASSDOCIATION TEST

CAT



Prosíme přiřaďte prostřednictvím barevné škály tři barvy ke každému slovu, které nejlépe vyjadřují Váš pocit z tohoto slova a to v pořadí v jakém Vás napadnou.

1. potok
2. lev
3. kniha
4. tma
5. láska
6. dítě
7. stůl
8. hlava
9. smrt
10. chlapec
11. nemoc
12. ruka
13. hora
14. sex
15. pláč
16. jehla
17. rodina
18. sýr
19. měsíc
20. strach
21. okno
22. ulice
23. trest
24. sůl
25. muž
26. zlost
27. voják
28. doktor

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6. LIST OF PUBLICATIONS

Publication in journals with IF related to dissertation

1. Neckar, M., Bob., P. (2014). Neuroscience of synesthesia and cross-modal associations. *Reviews in the Neuroscience, 6*, 833-40. doi: 10.1515/revneuro-2014-0033. IF(2014) = 3,330.

2. Neckar, M., Bob, P. (2016). Synesthetic associations and psychosensory symptoms of temporal epilepsy. *Neuropsychiatric Disease and Treatment*, *12,* 109-12. doi: 10.2147/NDT.S95464. IF(2015) = 1,741

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Other Publications indexed in Scopus

3. Neckar, M., Bob, P. (2016). Synesthetic associations and psychopatological symptoms: Preliminary evidence in young women. *Activitas Nervosa Superior, 58*, 3-4.

7. PUBLISHED ARTICLES

Marcel Neckar and Petr Bob*

Neuroscience of synesthesia and cross-modal associations

Abstract: Synesthesia is a condition in which stimulation of one sensory modality causes unusual experiences in a different, unstimulated modality. Recent findings suggest that research on synesthesia offers a unique opportunity to study the neural basis of subjective experiences in healthy and pathological brains. This review summarizes and reflects current knowledge concerning synesthesia in its various aspects, including its cognitive, neural, and behavioral aspects. In this context, recent data suggest new connections between specific conditions related to synesthesic mechanisms and association processes linked to construction of synesthetic cross-modal metaphors that may play a role in psychopathological thinking and imagination.

Keywords: associations; cross-modal perception; metaphor; psychopathology; synesthesia.

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Introduction

Synesthesia (also synaesthesia, in plural synesthesiae or synaesthesiae) is derived from the ancient Greek words *syn* (union, together) and *aisthesis* (sensation). Synesthesia is a condition in which stimulation of one sensory modality causes unusual experiences in a different unstimulated modality; for example, hearing a sound may evoke seeing a color (Cytowic, 2002; Day, 2004; Hubbard and Ramachandran, 2005; Mulvenna and Walsh, 2006; Eagleman and Goodale, 2009; Ward, 2013).

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According to reported estimations, the prevalence of synesthesia is likely at about 5% or less (Galton, 1883; Cytowic, 1989; Ward, 2013). The most widely cited study to date suggests that synesthesia occurs in at least 1 in 2000 people (Baron-Cohen et al., 1996), although this is now generally regarded as an underestimation. Some other studies suggest that, for example, the prevalence of grapheme-color synesthesia might be between 1 in 200 and 1 in 100 (Ramachandran and Hubbard, 2001b; Mulvenna et al., 2004). Subsequent large-scale studies have suggested the prevalence of synesthesia to be as high as 1 in 20 across all forms and 1 in 100 for grapheme-color synesthesia (Ramachandran and Hubbard, 2003). This high prevalence argues against the notion that synesthesia is merely a 'benign cognitive variant' (see Ramachandran and Hubbard, 2003; Ward and Mattingley, 2005; van der Veen et al., 2014) and instead suggests that it is a widespread phenomenon that may provide novel insights into the neural basis of the mind (Ramachandran and Hubbard, 2001b). Some of this variability is probably due to differences in definitional criteria used by different researchers and its different subtypes (Simner and Hubbard, 2013).

In this context, synesthesia, in general, is a phenomenon of intersensory and intrasensory linkage that may be observed in various conditions, including artistic creativity, and also manifests in conditions of various brain dysfunctions and injuries (Armel and Ramachandran, 1999; Grossenbacher and Lovelace, 2001; Steven and Blakemore, 2004; Hochel and Milan, 2008). In many cases, synesthesia also may be influenced by drugs, for example, synesthetic hallucinations due to exposition of the lysergic acid diethylamide, mescaline, and ayahuasca (Hartman and Hollister, 1963; Stuckey et al., 2005; Spector and Maurer, 2009), or other psychotropic drugs (Ramachandran and Hubbard, 2001b; Sinke et al., 2012; Brogaard, 2013). In addition, synesthesia has also been reported in healthy individuals between sleep and wakefulness and in a high proportion of meditators (Walsh, 2005), and it may also be influenced by hypnotic suggestions (Fuentes et al., 2007; Terhune et al., 2010). Taken together, these findings suggest that synesthesia is a phenomenon on a general level based on and represented by transmodal associative connections that may represent a continuum from strong

synesthetic phenomena to its mild forms that may enable creation of 'synesthetic' metaphors.

Typology of synesthesia

Synesthesia occurs in various forms, and more than 60 different types of synesthesia that connect various sensory modalities have been described (Cytowic and Wood, 1982a,b; Day, 2004; Marks, 2011; Simner, 2013; Simner and Hubbard, 2013; Ward, 2013). Most frequently experienced forms of synesthesia are colored hearing or hearing-induced vision, and about 18% of these experiences represent colors induced by auditory stimuli such as music and noise (Day, 2004). Many synesthetes experience colors related to speech but not to other types of auditory stimuli (Sagiv and Ward, 2006), and the color experiences frequently depend on the linguistic properties of the stimulus. For example, graphemic composition is more important than acoustic properties; that is, heard words beginning with the letter 'p' tend to elicit the same color even though the letter may have different pronunciations (e.g., 'psychology', 'photo', and 'potato' have the same color) (Baron-Cohen et al., 1993, 1996; Sagiv and Ward, 2006).

A frequently occurring form of synesthesia is also based on linking of visual and tactile modalities (for a review, see Schiltz et al., 1999; Spence, 2002; Ward, 2013). For example, Armel and Ramachandran (1999) documented an acquired case of synesthesia related to retinal damage in which tactile stimulation of the arms induced color photisms. Synesthesia-like tactile and kinesthetic sensations also have been induced in amputated limbs using mirrors, and interesting findings show that synesthesia-like sensations can be turned on or off depending on the presence or absence of a mirror (Ramachandran and Rogers-Ramachandran, 1996).

Some findings also show a relationship of synesthetic phenomena with emotional activation, for example, experience of mental colors in response to faces, human figures, and visual scenes related to specific emotional contents (Ramachandran and Hubbard, 2001b; Cytowic, 2002; Ward, 2004; Milán et al., 2007). Synesthetic experience *per se* most frequently is linked to positive emotions, but occasionally, it may be related also to negative feelings (Hochel and Milan, 2008; Dael et al., 2013; Perry and Henik, 2013).

