

Univerzita Karlova v Praze

1. lékařská fakulta

Autoreferát disertační práce



**Synestetické asociace a psychopatologické
symptomy**

*Synesthetic associations and psychopathological
symptoms*

Mgr. Marcel Neckář

2017

Doktorský studijní program psychologie
Univerzita Karlova v Praze

Obor: Lékařská psychologie a psychopatologie
Předseda oborové rady: Prof. MUDr. Jiří Raboch, DrSc.
Školící pracoviště: Psychiatrická klinika 1. lékařská fakulta
Školitel: Doc. RNDr. Petr Bob, Ph.D.

Content

Summary.....	3
Shrnutí.....	4
1. Introduction.....	5
2. Hypotheses and aims of the study.....	5
3. Methods.....	7
4. Results.....	8
5. Discussion.....	9
6. Conclusions.....	10
7. References.....	13
8. List of original publications.....	21

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.

Shrnutí

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 synestetických 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 barevně-slovních 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 intenzity 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 konfliktním situacím a stresujícím zážitkům. V tomto metaforickém procesu jsou synestetické zkušenosti asociovány s paměťovými stopami konsolidovanými v hippocampu a v některých dalších strukturách, které vytvářejí kontextuální rámce, které jsou specificky ovlivněny stresujícími okolnostmi. Tyto poznatky o metaforických 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.

1. Introduction

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 (Armeli & 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). These findings are in agreement with previously 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). 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. Further research might 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.

2. Hypotheses and aims of the study

2.1. 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.

2.2. 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.

2.3. A purpose of this study was to assess relationships between mild forms of temporal lobe psychosensory symptoms and word-color synesthetic experience 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.

3. Methods

3.1. In order to examine the hypothesis, assessment of color-word associations was 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. 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. 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 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.

Other psychometric methods used in this study were Beck Depression Inventory (BDI-II), Self-Rating Anxiety Scale (SAS), Toronto Alexithymia Scale (TAS-20) and Trauma Symptoms Checklist (TSC-40). These measures were used in group of participants consisted of 43 healthy young women (Mean age=18.25; SD=0.86, age range 17-19).

3.2. With the purpose to examine the hypotheses, we have investigated Group of participants consisted of 40 healthy young men (Mean age=26.12; SD=5.16, age range 19-34). In this study we have used the method of color-world associations, Dissociative Experiences Scale (DES), Somatoform Dissociation Questionnaire (SDQ-20), Splitting index (SI) and Trauma Symptom Checklist (TSC-40).

3.3. A purpose of this research was to examine 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. 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. Other used measures were Trauma Symptoms Checklist (TSC-40), Beck Depression Inventory (BDI-II) and color-word associations.

4. Results

4.1. 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.

4.2. 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 de-pression, anxiety, alexithymia and traumatic stress.

4.3. Results of descriptive statistics from 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 as-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).

5. Discussion

5.1. 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.

5.2. 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.

5.3. The results of descriptive statistics are congruent with previously reported studies which suggest that positive emotional meanings are more frequently associated with lighter colors. These findings are in agreement with data that spoken words influence activations in brain visual areas. The results show specific differences between both sub-groups 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.

6. Conclusions

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 suggest that they 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 addition, results of this study 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. These 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 anti-epileptic medication.

