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**Review of PhD thesis by Izabela Szumska:**
**'Effects of response modality and task instruction in meta-contrast masking studies: Implications for theories of visual consciousness'**

The doctoral dissertation submitted to me for evaluation constitutes an important contribution to the current debate on the topic of consciousness and conscious vs. unconscious processing of incoming visual information. The findings of Izabela Szumska's studies have substantial implications for existing models of visual consciousness. All studies included in this dissertation were carefully planned and conducted. Results of those studies were adequately analyzed, reported, and discussed. PhD candidate used in her research both behavioral and electrophysiological methods as well as complex methods of data analyses. In addition, the traditional null-hypothesis significance-testing approach was complemented with Bayesian analysis methods.

Izabela Szumska's doctoral dissertation consists of an extensive introduction (Chapter 1) presenting both the theoretical framework (description of various theories of consciousness and subliminal visual processing) and methodological aspects of conducted studies (a brief description of EEG recordings and ERP method). Thus, this introduction is a good starting point for reading further parts of PhD thesis.

Chapter 2 describes the first experiment and – as stated by PhD candidate by herself - is related to the paper published in 2016 (Szumska I, Van der Lubbe RHJ, Grzeczkowski L, Herzog MH. 2016. Does sensitivity in binary choice tasks depend on response modality? Consciousness and Cognition, 43,57-65). This is also the case for Chapter 3 with a description of the second experiment. This chapter is related to the paper published in 2019 (Szumska I, Baran W, Pinkas E, Van der Lubbe, R HJ. 2019. Does the Influence of Near-threshold Primes Depend on the Type of Task? Consciousness and Cognition, 76:102827). In both papers, PhD candidate was not only the first but also the corresponding author. This indicates the major role of Izabela Szumska in those publications. It is worth noting that based on current rules referring to a PhD thesis, it is possible to defend PhD based on a series of articles on similar/coherent topics. Nevertheless, Izabela Szumska decided to prepare a regular, full-length PhD thesis, with an additional (third) experiment (Chapter 4). This experiment built up upon findings reported in already published papers.

I am fully aware that for each of these papers, Izabela Szumska and co-authors had to undergo a rigorous manuscript review procedure. Therefore, I would like to emphasize that the fact these articles have been already published means that the material contained in the doctoral dissertation has already been positively assessed by a group of reviewers appointed by the editorial offices, who are experts in the field of signal analysis and/or brain correlates of the studied cognitive processes. Hence, I must admit that it makes my reviewer's task much easier. Nevertheless, I do have some questions and comments that should be addressed by PhD candidate. These comments are presented at the end of my review in the order in which they appeared during the reading of the doctoral dissertation.

In the first experiment (Chapter 2), the impact of different response modalities (manual, saccade, verbal) on performance in a shape localization task was investigated. The visibility of the target was manipulated by a meta-contrast masking procedure at various inter-stimulus intervals (ISI). While a large number of very detailed results were presented, the main findings were as follows. Performance was worse for saccadic responses than for manual and verbal ones and it gradually increased with the length of ISIs. Substantial differences in response times were found for three response modalities, with the shortest RT for saccades, the longest for verbal responses, with RTs for manual responses in between. Results were

discussed in relation to the Two-Streams Hypothesis and the Global Workspace Theory. Some results (e.g. lower percent of correct responses in the case of saccadic responses than for manual and verbal modality) were not in line with either of those theories.

The next part of Izabela Szumska'a PhD thesis is a description of the second experiment (Chapter 3). The study aimed to test the role of the employed task instructions on the processing of prime stimuli. To examine this, three tasks were used: one main task and two prime tasks (a prime localization and a prime identification task, commonly used in subliminal priming studies). Additionally, by using short and long SOAs, it was tested whether differences between conscious and unconscious processing of the prime were qualitative or rather quantitative. Crucially, besides behavioral measures, the neural basis of plausible differences in prime processing among different tasks was investigated. To achieve that goal EEG was recorded and subsequently analyzed. Briefly, LRP and PCN findings showed that masked primes exerted a substantial influence on both motor and attentional processes. Moreover, PCN and LRP components had larger amplitudes in the main task than in the prime localization and the prime identification task. Altogether, the PhD candidate suggested two alternative interpretations: (1) both prime-related and target-related effects impacted analyzed ERL components; (2) ERLs may be prime-related only, but observed between-tasks differences may result from different attentional loads in these tasks. The latter would be in line with the global workspace theory.

The third study (Chapter 4) is a kind of a follow-up of the previous study, with one major modulation - exclusion of motor responses (i.e. all participants' responses were verbal). In this way, all confounding effects that may be linked to the preparation and execution of hand movements were eliminated. Results of that study clearly showed the lateralized activity over posterior-occipital areas, reflecting a shift of attention towards the relevant prime. This finding confirmed conclusions from previous studies that the subliminal prime may attract attention leading to faster responses to the target. In sum, gathered evidence supported the notion of the attention-related nature of subliminal priming effects in the case of meta-contrast masking paradigms. In the authors' view, findings reported in that study did not undermine the Two-Streams Hypothesis even though this theory does not fully explain the subliminal priming

effect.