Several functional magnetic resonance imaging (fMRI) findings suggest that synesthetes can be divided into two distinct groups: (1) those with perceptually mediated synesthesia expressed in the abnormal activation of visual areas and (2) those with semantically mediated synesthesia expressed in the abnormal activation of the parietal lobes (Kadosh et al., 2007b). These data are in agreement with the description of two basic forms of synesthetic experience, 'lower' (referring to lower perceptual processes) and 'higher' (referring to higher cognitive processes), in which the different forms of synesthesia represent different stages of brain processing (Ramachandran and Hubbard, 2001a; Pearce, 2006; Hochel and Milan, 2008; Marks, 2011; Simner, 2013; Ward, 2013). With respect to these types of synesthetic mechanisms, two basic subjective forms of synesthetic experience have also been described: 'out in space', likely corresponding to higher activation of sensory cortices, that is, projective synesthesia ('projector synesthetes'), or associative synesthesia, which is not experienced in the outside world like projective synesthesia but 'in the mind's eye' ('associator synesthetes'). For example, in projector synesthetes, naming the color of the ink in which a grapheme was presented induced greater Stroop interference than did naming the photism color, whereas in mind's eye associator synesthetes, the opposite pattern was observed (Dixon et al., 2004; Pearce, 2006; Marks, 2011; Simner, 2013).

In this context, typical differences in neural connectivity between associator and projector synesthetes have been reported (Rouw and Scholte, 2007), which suggest a hypothesis that synesthesia represents a consequence of specific forms of sensory connectivity (Esterman et al., 2006; Mulvenna and Walsh, 2006; Simner, 2012b, 2013).

Psychological and neurobiological mechanisms of synesthetic phenomena

Developmental studies based on synesthetes' subjective reports suggest that synesthesia is acquired very early during development and is stable over lifetime (Hochel and Milan, 2008; Simner and Hubbard, 2013). Other results suggest that the mechanisms underlying synesthesia are related to sensory processes and cannot be explained only by memory associations (Baron-Cohen et al., 1993; Ramachandran and Hubbard, 2001a; Hubbard et al., 2005; Radvansky et al., 2011; Simner, 2012a; Ward, 2013).

Synesthetic brain

Basic neurobiological mechanisms of synesthesia most likely are linked to a balance of synaptic pruning, neuronal

inhibition, and connections between sensory cortical areas, which, in principle, might be linked to amplification of normal sensory processes (Spector and Maurer, 2009; Simner and Hubbard, 2013; Tomson et al., 2013).

Various neural mechanisms likely play a role in these different types of synesthesia that may be linked to local cross-activations and re-entrant feedback mechanisms involving processed modalities in different brain areas that create various associations, for example, word-color, tone-color, grapheme-color, and other forms of synesthesia (Smilek et al., 2001; Myles et al., 2003; Ramachandran and Hubbard, 2003; Hubbard, 2007; Ward, 2013).

For example, a lexical-color synesthesia characterized by observation of an achromatic grapheme is related to specific neural signals from the retina that arrive to lower visual areas. Subsequently, these signals are processed by a shape-processing area (the posterior fusiform gyrus), and finally, they are processed in the area that is in charge of the interpretation analysis of the meaning, in which the anterior fusiform gyrus plays a significant role (Hochel and Milan, 2008). According to Smilek et al. (2001), activation of photisms in 'projector' synesthetes is a result of cyclic feedback communication from shape- and meaning-processing areas to color regions, V4. According to current data, two linked basic mechanisms are local cross-activation and disinhibited feedback, which may play a role in synesthetic experiences (Grossenbacher and Lovelace, 2001; Ramachandran and Hubbard, 2003; Hochel and Milan, 2008; Neufeld et al., 2012). In addition, according to some data based on research on event-related potentials, synesthetic phenomena likely occur in relatively later stages of sensory processing because differences in brain activity in synesthetes and nonsynesthetes are not observed until 200 ms after stimulus onset (Schiltz et al., 1999; Kadosh et al., 2007a; Goller et al., 2009; Volberg et al., 2013).

Based on recent neuroimaging findings and existing theories, basic neuronal mechanisms underlying synesthesia are still poorly understood. In recent years, advanced neuroimaging methods such as fMRI have been used to compare brain activities of synesthetes and nonsynesthetes (Marks, 2011; Simner et al., 2011). Most of these studies examined neuronal correlates of grapheme-color synesthesia, with controversial results. Some studies suggest that synesthesia is due to anomalous functioning of occipitotemporal areas such as V4/V8, and others found that synesthetic experience is correlated with abnormal activation of the parietal lobes (Kadosh et al., 2007b; Simner, 2012a; Ward, 2013; van der Veen et al., 2014).

Recent studies indicate that neural mechanisms underlying synesthesia most likely are based on different types of neurocognitive processes related to various sensory modalities (Kadosh and Walsh, 2008; Simner, 2013; Ward, 2013). These studies, for example, using positron emission tomography, show that synesthetes manifest increased activation of several visual associative areas, mainly posterior inferior temporal cortex and parieto-occipital junctions, and also right prefrontal cortex, insula, and superior temporal gyrus (Hubbard et al., 2011; Rouw et al., 2011). In this context, also some other data suggest that the right hemisphere functions might have a specific role in synesthesia because the right hemisphere, more than the left, likely plays a role in various interconnections of different brain zones that may create unusual associations (Rotenberg, 2004, 2013; Iturria-Medina et al., 2011). This specific right hemispheric interconnectivity may explain manifestations of synesthesia in certain mental states that create atypical experiences and associations such as meditation, hypnosis, or psychedelic experiences and also higher occurrence of synesthesia in artists (Cytowic, 2002; Ione and Tyler, 2004; Stuckey et al., 2005; Cohen Kadosh et al., 2009; Terhune et al., 2010; Jewanski et al., 2011; Voskuil, 2013; Ward, 2013).

Other studies used fMRI; for example, Nunn et al. (2002) found that most activated regions by speech in synesthetes represent areas V4 and V8 of the left hemisphere, and also, overlap of this V4/V8 activation in normal controls in response to color has been reported. Some other studies also found that synesthesia is linked to color processing areas V4 and V8, which are necessary for the generation and experiencing of photisms (Pearce, 2006; Steven et al., 2006; Hochel and Milan, 2008). An interesting case study reported by Pearce (2006) documented increased activity in visual cortical areas specifically related to illusory colored and spatially located visual percepts in a synesthetic man, who had been completely blind for 10 years (Pearce, 2006).