7. References

- Armel, K. C., & Ramachandran, V. S. (1999). Acquired synesthesia in re-tinitis pigmentosa. *Neurocase*, 5(4), 293-296.
- Asher, J. E., Lamb, J. A., Brocklebank, D., Cazier, J. B., Maestrini, E., Ad-dis, L., Monaco, A. P. (2009). A whole-genome scan and fine-mapping linkage study of auditory-visual synesthesia reveals evidence of linkage to chromosomes 2q24, 5q33, 6p12, and 12p12. *American Journal Human Genetics*, 84, 1-7.
- Baars, B. J. (2002). The conscious access hypothesis: origins and recent evidence. *Trends in Cognitive Sciences*, 6, 47-52.
- Baars, B. J. (1988). *A Cognitive Theory of Consciousness*. Cambridge: Cambridge University Press.
- Bagby, R. M., Parker, J. D. A., Taylor, G. J. (1994). The twenty-item Toronto-Alexithymia Scale-I. Item selection and cross-validation of the factor structure. *Journal of Psychosomatic Research*, 38, 23-32.
- Baron-Cohen, S., Bor, D., Billington, J., Asher, J., Wheelwright, S., Ashwin, C. (2007). Savant memory in a man with colour form-number synaesthesia and Asperger syndrome. *Journal of Consciousness Studies*, 14(9-10), 237-251.
- Baron-Cohen, S., Burt, L., Smith-Laittan, F., Harrison, J., Bolton, P. (1996). Synaesthesia: Prevalence and familiarity. *Perception*, 25(9), 1073-1079.
- Baron-Cohen, S., Harrison, J., Goldstein, L. H., Wyke, M. (1993). Coloured speech perception: Is synaesthesia what happens when modularity breaks down? *Perception*, 22(4), 419-426.
- Beck, A. T., Brown, G., Steer, R. A. (1996). *Beck Depression Inventory II manual*. San Antonio, TX: The Psychological Corporation.
- Berman, G. (1999). Synesthesia and arts. *Leonardo*, 32, 15-22.
- Bernstein, E.M., & Putnam, F.W. (1986). Development, reliability, and validity of a dissociation scale. *Journal Nervous Mental Disease*, 174, 727-35.
- Bob, P. (2008). Pain, dissociation and subliminal self-representations. *Consciousness and Cognition*, 17, 355-369.
- Bob, P. (2011). *Brain, Mind and Consciousness: Advances in Neuroscience Research*. Springer, New York.

- Bolognini, N., Miniussi, C., Gallo, S., Vallar G. (2013). Induction of mirror-touch synaesthesia by increasing somatosensory cortical excitability. *Current Biology*, 23(10), 436-7.
- Breuer, J., & Freud, S. (1895). *Studies in hysteria*. New York: Basic Books.
- Briere J. (1996) Psychometric review of the Trauma Symptom Checklist-40. In Measurement of stress, trauma, and adaptation. Edited by Stamm BH. Lutherville: Sidran Press.
- Brogaard, B. (2013). Serotonergic hyperactivity as a potential factor in developmental, acquired and drug-induced synesthesia. *Frontiers in Human Neuroscience*, 7, 657.
- Brown, B. G. (1984). Towards a theory of multiple personality and other dissociative phenomena. *Psychiatric Clinics of North America*, 7, 171-193.
- Bunge, S. A., Ochsner, K. N., Reskond, J. E., Dover, G. H., Gabrieli, J. D. E. (2001). Prefrontal regions involved in keeping information in and out of mind. *Brain*, 124, 2074-86.
- Campen, C. van, & Froger, C. (2003). Personal profiles of color synesthesia. Developing a testing method for artists and scientists. *Leonardo*, 36, 291-294.
- Carmichael, D. A., & Simner, J. (2013). The immune hypothesis of synesthesia. *Frontiers in Human Neuroscience*, 7, 563.
- Cohen Kadosh, R., & Walsh, V. (2008). Synaesthesia and cortical connections: Cause or correlation? *Trends in Neurosciences*, 31(11), 549-550.
- Cohen Kadosh, R., Henik, A., & Walsh, V. (2007). Small is bright and big is dark in synaesthesia. *Current Biology*, 17(19), R834-R835.
- Cohen Kadosh, R., Henik, A., Catena, A., Walsh, V., Fuentes, L. J. (2009). Induced cross-modal synaesthetic experience without abnormal neuronal connections. *Psychological Science*, 20(2), 258-265.
- Cohen Kadosh, R., Sagiv, N., Linden, D. E., Robertson, L. C., Elinger, G., Henik, A. (2005). When blue is larger than red: colors influence numerical cognition in synesthesia. *Journal of Cognitive Neuroscience*, 17(11), 1766-73.
- Collier, G. L. (1996). Affective synesthesia: Extracting emotion space from simple perceptual stimuli I. *Motivation and Emotion*, 20(1), 1-32.
- Crawford, H. J. (1994). Brain dynamics and hypnosis. *International Journal of Clinical and Experimental Hypnosis*, 42, 204-232.
- Cytowic, R. E. (1989). Synesthesia and mapping of subjective sensory dimensions. *Neurology*, 39(6), 849-850.
- Cytowic, R. E., & Wood, F. B. (1982). Synesthesia. I. A review of major theories and their brain basis. *Brain and Cognition*, 1(1), 23-35.
- Cytowic, R. E., & Wood, F. B. (1982). Synesthesia. II. psychophysical relations in the synesthesia of geometrically shaped taste and colored hearing. *Brain and Cognition*, 1(1), 36-49.
- Cytowic, R. E. (2002). *Synesthesia: A union of the senses*. 2nd ed. Cambridge: MIT Press.