The general discussion is the last part of Izabela Szumska's dissertation (Chapter 5). Here the PhD candidate presented concisely the main results of the research shown in earlier parts of her dissertation and discussed them in detail in relation to the current theories of visual consciousness the Two-Streams Hypothesis, the Global Workspace Theory, and the Theory of Micro-Consciousness. I do appreciate the way experimental findings were interpreted. However, the final part of the discussion, i.e. 'Conclusions', should be rather named 'Summary' as this section just summarized experimental findings.

My other comments are as follows.

Chapter 2: The number of participants was rather low (10). Is it a typical sample size in studies with similar methods/tasks?

Chapter 3:

- Participants' age ranged from 18 to 57. Were any age-related differences observed?

- Manual responses were given by pressing the left/right CTRL key on a standard QWERTY keyboard. I suggest using response pads (e.g. CEDRUS response pad) in future studies. They are more precise.

- I wonder why the PhD candidate preferred to use the name PCN instead of N2pc. Posterior contralateral negativity is a phrase typically used in the SPCN, i.e. sustained posterior contralateral negativity (e.g. Jolicœur, P., Brisson, B., and Robitaille, N. 2008. Dissociation of the N2pc and sustained posterior contralateral negativity in a choice response task. Brain Res. 1215, 160–172).

- Topographical distributions of brain activity were missing (Figure 15, Figure 16). Typically, such topographical maps are shown together with ERPs. It is worth noting that nowadays it is a golden standard that electrodes selection for statistical analyses has to be orthogonal to potential differences between experimental conditions, i.e. different stimuli, different tasks, different groups, etc. (e.g. van Driel et al., 2012). Therefore, to avoid the so-called double-dipping problem (Kriegeskorte et al., 2009), the selection of electrodes should be based on maps of the topographical distribution

of recorded brain activity averaged across all experimental conditions, in time windows corresponding to a given ERP component. Recently, Luck and Gaspelin (2017) strongly recommended this approach in their influential paper 'How to get statistically significant effects in any ERP experiment (and why you shouldn't)'. The PhD candidate selected electrodes based on previous studies with similar paradigms. Nevertheless, figures with topographical maps would ensure a reader that in that specific study, analyzed electrodes (P7, P8, PO7, PO8) were localized within regions of the lowest activity. I did notice, however, that in the last study (Experiment 3, Chapter 4), included in this PhD dissertation, topographical maps of the event-related lateralization were provided (Figure 20, Figure 22). Thus it looks like PhD candidate improved the way of presenting her electrophysiological results ☺

van Driel J, Ridderinkhof KR, Cohen MX (2012) Not All Errors Are Alike: Theta and Alpha EEG Dynamics Relate to Differences in Error-Processing Dynamics. Journal of Neuroscience, 32, 16795-16806.

Kriegeskorte N, Simmons WK, Bellgowan PSF, Baker CI (2009) Circular analysis in systems neuroscience – the dangers of double dipping. Nature Neuroscience, 12, 535-540.

Luck SJ, Gaspelin N (2017) How to get statistically significant effects in any ERP experiment (and why you shouldn't). Psychophysiology, 54, 146-157.

Chapter 4: EEG was recorded from 32 electrodes and was not re-referenced off-line to some passive electrodes (for instance – an average signal recorded at the left and right earlobes). It was also the case in the earlier study described in Chapter 3. To the best of my knowledge, all ERP components are typically more pronounced after such re-referencing procedure. I recommend that PhD candidate consider that step in EEG recording and preprocessing in her future studies.

Chapter 5: Typically, in the final part of the general discussion, limitations of conducted studies and directions of the future research are mentioned. Here it was not the case. Therefore, I wonder whether PhD candidate is aware of any limitations of her studies and whether PhD candidate has any plans to continue studies on the topic of visual consciousness.

At the end of my review and being fully aware that any review of the doctoral dissertation should concern purely substantive issues of the presented research, I cannot, however, refrain from commenting on the purely esthetical aspects of this dissertation. A clean and clear layout as well as beautiful graphs and illustrations proved that Izabela Szumska put a lot of effort into the graphic design of her PhD thesis.

In conclusion, the PhD thesis by Izabela Szumska makes a significant contribution to the research on the role of response modality and task instruction in meta-contrast masking studies and has substantial implications for theories of visual consciousness. The significance of presented here findings is strengthened by the fact that two studies have been already published and all of them have been supported by either the Scientific Exchange Programme NMS-CH grant (SCIEX) or the Polish National Centre.

I hereby declare that reviewed by me Izabela Szumska's PhD dissertation meets the criteria and conditions set out in Art. 13 of the Act of March 14, 2003 on academic degrees and academic title as well as degrees and titles in the field of art (Journal of Laws No. 65, item 595, as amended). Therefore without any doubt I recommend the Scientific Council of the Institute of Psychology of the Polish Academy of Sciences to accept Izabela Szumska for further stages of her doctoral procedure.

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