Although the basic neural mechanisms of synesthesia are poorly understood, the majority of these neuroimaging studies are in agreement with the two basic concepts of synesthesia, the lower synesthesia, which is characterized by typical cross-activations that may occur between adjacent regions of the fusiform gyrus involved in letter recognition and color processing, and the higher synesthesia, which may arise from cross-activation in the parietal cortex, particularly in the angular gyrus, the ventral intraparietal area, and the lateral intraparietal area (Hubbard and Ramachandran, 2005; Pearce, 2006; Marks, 2011). Cross-activation in the region of the parietal lobe in higher synesthetes also might explain synesthetic number forms,

in which numerical and other ordinal sequences are experienced as having specific locations in space, in addition to colors (Dixon et al., 2004; Hubbard and Ramachandran, 2005; Hubbard et al., 2011). In addition, since graphemes, phonemes, music, and color function are processed in different brain regions, several manifestations of synesthesia likely may have different anatomical neuronal substrates (Ward and Simner, 2005; Pearce, 2006; Simner, 2012a; Carmichael and Simner, 2013; Tomson et al., 2013).

In the overall context, neurocognitive processing related to synesthesia is linked to large-scale communication in the brain, whose connectivity is closely associated with basic mechanisms of consciousness that most likely cannot be explained by neuroanatomically defined active connections, and various unknown mechanisms related to information transfer may play a role (Baron-Cohen et al., 1993; Hochel and Milan, 2008; Simner, 2012a; Tomson et al., 2013).

Synesthesia and emotions

Synesthesia, in a broader sense, might be based on a continuum based on a great variety of conditions ranging from 'lower' synesthesia to more 'associative' emotional synesthesia (Hochel and Milan, 2008; Marks, 2011; Simner et al., 2011; Simner, 2012a). Most likely, these forms of lower projective synesthesia and associative 'emotional' synesthesia (Ramachandran and Hubbard, 2001b; Cytowic, 2002; Ward, 2004; Milán et al., 2007) are related to different neural mechanisms, and recent data suggest that 'projectors' show stronger structural connectivity in the inferior temporal cortex than 'associators' do (Rouw and Scholte, 2007; Simner, 2012b).

For example, Galeyev (2007) considered synesthesia in the context of higher associative synesthesia as a specific manifestation of non-verbal thinking based on involuntary or purposeful comparison of the impressions of different modalities, on the basis of structural, semantic, and emotional similarity. In this context, synesthesia can be characterized as focused and simultaneous actualization of the 'sensuous' modalities in a wide range of manifestation implemented by means of emotions (Galeyev, 2007).

Important aspects of synesthetic phenomena represent emotional reaction in which the spoken form can be transformed into an affective component of a word (or other stimulus) that can directly trigger a synesthetic sensation of color (Ward, 2004; Moller et al., 2009; Okubo and Ishikawa, 2011; Kuhbandner and Pekrun, 2013). For example, Collier (1996) reported that subjects tend to choose the color blue for 'sad', yellow for 'cheerful', and gold for 'proud', and there is some correspondence between emotional valence and hue; that is, darker and less saturated colors (e.g., brown, black) tend to be associated with negative emotions, and lighter and more saturated colors (e.g., yellow, green, red) tend to be associated with positive emotions (Okubo and Ishikawa, 2011). Similarly, positive emotions tend to be mapped onto rounded forms and negative ones onto angular forms. The extent to which these links between colors and emotions reflect cultural associations is not clear (Marks, 2011; Simner, 2012b; Palmer et al., 2013).

Other forms of synesthesia that reported widely consistent patterns across subjects have also been described. For example, in pitch-color synesthesia, lower-pitched sounds tend to be darker and higher-pitched sounds tend to be brighter (Marks, 1975). In a series of experiments, Marks has shown that the same pitch brightness may be observed in matching tasks and metaphors produced by nonsynesthetic individuals (e.g., Marks, 1982; Simner et al., 2011; Simner, 2013). This suggests that some forms of synesthesia can be conceptualized as an exaggeration of basic and usually occurring neurophysiological cross-modal mechanisms.

In this context, some researchers suggested that synesthesia may reflect stronger cross-wiring or cross-activation of areas in the brain that normally, in most usual neurophysiological conditions, are less connected (Baron-Cohen et al., 1996; Maddock, 1999; Ramachandran and Hubbard, 2001b; Simner, 2012a, 2013).

Synesthesia and metaphor

Metaphor can usually be understood as a form of 'mapping' of one domain into another domain as a spontaneous and emergent property of mind (Lakoff, 1993). Synesthesia from this 'metaphoric' point of view may be understood as intersensorial links of colors, tones, and spatial images representing a typical polysensory form of perception based on cross-modal association mechanisms (Lakoff and Johnson, 1980; Day, 1996; Martino and Marks, 2001; Galeyev, 2007; Marks, 2011). Those cross-modal association mechanisms due to extensive cross-wiring between brain regions that usually represent abstract concepts might explain links among creativity, metaphor, and synesthesia that typically have higher incidence among artists and poets (Dailey et al., 1997; Ramachandran and Hubbard, 2001b; Marks and Mulvenna, 2013). Similarly, metaphor may be understood

as a form of cross-activations of conceptual maps in a manner analogous to cross-activation of perceptual maps in synesthesia (Ramachandran and Hubbard, 2001b; Marks, 2013; Simner, 2013). This similarity might explain the higher incidence of synesthesia in artists and poets, which likely is based on opportunity of creative mapping related to hyperconnectivity that typically involves sensory-limbic connections (Martino and Marks, 2001; Ramachandran and Hubbard, 2001b; Simner, 2013).

A specific structure that may play a significant role in these cross-modal connections is angular gyrus, which is in agreement with its strategic location at the crossroads between the temporal, parietal, and occipital lobes. Ramachandran and Hubbard (2001b) suggested that angular gyrus might play a critical role in forming cross-modal associations. In addition, this structure might be related to a dynamic interplay between learned and naturally biased constraints on the development of neural structures (Spector and Maurer, 2009). Some research data also show that various cross-modal interactions between synesthetically corresponding dimensions likely play a role in synesthetic associations linked to multisensory integration (Parise and Spence, 2009).

Some authors also suggest that cross-modal interactions in weaker forms of synesthesia follow the same principles of organization that occur in individuals with specific synesthetic abilities (Kadosh et al., 2007a; Kadosh and Walsh, 2008; Marks, 2011; Simner et al., 2011; Marks and Mulvenna, 2013; Simner, 2013). For example, Kadosh et al. (2008), using posthypnotic suggestion, reported induction of a grapheme-color synesthesia that is usually observed in stronger forms of 'developmental' synesthesia. This finding is in agreement with the concept of synesthetic metaphors and suggests that posthypnotic suggestion can induce behavior similar to that of congenital synesthetes likely due to hyperconnectivity (Kadosh et al., 2008).