- Dael, N., Sierro, G., & Mohr, C. (2013). Affect-related synesthesias: A prospective view on their existence, expression and underlying mechanisms. *Frontiers in Psychology*, 4, 754.
- Dailey, A., Martindale, C., Borkum, J. (1997). Creativity, synesthesia, and physiognomic perception. *Creativity Research Journal*, 10, 1-8.
- Day, S. (1996). Synaesthesia and synaesthetic metaphors. *Psyche*, 2(32).
- Day, S. (2005). Some demographic and socio-cultural aspects of synesthesia. *Synesthesia: Perspectives from Cognitive Neuroscience*, 11-33.
- Diaz, M. T., & McCarthy, G. (2007). Unconscious word processing engages a distributed network of brain regions. *Journal of Cognitive Neuroscience*, 19, 1768-75.
- Dixon, M. J., Smilek, D., & Merikle, P. M. (2004). Not all synaesthetes are created equal: Projector versus associator synaesthetes. *Cognitive, Affective and Behavioral Neuroscience*, 4(3), 335-343.
- Eagleman, D.M., & Goodale, M.A. (2009). Why color synesthesia involves more than color. *Trends in Cognitive Sciences*, 13, 288-92.
- Ellenberger, H. F. (1970). *The Discovery of the Unconscious: The History and Evolution of Dynamic Psychiatry*. New York: Basic.
- Esterman, M., Verstynen, T., Ivry, R. B., & Robertson, L. C. (2006). Coming unbound: Disrupting automatic integration of synesthetic color and graphemes by transcranial magnetic stimulation of the right parietal lobe. *Journal of Cognitive Neuroscience*, 18(9), 1570-1576.
- Fitzgibbon, B. M., Enticott, P. G., Rich, A. N., Giummarra, M. J., Georgiou-Karistianis, N., Tsao, J. W., Bradshaw, J. L. (2010). High incidence of 'synaesthesia for pain' in amputees. *Neuropsychologia*, 48(12), 3675-3678.
- Fitzgibbon, B. M., Giummarra, M. J., Georgiou-Karistianis, N., Enticott, P. G., & Bradshaw, J. L. (2010). Shared pain: From empathy to synaesthesia. *Neuroscience and Biobehavioral Reviews*, 34(4), 500-512.
- Fraser, A. M., Brockert, J. E., Ward, R. H. (1995). Association of young maternal age with adverse reproductive outcomes. *New England Journal of Medicine*, 332, 1113-17.
- Fuentes, L., Cohen-Kadosh, R., Catena, A., & Henik, A. (2007). Synesthesia experience under posthypnotic suggestion: Evidence in favour of the disinhibition hypothesis. Paper presented at the Synaesthesia, Science & Art.
- Galeyev, B.M. (2007). The nature and functions of synesthesia in music. *Leonardo*, 40, 285-288.
- Galton, F. (1883). *Inquiries into human faculty and its development*. Francis Galton. First Edition, Macmillan, 1883. Second Edition, Dent & Dutton (Everyman), 1907. Match.
- Goller, A. I., Otten, L. J., & Ward, J. (2009). Seeing sounds and hearing colors: An event-related potential study of auditory-visual synesthesia. *Journal of Cognitive Neuroscience*, 21(10), 1869-1881.
- Gould, J. R., Prentice, N. M., & Ainslie, R. C. (1996). The Splitting Index: Construction of a Scale Measuring the Defense Mechanism of Splitting. *Journal of Personality Assessment*, 66, 1414-1430.