Taken together, these findings enable one to understand that differences between two typical forms of synesthesia, defined as 'strong' and 'weak', are represented by typical distinguished activations of neural network and not specific differences in neural substrate (Martino and Marks, 2001; Ramachandran and Hubbard, 2001b; Marks, 2011, 2013; Marks and Mulvenna, 2013). There is also evidence that strong synesthesia is usually characterized by a vivid image in one sensory modality in response to stimulation in another sensory domain (Cytowic, 1989; Baron-Cohen et al., 1996). On the other hand, weak (metaphoric) synesthesia usually describes milder forms of cross-sensory connections that are characterized by cross-sensory correspondences expressed through language, perceptual similarity, and perceptual interactions during information processing (Martino and Marks, 2001; Marks, 2011).

Typical forms represent cross-modal metaphors that occur in common language (e.g., warm color and sweet smell), in literature (e.g., Baudelaire's poem 'Correspondences'), and experimental data focused on cross-modal associations in which participants are asked to pair a stimulus from one sensory modality to a stimulus from another sensory domain (Marks, 1978; Martino and Marks, 2001; Moller et al., 2009; Marks and Mulvenna, 2013). For example, when participants were given a set of notes varying in pitch and a set of colors varying in lightness, the higher the pitch, the lighter the color paired with it (see Marks, 1978, 2011; Kuhbandner and Pekrun, 2013). Compared with strong synesthesia, in weak synesthesia, correspondences are defined by context, which means that the highest pitch is always associated with the lightest color. This enables one to define cross-modal correspondences in weak synesthesia as 'contextual', whether strong synesthesia has the same manifestations independent of experimental or situational context (Baron-Cohen et al., 1996; Cytowic, 1989, 2002; Martino and Marks, 2001; Fitzgibbon et al., 2010a, b; Marks, 2013).

Also, other studies suggest basic parallels between synesthesia and cross-modal associations in nonsynesthetes (Simner et al., 2011; Marks and Mulvenna, 2013; Simner, 2013). For example, Ward et al. (2006) demonstrated that associations of sounds to colors in synesthesia showed same patterns of correspondence between luminosity and tone pitch, as were observed in cross-modal associations of normal persons. Similarly, Hochel and Milan (2008) suggest that specific regions of the human brain may have an innate capacity to extract common, abstract properties from otherwise unrelated domains that may be less or more 'contextual' or 'hardwired' in the nervous systems that might be environmentally or genetically influenced (Smilek et al., 2005; Hochel and Milan, 2008; Asher et al., 2009; Spector and Maurer, 2009).

Within this context, the synesthetic phenomena could be conceptualized as more 'contextually' enhanced or more neural based ('perceptual' or 'developmental') based on cross-activation of brain maps. Similarly, also Ramachandran and Hubbard (2001b) proposed that various levels of extensive cross-wirings between brain regions may represent abstract concepts that might explain also the links between creativity, metaphor, and synesthesia and their neural correlates. In this context, the terms *synesthesia* and *synesthetic metaphor* most likely have significant overlap with basic mechanisms of cross-modal associations, which may help to explain synesthetic and metaphoric phenomena as a continuum of

various forms of intersensory experiences related to verbal and emotional memories (Marks, 2011; Kuhbandner and Pekrun, 2013; Simner, 2013).

Conclusions

This review discussed recent findings and specific relationships of synesthesia, cross-modal associations, and metaphor. Mainly, recent research findings have focused on grapheme-color and tone-color synesthesia, which may help to explain the basic neural mechanisms of conscious experience and the nature of perceptual qualia (Hochel and Milan, 2008). On the other hand, research on strong and weak synesthetic phenomena provides various neuroscientific findings about the basic mechanisms involved in perceptual coding and cross-modal information processing (Martino and Marks, 2001; Dael et al., 2013).

More comprehensive understanding of the neural mechanisms of synesthesia is provided also in research in patients with autism-spectrum disorders (Harrison and Hare, 2004). Important findings show neuropathological studies that reported abnormally increased connectivity in autism and specific alterations of white matter, which indicate increased connectivity in synesthesia (Asher et al., 2009; Brogaard, 2013), mainly in some cases of autistic savants that manifest strong forms of synesthesia (Baron-Cohen et al., 2007). Nevertheless, future research is needed to elucidate the specific relationships between synesthetic phenomena and neuronal connectivity and also certain disinhibitory mechanisms that may underlie hyperconnectivity related to intrasensory and associative links connecting various sensory domains ranging from 'lower' synesthesia to more 'associative' synesthesia and cross-modal metaphors (Marks, 1978; Cytowic, 2002; Hochel and Milan, 2008; Simner, 2013). Future research study of increased cross-modal connections may explain specific psychopathological phenomena such as hallucinations or delusions and also disturbed forms of imagination that occur in mental disorders, for example, in schizophrenia and also in other mental disorders.

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ORIGINAL RESEARCH

Synesthetic associations and psychosensory symptoms of temporal epilepsy

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Background: Synesthesia manifests as unusual associative connections that may cause intriguing experiences due to various cross-modal connections, for example, a sound may be experienced as color. Several findings indicate that temporal lobe seizures or seizure-like conditions and increased excitability may influence various unusual cross-sensory links and synesthetic experiences.

Methods: In this context, the purpose of this study is to find relationships between word–color associations and psychopathological symptoms related to temporal lobe epilepsy and limbic irritability (Limbic System Checklist [LSCL-33]), symptoms of traumatic stress (Trauma Symptoms Checklist [TSC-40]), and depressive symptoms (Beck Depression Inventory [BDI-II]) in 71 participants (mean age =25.23 years) recruited from the general population. The whole sample included two subgroups according to levels of psychosensory and affective symptoms related to temporal epilepsy measured by LSCL-33.

Results: The results in both subgroups indicate specific words correlated with the scores of psychopathological symptoms measured by LSCL-33, BDI-II, and TSC-40. Significant Spearman correlations have been predominantly found in the subgroup of participants with higher levels of LSCL-33.

Conclusion: The results indicate a specific synesthetic-like mechanism in association processes that reflects psychopathological symptoms related to increased temporo-limbic excitability.

Keywords: word associations, colors, stress, synesthesia, temporal lobe epilepsy, limbic irritability

Introduction

Temporal lobe epilepsy represents the neurological pathological condition, which is also related to a wide spectrum of psychopathological symptoms that manifest as various sensory distortions, hallucinatory experiences, depersonalization, derealization and other psychosensory, and affective symptoms usually reported in patients with temporal lobe epilepsy.[1–4] Recent research indicates that these symptoms may occur as a continuum of complex partial seizure-like symptoms also in patients with mental disorders and in the normal population.[1,4] Some data also show that these symptoms may be related to stressful and traumatic experiences that may influence inhibitory functions and neural excitability mainly in the limbic system.[1–3] Several findings also show that temporal lobe seizures or seizure-like conditions may manifest in various unusual cross-sensory links and unusual associative connections that may cause synesthetic phenomena.[5,6] Synesthesia is a phenomenon related to various forms of inter-sensory connections, for example, hearing a sound may evoke seeing a color.[5,7,8]

According to recent findings, synesthesia in its mild forms may have relatively high prevalence in the population, which according to some reported data may be at approximately 30%–50%.[7,9] Recent studies indicate that the phenomenon of the

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so-called "soft synesthesia" may be related to various forms of associative connections as, for example, grapheme-color synesthesia[10–11] or sound-color synesthesia where higher sounds evoke images of lighter and brighter colors and vice versa.[10,12] Several studies documented that lighter colors are more frequently associated with positive emotional meanings (eg, happy, good) and certain color-specific associations were found for red color ("strong" and "angry"), blue ("good"), green ("strong"), purple ("sad").[11,13]

In this context, the purpose of this study is to assess relationships between mild forms of temporal lobe psychosensory symptoms and word–color synesthetic experience using a novel method of word–color associations. This method reflects an emotional response to words that according to their emotional meaning may be specifically associated with darker or lighter color and quantified on a Likert scale. These findings suggest a hypothesis that colors related to emotions in response to certain specific words could be more associated with the actual presence of psychosensory symptoms related to temporal lobe epilepsy than with other psychopathological symptoms. For the purpose to test the hypothesis we have compared two subgroups of participants selected from the general population. The first subgroup of participants who had higher level of psychosensory and affective symptoms related to temporal epilepsy was compared with a healthy control subgroup of participants who had only minor level of these symptoms.

Participants and methods

Participants

The sample included 71 participants (mean age =25.23; SD =7.21, age range: 18–39 years) selected by advertising from the general population and consisted of 41 women and 30 men predominantly with high school education. The whole sample included two subgroups according to levels of psychosensory and affective symptoms related to temporal epilepsy measured by Limbic System Checklist (LSCL-33). The first subgroup (N=31) included participants with LSCL-33 score 28 or more and the second subgroup (N=40) included participants with LSCL-33 score less than 10. All participants signed informed consent and the study was approved by Charles University ethical committee.

Methods

Symptoms similar to ictal temporal lobe epilepsy, such as somatic, sensory, behavioral, and memory symptoms linked to temporal lobe epileptiform activity, were assessed by LSCL-33.[1] LSCL-33 is designed to measure temporolimbic activity in the form of somatic, sensory, behavioral, and memory symptoms known to be associated with the phenomena of ictal temporal lobe epilepsy. These symptoms may be generally described as brief hallucinations, paroxysmal somatic disturbances, automatisms, and dissociative disturbances. The Czech version of LSCL-33 as well as the original English version[1] shows good psychometric properties and internal consistency (Cronbach's alpha 0.90 with test–retest reliability r=0.91).

Trauma Symptoms Checklist

Symptoms of traumatic stress were assessed using the Trauma Symptom Checklist (TSC-40).[14] TSC-40 is a self-reported questionnaire with 40 items scored on a 4-point Likert scale (total score from 0 to 120). TSC-40 evaluates stress symptoms in adult individuals associated with childhood or adult traumatic experiences and measures aspects of post-traumatic stress and other symptom clusters found in some traumatized individuals. The Czech version of the TSC-40 has high reliability and internal consistency (Cronbach's alpha 0.91, test–retest reliability after 1 week 0.88).

Beck Depression Inventory

For the assessment of depressive symptoms, Czech version of Beck Depression Inventory (BDI-II)[15] that represents 21-item questionnaire for assessing depression (Cronbach's alpha 0.89, test–retest reliability after week 0.85) was used. Subjects indicate the degree of their experience of depressive symptoms on a 4-point Likert scale. The scale is sensitive to the changes of the mental state of the individual during the course of time.

Assessment of word–color associations

The method of word–color associations is based on emotional response to words according to their emotional meaning that may be specifically associated with lighter or darker color and quantified on color scale from 1 to 10 (Figure 1). In the assessment, colors are associated with words that also

Figure 1 Color scale used for measurement of color associations in response to word stimuli, which in black–white projection provides gray continuous Likert scale from white to black (1–10).

include a number of critical words, which usually have particular psychological significance that may cause association disturbances.[16,17] The critical words are designed to recall previous affective associations that modulate new defensive reactions and lead to significant physiological response.[16] During the experiment, the standard list of 25 stimulus words plus three added words (love, sex, and punishment) were presented in the following order (critical words in italic): 1) brook, 2) lion, 3) book, 4) dark, 5) *love*, 6) child, 7) table, 8) head, 9) *death*, 10) boy, 11) *illness*, 12) hand, 13) mountain, 14) *sex*, 15) *crying*, 16) needle, 17) family, 18) cheese, 19) moon, 20) *fear*, 21) window, 22) street, 23) *punishment*, 24) salt, 25) man, 26) *anger*, 27) soldier, and 28) doctor. To each stimulus word three colors in the sequences that they came to mind were associated, and these colors were quantified by three numbers on the color scale. The mean score of these three numbers assigned to the three colors, number of the first associated color (1), and maximum difference (dif) between the two numbers (reflecting maximum and minimum of these 3 numbers associated with the darkest and lightest colors) were used for scoring.

Statistical methods

Statistical evaluation for the results of word–color associations and other psychometric measures included descriptive statistics and Spearman correlation coefficients. All the methods of statistical evaluation were performed using the software package Statistica version 6.

Results

The results of descriptive statistics for all included participants indicate a tendency to link the level of darkness on the scale of colors (from white 0 to black 10) with words generally perceived as negative anger (mean =7.89), punishment (mean =7.68), fear (mean =7.65), death (mean =7.56), disease (mean =7.09), crying (mean =6.61) on the other hand the less "dark" (lighter) scores were for example linked to words such as child (mean =4.04) and family (mean =4.67).

In addition, the data show specific differences between both subgroups related to occurrences of significant correlations of means, first associated color (1) and the maximum difference of the lightest and darkest associated color (dif) with psychopathological symptoms of temporal lobe epilepsy (LSCL-33), depression (BDI-II), and traumatic stress (TSC-40).

The results in both subgroups indicate specific words correlated with the scores of psychopathological symptoms measured by LSCL-33, BDI-II, and TSC-40. In the first subgroup of participants with high LSCL-33 were significant Spearman correlations of scores related to associated colors with LSCL-33 (Brook [mean] Spearman R=0.36, P<0.05; love (1) −0.48, P<0.01; child (1) −0.42, P<0.01; cheese [mean] 0.41, P<0.01; fear [mean] −0.39, P<0.05) with TSC-40 (table [mean] −0.43, P<0.05; table (1) −0.52, P<0.01; death (1) −0.47, P<0.01; hand (1) −0.40, P<0.01; cheese [dif] 0.45, P<0.01; moon [mean] 0.36, P<0.05; punishment (1) −0.43, P<0.05; doctor (1) −0.42, P<0.05), and BDI-II (Book [mean] 0.40, P<0.05; hand (1) −0.51, P<0.01; mountain (1) −0.46, P<0.05; moon [mean] 0.45, P<0.01; street (1) 0.42, P<0.05; man (1) −0.42, P<0.05).