- Grossenbacher, P. G., & Lovelace, C. T. (2001). Mechanisms of synesthesia: Cognitive and physiological constraints. *Trends in Cognitive Sciences*, 5(1), 36-41.
- Harrison, J., & Hare, D. J. (2004). Brief report: Assessment of sensory abnormalities in people with autistic spectrum disorders. *Journal of Autism and Developmental Disorders*, 34(6), 727-730.
- Hartman, A. M., & Hollister, L. E. (1963). Effect of mescaline, lysergic acid diethylamide and psilocybin on color perception. *Psychopharmacologia*, 4(6), 441-451.
- Hilgard, E. R. (1986). *Divided Consciousness. Multiple Control in Human Thought and Action*. New York: Wiley.
- Hochel, M., & Milan, E. G. (2008). Synaesthesia: The existing state of affairs. *Cognitive Neuropsychology*, 25(1), 93-117.
- Hubbard, E. M. (2007). Neurophysiology of synesthesia. *Current Psychiatry Reports*, 9(3), 193-199.
- Hubbard, E. M., & Ramachandran, V. S. (2005). Neurocognitive mechanisms of synesthesia. *Neuron*, 48(3), 509-520.
- Hubbard, E. M., Arman, A. C., Ramachandran, V. S., & Boynton, G. M. (2005). Individual differences among grapheme-color synesthetes: Brain-behavior correlations. *Neuron*, 45(6), 975-985.
- Hubbard, E. M., Brang, D., & Ramachandran, V. S. (2011). The cross-activation theory at 10. *Journal of Neuropsychology*, 5(2), 152-177.
- Ione, A., & Tyler, C. (2004). Neuroscience, history and the arts synesthesia: Is F-sharp colored violet? *Journal of the History of the Neurosciences*, 13(1), 58-65.
- Iturria-Medina, Y., Fernández, A. P., Morris, D. M., Canales-Rodríguez, E. J., Haroon, H. A., Pentón, L. G., Melie-García, L. (2011). Brain hemispheric structural efficiency and interconnectivity rightward asymmetry in human and nonhuman primates. *Cerebral Cortex*, 21(1), 56-67.
- Janet, P. (1890). *L'Automatisme Psychologique*. Paris: Felix Alcan.
- Jewanski, J., Day, S.A. & Ward, J. 2009. A colorful albino: The first documented case of synesthesia, by Georg Tobias Ludwig Sachs in 1812. *Journal of the History of the Neurosciences*, 18, 293–303.
- Jewanski, J., Simner, J., Day, S. A., & Ward, J. (2011). The development of a scientific understanding of synesthesia from early case studies (1849-1873). *Journal of the History of the Neurosciences*, 20(4), 284-305.
- Jung, C. G. (1910). The association method. *American Journal of Psychology*, 31, 219–269.
- Kadosh, R. C., Kadosh, K. C., & Henik, A. (2007). The neuronal correlate of bidirectional synesthesia: A combined event-related potential and functional magnetic resonance imaging study. *Journal of Cognitive Neuroscience*, 19(12), 2050-2059.
- Kernberg, O. F. (1975). *Borderline Conditions and Pathological Narcissism*. Janson Aronson, New York.
- Kondas, O., (1989). Asociativní experiment. *Psychodiagnostika*, Bratislava.
- Kuhbandner, C., & Pekrun, R. (2013). Joint effects of emotion and color on memory. *Emotion*, 13(3), 375-379.