In the second subgroup that included healthy controls with low LSCL-33 score, we found significant correlations for scores associated on the color scale with LSCL-33 (book [mean] −0.34, P<0.05; book (1) −0.44, P<0.01; child [dif] −0.45, P<0.01; sex [dif] 0.33, P<0.05; family [mean] 0.36, P<0.05; moon [mean] −0.40, P<0.05; moon [dif] −0.46, P<0.01; fear (1) −0.38, P<0.01; street [dif] −0.33, P<0.05; punishment (1) −0.41, P<0.01) with TSC-40 (hand (1) −0.32, P<0.05; street (1) −0.36, P<0.05; punishment (1) −0.34, P<0.05; soldier [mean] 0.37, P<0.05; doctor (1) 0.40, P<0.05). No significant correlations related to scores of associated colors with BDI-II have been found.

It is important to note that we refer to these significant correlations based on single tests, and due to multiple comparisons, the Bonferroni correction should be considered. Nevertheless, the results of the correlations of word–color associations with psychometric measures have nonrandom pattern. In order to avoid the type II errors due to taking assessed correlations as independent we refer to uncorrected statistical significance.

Discussion

The results of descriptive statistics are congruent with previously reported studies, which suggest that positive emotional meanings are more frequently associated with lighter colors.[11,13] These findings are in agreement with data that spoken words influence activations in brain visual areas.[18] The results show specific differences between both subgroups related to occurrences of significant correlations of means, first associated color (1), and the maximum difference of the lightest and darkest associated color (dif) with psychopathological symptoms indicating that the subgroup with higher level of temporal lobe seizure-like symptoms measured by LSCL-33 has higher ability to represent emotional meaning of words by associated colors.

In this context, Terhune et al[6] reported that increased excitability in the primary visual cortex using transcranial direct current stimulation applied in five volunteers who

usually and spontaneously have synesthetic experiences led to a stronger experience of colors connected with words or numbers. Similar findings about increased cortical excitability and synesthesia was also reported by Bolognini et al.[19] These results are also documented by some case studies, for example, the reported data about Vincent van Gogh, who most likely had synesthetic experiences related to temporal lobe seizures.[20]

Taken together these data support the hypothesis that the associated colors manifest much stronger relationship with LSCL-33 than with the symptoms of traumatic stress and depressive symptoms. This relationship is likely due to seizure-like conditions and increased excitability reflected by the symptoms of limbic irritability (LSCL-33) that may cause increased association connectivity.

Conclusion

The results indicate specific synesthetic-like mechanism in association processes that reflects psychopathological symptoms related to increased temporo-limbic excitability. Although the results of this study provide promising data for the quantification of projective assessments using word–color associations, further research in large samples with specific age and sex is warranted. This future detailed research could enable to find quantified psychodiagnostic projective assessments of cognitive and affective symptoms related to temporal lobe epilepsy in psychiatric patients. This projective synesthetic-like assessment altogether with LSCL-33 could be helpful for diagnostic consideration of anticonvulsant treatment in patients who do not have abnormalities on scalp electroencephalograms, but might positively respond to antiepileptic medication.

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Disclosure

The authors report no conflicts of interest in this work.

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SHORT COMMUNICATION

SYNESTHETIC ASSOCIATIONS AND PSYCHOPATHOLOGICAL SYMPTOMS: PRELIMINARY EVIDENCE IN YOUNG WOMEN

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Abstract

Synesthesia is a neuropsychological condition in which stimulation of one sensory modality or cognitive pathway is associated with unusual experiences in a different unstimulated modality. In this context a purpose of this study is to find relationships between word-color associations and psychopathological symptoms of anxiety (SAS), depression (BDI-II), alexithymia (TAS-20) and symptoms of traumatic stress (TSC-40) in 43 healthy young women (mean age 18.25). Results of this study show that colors associated to specific words have significant correlations with symptoms of anxiety, depression, alexithymia and symptoms of traumatic stress. Sum of scores related to color associations to these words create subscales that are significantly correlated with BDI-II (Spearman R= -0.60), SAS (-0.44), TAS-20 (-0.70) and TSC-40 (-0.64); $p<0.01$. The results indicate specific synesthetic-like mechanisms in association processes specifically linked to psychopathological thinking, feelings and imagination.

Key words: *Alexithymia; Anxiety; Word associations; Colors; Depression; Stress; Synesthesia*

1. INTRODUCTION

Synesthesia is a neuropsychological condition in which stimulation of one sensory modality or cognitive pathway is associated with unusual experiences in a different unstimulated modality, for example, hearing a sound may evoke seeing a color (Martino & Marks, 2001; Eagleman & Goodale, 2009; Ward, 2013). The first reported case of synesthesia was published in 1812 by Sachs, who documented colored sequences of vowels and music and later Fechner reported colored letter photisms (Jewanski, Day & Ward, 2009; Jewanski et al., 2011). Later research after the Second World War documented growing evidence about synesthetic phenomena and recent findings show that synesthesia is a phenomenon related to various forms of inter-sensory connections from which most frequent form is experience of colored hearing (Martino & Marks, 2001; Nunn et al., 2002; Simner & Hubbard, 2013). For example, it has been documented that higher sounds evoke images of lighter and brighter colors and vice versa (Marks, 1978, 2011; Kuhbandner & Pekrun, 2013).

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Recent studies indicate that phenomenon of synesthesia may be also related to various forms of associative connections as for example grapheme-color synesthesia (Marks, 1978; Cohen, 2005, Ward, 2013). In this context it has been reported that lighter colors are more frequently associated with positive emotional meanings (e.g. happy, good) and certain color specific associations were found for red color ("strong" and "angry"), blue ("good"), green ("strong"), purple ("sad") (Dailey et al., 1997; Kadosh et al., 2005; Okubo & Ishikawa, 2011).

According to recent findings synesthesia in its mild forms may have relatively high prevalence in population which according to some reported data may be at about 30-50% (Cytowic, 2002; Campen & Froger, 2003; Simner & Hubbard, 2013). In this context a purpose of this study is to assess mild forms of synesthetic experience using novel method of word-color associations which is based on emotional response to words that according to their emotional meaning may be specifically associated with darker or lighter color and quantified on a Likert scale. This method in context of other findings suggest a hypothesis that associated colors as related to more specific emotions in response to certain specific emotional words could be related to psychopathological processes related to depression, anxiety, alexithymia and stress symptoms.

2. PARTICIPANTS AND METHOD

2.1. Participants

Group of participants consisted of 43 healthy young women (Mean age=18.25; SD=0.86, age range 17-19) with high school education. All participants signed informed consent and the study was approved by Charles University ethical committee.