- Lakoff, G. (1993). The Contemporary Theory of Metaphor, In Ortony, A. (ed.), *Metaphor and Thought*. 2nd ed. Cambridge: Cambridge University Press, pp. 202-251.
- Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. University of Chicago Press, Chicago.
- Lavenex, P., & Amaral, D. G. (2000). Hippocampal-neocortical interaction: A hierarchy of associativity. *Hippocampus*, 10, 420-430.
- Lewis, L. N., Hickey, M., Doherty, D. A., Skinner, S. R. (2009). How do pregnancy outcomes differ in teenage mothers? A Western Australian study. *Medical Journal of Australia*, 190, 537-41.
- Maddock, R. J. (1999). The retrosplenial cortex and emotion: New insights from functional neuroimaging of the human brain. *Trends in Neurosciences*, 22(7), 310-316.
- Marks, L. E. (1975). On colored-hearing synesthesia: Cross-modal translations of sensory dimensions. *Psychological Bulletin*, 82(3), 303-331.
- Marks, L. E. (1978). *The Unity of the Senses: Interrelations among the Modalities*. New York: Academic Press.
- Marks, L. E. (1982). Synesthetic perception and poetic metaphor. *Journal of Experimental Psychology: Human Perception and Performance*, 8(1), 15-23.
- Marks, L. E. (2011). Synesthesia, then and now. *Intellectica*, 55, 47-80.
- Marks, L. E. (2013). Weak synaesthesia in the general population. *Oxford Handbook of Synaesthesia*. J. Simner and E. Hubbard, eds. Oxford University Press, Oxford.
- Marks, L. E., & Mulvenna, C. M. (2013). Synesthesia, at and near its borders. *Frontiers in Psychology*, 4, 651.
- Martino, G., & Marks L. E. (2001). Synesthesia: Strong and Weak. *Psychological Science*, 10, 61-65.
- Melloni, L., Molina, C., Pena, M., Torres, D., Singer, W., & Rodriguez, E. (2007). Synchronization of neural activity across cortical areas correlates with conscious perception. *Journal of Neuroscience*, 27, 2858-65.
- Milan, E. G., Hochel, M., González, A., Tornay, F., McKenney, K., Díaz Caviendes, R., Vila, J. (2007). Experimental study of phantom colours in a colour blind synaesthete. *Journal of Consciousness Studies*, 14(4), 75-95.
- Moller, A. C., Elliot, A. J., & Maier, M. A. (2009). Basic hue-meaning associations. *Emotion*, 9(6), 898-902.
- Mulvenna, C. M., & Walsh, V. (2006). Synaesthesia: Supernormal integration? *Trends in Cognitive Sciences*, 10(8), 350-352.
- Mulvenna, C., Hubbard, E. M., Ramachandran, V. S., & Pollick, F. (2004). The relationship between synaesthesia and creativity. *The relationship between synaesthesia and creativity*. *Journal of Cognitive Neuroscience Suppl.* 16, 188.
- Myles, K. M., Dixon, M. J., Smilek, D., & Merikle, P. M. (2003). Seeing double: The role of meaning in alphanumeric-colour synaesthesia. *Brain and Cognition*, 53(2), 342-345.
- Nadel, L. & Jacobs, W.J. (1998). Traumatic memory is special. *Current Directions in Psychological Science*, 7, 154-157.

- Neufeld, J., Sinke, C., Zedler, M., Dillo, W., Emrich, H. M., Bleich, S., & Szycik, G. R. (2012). Disinhibited feedback as a cause of synesthesia: Evidence from a functional connectivity study on auditory-visual synesthetes. *Neuropsychologia*, 50(7), 1471-1477.
- Nijenhuis, E. R., Spinhoven, P., Van Dyck, R., Van der Hart, O., & Van-derlinden, J. (1996). The development and psychometric characteristics of the Somatoform Dissociation Questionnaire (SDQ-20). *Journal of Nervous and Mental Disease*, 184, 688-94.
- Nunn, J. A., Gregory, L. J., Brammer M., Williams, S. C. R., Parslow D. M., Morgan, M. J., Morris, R. G., Bullmore, E. T., Baron-Cohen, S., Gray, J. A. (2002). Functional magnetic resonance imaging of synesthesia: activation of V4/V8 by spoken words. *Nature Neuroscience*, 5(4), 371-375.
- Okubo, M., & Ishikawa, K. (2011). Automatic semantic association between emotional valence and brightness in the right hemisphere. *Cognition and Emotion*, 25(7), 1273-1280.
- Palmer, S. E., Schloss, K. B., Xu, Z., & Prado-León, L. R. (2013). Music-color associations are mediated by emotion. *Proceedings of the National Academy of Sciences of the United States of America*, 110(22), 8836-8841.
- Parise, C. V., & Spence, C. (2009). 'When birds of a feather flock together': Synesthetic correspondences modulate audiovisual integration in non-synesthetes. *PLoS ONE*, 4(5).
- Pearce, J. M. S. (2007). Synaesthesia. *European Neurology*, 57(2), 120-124.
- Perry, A., & Henik, A. (2013). The emotional valence of a conflict: Implications from synesthesia. *Frontiers in Psychology*, 4, 978.
- Radvansky, G. A., Gibson, B. S., McNeerney, M. W. (2011). Synesthesia and memory: Color congruency, von Restorff, and false memory effects. *Journal of Experimental Psychology: Learning Memory and Cognition*, 37(1), 219-229.
- Rainville, P., Hofbauer, R. K., Bushnell, M. C., Duncan, G. H., Price, D. D. (2002). Hypnosis modulates activity in brain structures involved in the regulation of consciousness. *Journal of Cognitive Neuroscience*, 14, 887-901.
- Ramachandran, V. S., & Hubbard, E. M. (2001). Psychophysical investigations into the neural basis of synaesthesia. *Proceedings of the Royal Society B: Biological Sciences*, 268(1470), 979-983.
- Ramachandran, V. S., & Hubbard, E. M. (2001). Synaesthesia - A window into perception, thought and language. *Journal of Consciousness Studies*, 8(12), 3-34.
- Ramachandran, V. S., & Hubbard, E. M. (2003). Hearing colors, tasting shapes. *Scientific American*, 288(5), 53-59.
- Ramachandran, V. S., & Rodgers-Ramachandran, D. (1996). Synaesthesia in phantom limbs induced with mirrors. *Proceedings of the Royal Society B: Biological Sciences*, 263(1369), 377-386.
- Roberts, R. J., Gorman, L. L., Lee, G. P., et al. (1992). The phenomenology of multiple partial seizure-like symptoms without stereotyped spells: an epilepsy spectrum disorder? *Epilepsy Research*, 13, 167-77.
- Rotenberg, V. S. (2004). The ontogeny and asymmetry of the highest brain skills and the pathogenesis of schizophrenia. *Behavioral and Brain Sciences*, 27(6), 864-865.

- Rotenberg, V. S. (2013). Moravec's paradox: Consideration in the context of two brain hemisphere functions. *Activitas Nervosa Superior*, 55(3), 108-111.
- Rouw, R., & Scholte, H. S. (2007). Increased structural connectivity in grapheme-color synesthesia. *Nature Neuroscience*, 10(6), 792-797.
- Rouw, R., Scholte, H. S., & Colizoli, O. (2011). Brain areas involved in synaesthesia: A review. *Journal of Neuropsychology*, 5(2), 214-242.
- Sagiv, N., & Ward, J. (2006). Crossmodal interactions: Lessons from synesthesia. *Progress in Brain Research*. 155, 259-71.
- Schiltz, K., Trocha, K., Wieringa, B. M., Emrich, H. M., Johannes, S., Münte, T. F. (1999). Neurophysiological aspects of synesthetic experience. *Journal of Neuropsychiatry and Clinical Neurosciences*, 11(1), 58-65.
- Shevrin, H. (2001). Event-related markers of unconscious processes. *International Journal of Psychophysiology*, 42, 209-218.
- Simner, J. (2012). Defining synaesthesia. *British Journal of Psychology*, 103(1), 1-15.
- Simner, J. (2012). Defining synaesthesia: A response to two excellent commentaries. *British Journal of Psychology*, 103(1), 24-27.
- Simner, J. (2013). Why are there different types of synesthete? *Frontiers in Psychology*, 2, 558.
- Simner, J., & Hubbard, E. (Eds.) (2013). *Oxford Handbook of Synaesthesia*. Oxford: Oxford University Press.
- Simner, J., Gärtner, O., & Taylor, M. D. (2011). Cross-modal personality attributions in synaesthetes and non-synaesthetes. *Journal of Neuro-psychology*, 5(2), 283-301.
- Sinke, C., Halpern, J. H., Zedler, M., Neufeld, J., Emrich, H. M., & Passie, T. (2012). Genuine and drug-induced synesthesia: A comparison. *Consciousness and Cognition*, 21(3), 1419-1434.
- Smilek, D., Dixon, M. J., & Merikle, P. M. (2005). Synaesthesia: Discordant male monozygotic twins. *Neurocase*, 11(5), 363-370.
- Smilek, D., Dixon, M. J., Cudahy, C., & Merikle, P. M. (2001). Synaesthetic photisms influence visual perception. *Journal of Cognitive Neuroscience*, 13(7), 930-936.
- Spector, F., & Maurer, D. (2009). Synesthesia: A new approach to understanding the development of perception. *Developmental Psychology*, 45(1), 175-189.
- Spence, C. (2002). Multisensory attention and tactile information-processing. *Behavioural Brain Research*, 135(1-2), 57-64.
- Steven, M. S., & Blakemore, C. (2004). Visual synaesthesia in the blind. *Perception*, 33(7), 855-868.
- Steven, M. S., Hansen, P. C., & Blakemore, C. (2006). Activation of color-selective areas of the visual cortex in a blind synesthete. *Cortex*, 42(2), 304-308.
- Stuckey, D. E., Lawson, R., & Luna, L. E. (2005). EEG gamma coherence and other correlates of subjective reports during ayahuasca experiences. *Journal of Psychoactive Drugs*, 37(2), 163-178.
- Teicher, M. H., Glod, C. A., Surrey, J., Swett, C. Jr. (1993). Early childhood abuse and limbic system ratings in adult psychiatric outpatients. *Journal of Neuropsychiatry and Clinical Neuroscience*. 5, 301-306.