2.2. Methods

Assessment of color-word associations

The method of color-world associations proposed for the purpose of this study is based on emotional response to words that according to their emotional meaning may be specifically associated with lighter or darker color and quantified on color scale from 1 to 10 (Figure 1). In the assessment, as a response to a stimulus words a participant provides spontaneous association of a color according to the scale on Figure 1. The words include usual words but also critical words which usually have particular psychological significance that may cause association disturbances (Jung, 1910; Kondas, 1989). The critical words are designed to recall previous affective associations that modulate new defensive reactions and lead to significant physiological response (Jung, 1910). During the experiment the standard list of 25 stimulus words plus 3 added words (*love, sex, punishment*) were presented in the following order (critical words in italic): 1. brook, 2. lion, 3. book, 4. dark, 5. *love*, 6. child, 6. *love*, 7. table, 8. head, 9. *death*, 10. boy, 11. *illness*, 12. hand, 13. mountain, 14. *sex*, 15. *crying*, 16. needle, 17. family, 18. cheese, 19. moon, 20. *fear*, 21. window, 22. street, 23. *punishment*, 24. salt, 25. man, 26. *anger*, 27. soldier, 28. doctor. To each stimulus words were associated 3 colors in a sequence which describes the word. For scoring is used mean score of 3 colors associated to the word, first associated color and maximum difference between darkest and lightest associated colors.

Beck Depression Inventory (BDI-II)

For the assessment of depressive symptoms was used Czech version of Beck depression inventory (Beck et al., 1996) that represents 21-items questionnaire for assessing depression (Cronbach's alpha 0.89, test-retest reliability after week 0.85). Subjects indicate degree of their

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experience of depressive symptoms on 4-point Likert scale. The scale is sensitive to changes of the mental state of the individual in the course of time.

Self-Rating Anxiety Scale (SAS)

Levels of anxiety symptoms were assessed using the Czech version of The Zung Self-Rating Anxiety Scale (Cronbach's alpha 0.89, test-retest reliability after week 0.85) (Zung, 1971). The SAS is 20-item self-reporting questionnaire focused on the most common general anxiety symptoms. Each question is scored on 4-point Likert scale from 1 to 4.

Toronto Alexithymia Scale (TAS-20)

Alexithymia was assessed using the validated Czech version of the 20-item Toronto Alexithymia Scale (Cronbach's alpha 0.81, test-retest reliability after 1 week 0.77) (Bagby et al., 1994). Each question is scored on a five-point Likert scale (1-5) and the TAS total score has range from 20 to 100.

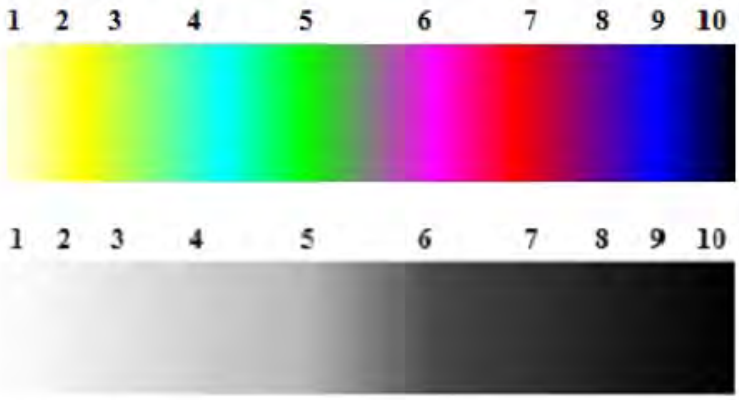

Figure 1. Color scale used for measurement of color associations in response to word stimuli, which in black-white projection provides gray continuous Likert scale from white to black (1-10).

Trauma Symptoms Checklist (TSC-40)

Symptoms of traumatic stress were assessed using Trauma Symptom Checklist (Briere, 1996). TSC-40 is a self-reported questionnaire with 40 items scored on a 4-point Likert scale (total score from 0 to 120). TSC-40 evaluates stress symptoms in adult individuals associated with childhood or adult traumatic experiences and measures aspects of posttraumatic stress and other symptom clusters found in some traumatized individuals. The scale includes subscales for dissociation, anxiety, depression, sexual abuse trauma index (SATI), sleep disturbances and sexual problems. The Czech version of the TSC-40 has high reliability and internal consistency (Cronbach's alpha 0.91, test-retest reliability after one week 0.88).

Statistical methods

Statistical evaluation of the results of the color-word associations and other psychometric measures included descriptive statistics and Spearman correlation coefficients. All the

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methods of statistical evaluation were performed using the software package Statistica version 6.

3. RESULTS

Results of descriptive statistic indicate a tendency to link level of darkness on scale of colors (from white 0 to black 10) with words generally perceived as negative *Anger* (Mean=8.20), *Punishment* (Mean=7.72), *Fear* (Mean=7.94), *Death* (Mean=7.65), *Disease* (Mean=7.64), *Crying* (Mean=6.97) on the other hand the less "dark" (lighter) scores were for example linked to words *Child* (Mean=4.07) and *Family* (Mean=4.69).

In addition the data show some significant correlations of means, first associated color (1) and the maximum difference of the lightest and darkest associated color (dif.) with psychopathological symptoms of depression, anxiety, alexithymia and traumatic stress. In statistical analysis following significant relationships were found:

Associated color score to the word *Child* (mean) indicates relatively high negative Spearman correlations with TAS-20 (-0.47; $p<0.01$), BDI-II (-0.33; $p<0.05$) and TSC-40 (-0.36; $p<0.05$), which suggest a link between level of lightness of associated color and symptoms of alexithymia, depression and symptoms of traumatic stress. *Child (1)* manifests negative correlations with TAS-20 (-0.55; $p<0.01$), BDI-II (-0.33; $p<0.05$), SAS (-0.35; $p<0.05$) and TSC-40 (-0.40; $p<0.01$) which also suggest a link between level of lightness of associated color to *child* and the psychopathological symptoms.

First associated color to word *Head* (1) manifests negative correlations with TAS-20 (-0.31; $p<0.05$), SAS (-0.39; $p<0.01$) and TSC-40 (-0.40; $p<0.01$) which also suggest a link between level of lightness of associated colors and the psychopathological symptoms.

Associated colors to word *Boy* (mean) are significantly negatively correlated with TAS-20 ($r=-0.49$; $p<0.01$) and *Boy* (dif) are significantly negatively correlated with TAS-20 ($r=-0.32$; $p<0.05$) and BDI-II (-0.31; $p<0.05$) which suggests that lighter associations to this word are linked to the symptoms. *Hand* (1) also manifests negative correlations with BDI-II ($r= -0.36$; $p<0.05$) and the link between higher lightness level and depressive symptoms is also documented by significant negative correlation between *sex* (1) and BDI-II (-0.32; $p<0.05$). *Salt* (mean) manifests negative correlations with TSC-40 (-0.41; $p<0.01$) and *Salt* (1) that also manifests negative correlations with TSC-40 (-0.33). *Month* (mean) has positive correlation with TAS-20 (0.36; $p<0.05$) and TSC-40 (0.31; $p<0.05$). Other correlations are *Family* (1) with TAS-20 (-0.33; $p<0.05$), *Cheese* (mean) with TSC-40 (-0.30; $p<0.05$) and *Fear* (1) with BDI-II (-0.45; $p<0.01$).