- Teicher, M. H., Andersen, S. L., Polcari, A., et al. (2003). The neurobiological consequences of early stress and childhood maltreatment. *Neuroscience and Biobehavioral Reviews*, 27, 33–44.
- Teicher, M. H., Tomoda, A., Andersen, S. E. (2006). Neurobiological consequences of early stress and childhood maltreatment: Are results from human and animal studies comparable? *Annals of the New York Academy of Sciences*, 1071, 313–23.
- Terhune, D. B., Cardena, E., & Lindgren, M. (2010). Disruption of synaesthesia by posthypnotic suggestion: An ERP study. *Neuropsychologia*, 48(11), 3360-3364.
- Terhune, D. B., Tai, S., Cowey, A., Popescu, T., Cohen Kadosh, R. (2006). Enhanced cortical excitability in grapheme-color synesthesia and its modulation. *Current Biology*, 21(23), 2006-9.
- Tomson, S. N., Narayan, M., Allen, G. I., Eagleman, D. M. (2013). Neural networks of colored sequence synesthesia. *Journal of Neuroscience*, 33(35), 14098-14106.
- Veen, Van der, F. M., Aben, H. P., Smits, M., Röder, C. H. (2014). Grapheme-color synesthesia interferes with color perception in a standard stroop task. *Neuroscience*, 258, 246-253.
- Vermetten, E. & Douglas, B. J. (2004). Functional brain imaging and the induction of traumatic recall: a cross-correlational review between neuroimaging and hypnosis. *International Journal of Clinical and Experimental Hypnosis*, 52, 280-312.
- Volberg, G., Karmann, A., Birkner, S., & Greenlee, M. W. (2013). Short- and long-range neural synchrony in grapheme-color synesthesia. *Journal of Cognitive Neuroscience*, 25(7), 1148-1162.
- Voskuil, P. H. A. (2013). Van Gogh's disease in the light of his correspondence. *Frontiers of Neurology and Neuroscience*. 31, 116-25.
- Walsh, R. (2005). Can synaesthesia be cultivated? Indications from surveys of meditators. *Journal of Consciousness Studies*, 12(4-5), 5-17.
- Ward, J. (2004). Emotionally mediated synaesthesia. *Cognitive Neuropsychology*, 21(7), 761-772.
- Ward, J. (2013). Synesthesia. *Annual Review of Psychology*, 64, 49-75.
- Ward, J., & Mattingley, J. B. (2006). Synaesthesia: An overview of contemporary findings and controversies. *Cortex*, 42(2), 129-136.
- Ward, J., & Simner, J. (2005). Is synaesthesia an X-linked dominant trait with lethality in males? *Perception*, 34(5), 611-623.
- Ward, J., Huckstep, B., & Tsakanikos, E. (2006). Sound-colour synaesthesia: To what extent does it use cross-modal mechanisms common to us all? *Cortex*, 42(2), 264-280.
- Zung, W.W.K. (1971). A rating instrument for anxiety disorders. *Psychosomatics*, 13, 371–379.

8. List of original 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

Cumulative IF = 5,071

Other Publications indexed in Scopus

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

Notes