With respect to these results we have found specific words associated with depression [Child (mean), Child (1), Boy (dif), Hand (1), sex (1), Fear (1)], anxiety [Child (1), Head (1)], alexithymia [Child (mean), Child (1), Head (1), Boy (mean), Boy (dif), Month (mean)- inverse score, Family (1)] and stress symptoms [Child (mean), Child (1), Head (1), Salt (mean), Salt (1), Month (mean)- inverse score, Cheese (mean)]. Sum of scores related to these specific words provide subscales that link the quantified projective associations with assessed psychopathological symptoms. Color-word subscale for depression (CWDep) shows highly significant correlation with BDI-II (Spearman $R= -0.60$, $p<0.01$), Color-word subscale for anxiety (CWAnx) shows highly significant correlation with SAS (-0.44, $p<0.01$), Color-word subscale for alexithymia (CWAlex) shows highly significant correlation with TAS-20 (-0.70, $p<0.01$), and Color-word subscale for symptoms for traumatic stress (CWStress) shows highly significant correlation with TSC-40 (-0.64, $p<0.01$).

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4. CONCLUSION

The results are in agreement with previous reported studies suggesting that lighter colors are more frequently associated with positive emotional meanings (Dailey et al., 1997; Kadosh et al., 2005; Okubo & Ishikawa, 2011). In addition the results indicate significant relationships of color-word associations to some specific words with depression, anxiety, alexithymia and symptoms of traumatic stress. For example, most significant relationship has been found between lighter associations of colors to word "child" with psychopathological symptoms of anxiety, depression, alexithymia and symptoms of traumatic stress. This finding suggests that young women who see child in light colors have higher levels of psychopathological symptoms and on the other hand tendency to see child in darker colors in young women of this age is more associated with mental health. This finding likely corresponds to understanding of early maternity as a negative factor (Fraser et al., 1995; Lewis et al., 2009).
Other results of this study also show specific relationships between the scores of associated colors on the color scale and psychopathological manifestations linked to depression, anxiety, alexithymia and stress symptoms. These results are in accordance with existing findings in context of the so-called metaphorical synesthesia (Galeyev, 2007). In this metaphorical context synesthetic experiences are closely associated to typical patterns of memory that create context specific associations consolidated in the hippocampus and other structures (Ramachandran & Hubbard, 2001; Cytowic, 2002; Simner, 2013).

Altogether results of this study provide promising data for quantification of projective assessments using color-word associations and further research in large age and gender specific samples likely might be promissing to develop quantified color-word projective assessment tools.

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8. LIST OF ABBREVIATION

DES- Dissociative Experiences Scale (škála disociativních zkušeností)
EEG- electroencephalogram (elektroencefalogram)
fMRI- functional magnetic resonance imaging (funkční magnetická rezonance)
SI - Splitting Index (index štěpení)
TSC-40 - Trauma Symptom Checklist (dotazník pro zjišťování traumatické zkušenosti)

SOUHRN

Synestézie v obecném smyslu představuje jev intersenzorického a intrasenzorického propojení, které může být pozorováno za různých fyziologických a patologických okolností, například jako kreativita v umění nebo v případě některých mozkových dysfunkcí. Synestézie jako jev je především formována prostřednictvím transmodálních asociativních spojení, které mohou tvořit kontinuum od tzv. "silných" synestetických jevů až k jejím mírným formám, které pravděpodobně umožňují tvorbu syneatetických metaphor a imaginace. Tato studie je zaměřena na projektivní analýzu slovně barevných asociací a jejich vztahu k psychoaptologickým měřením reflektujícím stres, depresi, disociaci a dalších psychometrických měření u 154 účastníků vybraných z obecné populace.

Výsledky této studie jsou v souladu s dosavadními publikovanými poznatky, které dokládají, že světlejší barvy jsou mnohem častěji asociovány s pozitivními emocionálními významy ve srovnání s tmavšími barvami. Navíc výsledky této studie ukazují vztahy těchto barevněslovních asociací k psychopatologickým symptomům a to prostřednictvím vztahu některých specifických slov k symptomům deprese, úzkosti, alexithymie a některým symptomům traumatického stresu. Tyto výsledky jsou v souladu s existujícími poznatky získanými v kontextu tzv. metaforické synestézie, kde se zjistila významná role intensity barev ve vztahu k emočním obsahům. V tomto kontextu výsledky této studie ukazují na vztah podnětových slov a barev k disociovaným psychickým obsahům, které vykazují vztah ke konflitním situacím a stresujícím zážitkům. V tomto metaforickém procesu jsou synestetické zkušenosti asociovány s paměťovými stopami konsolidovanými v hippokampu a v některých dalších strukturách, které vytvářejí kontextuální rámce, které jsou specificky ovlivněny stresujícími okolnostmi. Tyto poznatky o metaroficky synestetických asociacích mohou pravděpodobně hrát specifickou úlohu v symbolické imaginaci, kde různé barvy a jejich úroveň světlosti nebo tmavosti mohou charakterizovat jejich asociaci nebo disociaci s dominantním kontextuálním rámcem reflektujícím nevědomé psychické procesy.

SUMMARY

Synesthesia in general is a phenomenon of intersensory and intrasensory linkage that may be observed in various conditions including artistic creativity and also manifests in conditions of various brain dysfunctions and injuries. Synesthesia is a phenomenon represented by transmodal associative connections that may represent a continuum from strong synesthetic phenomena to its mild forms that may enable creation of "synesthetic" metaphors. This study is focused on projective assessments of word-color association and their relationship to psychopathological measures reflecting stress, depression, dissociation and other psychometric measures in 154 participants selected from general population.

The results are in agreement with previous reported studies suggesting that lighter colors are more frequently associated with positive emotional meanings. In addition the results indicate significant relationships of color-word associations to some specific words with depression, anxiety, alexithymia and symptoms of traumatic stress. These results are in accordance with existing findings in context of the so-called metaphorical synesthesia where significant role might be attributed to color intensity. In this context, results of this study suggest that color associations may reflect various mental contents and specifically indicate stimulus words related to dissociated states that manifest as response to conflicting contextual frameworks and stressful experiences. Mainly these results are in accordance with existing findings in context of the so-called metaphorical synesthesia. In this metaphorical process synesthetic experiences are closely associated to typical patterns of memory functionally and specifically consolidated in the hippocampus and other structures that create various contextual frameworks that are specifically influenced by stressful conditions. These findings about metaphoric synesthetic associations may play a specific role in symbolic imagination, where various colors and their levels of lightness or darkness may characterize their association or dissociation ("dis-association") with predominant contextual framework and reflect unconscious mental processes.