May 2nd, 2024

Review of doctoral thesis by **Łucja Doradzińska** *"Automaticity of attention capture and engagement: the role of semantic congruency and emotional relevance".* **(Supervisor – Dr. Michał Bola, Ph.D., D.Sc.)**

This doctoral dissertation addresses three loosely related topics. The first study is a follow-up on a previous paper (on which Łucja Doradzinska was a co-author) showing that relative to congruent scenes, incongruent scenes do not capture attention: the present study investigates whether once they are attended, incongruent scenes retain attention more than congruent scenes, with disgust-provoking images serving as a positive control. The second study investigates whether relative to masked neutral faces, masked fearful faces engage attention, relying on ERP methodology: the author examines emotion-based modulation for several components with masked and with unmasked faces. Finally, the third study relies on the same data to investigate whether endogenous attention (defined as task-relevance) and exogenous attention (defined as emotional salience) modulate the VAN.

Evaluation and comments

Overall, the dissertation is very well written. The introduction sections of all three papers make an excellent job justifying their respective experiments. Finally, the methods and analyses are sound. These positive comments resonate with the fact that all three papers were accepted in top-tier journals.

I do have some questions / comments with regard to each study.

Study 1.

This study is quite straightforward. My only question is about the stimuli used: the stimuli in the 'congruence' block seem to be much more complex than the stimuli in the 'disgust' block. It is possible that participants did not have time to make sense of the (irrelevant) congruent / incongruent stimuli within 300ms, whereas this duration sufficed for making sense of the 'disgust' stimuli. In this regard it is important to note that most of Mudrik et al. (2010) findings with such stimuli were not replicated (even by the authors themselves, see Biderman & Mudrik, 2018); the only finding indicative of congruency processing was slower RTs to briefly presented task-relevant images (but not with 500-ms presentations). As the images in the present study were both task-irrelevant and presented for >500ms, it is difficult to rely on Mudrik et al.'s findings to claim that the congruency/incongruency was at all processed.

Study 2.

A particularly impressive feature of Study 2 is that the sample size was based on a published meta-analysis on the effect of interest. The author's conclusion is that subliminal fearful faces do not modulate any attention-related component.

Main comments:

Isn't it possible that the stimulation in the masked condition was not strong enough to elicit preconscious effects? To push the argument, if the subjects had closed their eyes, it would not be surprising to find no effect. The point is that there are no significant effects involving the masked faces. True, there was a significant P1 component but for all we know, it could be in response to the stimulus-mask compound rather than specifically to the face.

The author relies on the finding that d' in the ID block was actually above chance for the masked faces to claim that there was some processing of emotion (which would refute my previous criticism). However, it is possible that in the ID block, the dots served as a retro cue, and it is possible that above-chance performance arose from awareness *after* the dots appeared (e.g., Sergent et al., 2012)- which is not what is measured by the ERP analyses. Relatedly, as the conditions prevailing in the DP block are very different from those of the ID block (no retro-cueing, no relevance), the above-chance d' on the ID task cannot be generalized to the DP task and it is possible that presentation was too short for any relevant processing of the masked face.

To summarize the argument, the conclusion that subliminal fearful faces do no draw attention may be too strong: with the present stimulation, such attentional processing did not occur- but in the absence of any independent evidence that emotion was processed, further evidence is required. Note however, that the fact that the effect of emotion for masked faces was in the right direction for the N170 is encouraging and supports the author's conclusion.

Minor comments

- The review of the ERP components does not reflect the debates surrounding the interpretation of each component. For instance, several papers have shown that the N2pc does not reflect shifts of attention but rather attentional engagement (e.g., Kiss, Velzen & Eimer, 2008; Zivony et al., 2018).
- I did not understand the rationale for using a 500-ms interval which is indeed not ideal to measure behavioral performance on the DP task. 500ms is far more than is required to obtain separate signals on the ERP measure.
- For ERPs I could not see how the symmetrical and asymmetrical trials were treated. For instance, for the N2pc analysis were only asymmetrical trials included in the analyses?
- The author writes: 'several studies reporting no preconscious attentional prioritization of fearful faces failed to find the N170 effect'. As far as I could see, this also happened here (despite a non-significant trend in the expected direction).

Study 3

- The results were a bit difficult to follow because they seem to jump to specific contrasts rather than reporting main effects and interactions with follow-up analyses. Therefore, I could not see the specific analysis on which the authors relied to claim in the discussion, that "endogenous attention modulated the amplitude of VAN in both time windows, with task-relevant stimuli resulting in greater VAN amplitudes than task-irrelevant ones". The results presented in Fig.3 suggest that the effect of relevance for the early VAN occurs only for unmasked faces. Likewise, the claim that exogenous attention had an effect mainly for the late VAN is clear for unmasked but not for masked faces (again, based on the graphs).
- Similar to what I noted for the previous study, the VAN associated to the masked stimuli may reflect a response to the face-mask compound. As far as I could understand there is no specific evidence that modulation of VAN (if any) by endogenous attention reflects modulation of the face stimulus rather than of the compound. Any emotion-related modulation of VAN for masked faces would indicate that the modulation occurs for the face itself, but I could not spot any such effect in the paper (and most strikingly so by looking at the figures).
- The implication of the above is that what the study shows is that for unmasked stimuli, attention (here operationalized as task relevance and emotional salience) modulates VAN. As the author asserts, this is in contrast to Lamme's claims. In addition, however, the results also show that the VAN is more pronounced for unmasked than for masked faces.
However, I may have missed emotion-based effects on the VAN for the masked faces.
- I very much liked the final sentence: 'Furthermore, it is our opinion that disentangling neural activity responsible for awareness and attention using standard neuroimaging methods such as ERPs might be impossible'. It would have been interesting to develop the arguments supporting this idea.
- There is a typo in the behavioral results: I suppose participants were more likely to correctly respond fearful when the second face was also fearful (and not neutral).

Please note that these comments are only the basis for a discussion. The thesis fulfils the requirements for a PhD and I fully endorse it in its present form.

Prof. Dominique Lamy
The School of Psychological Sciences and The Sagol School of Neuroscience
Tel Aviv University

Dr hab. Jarosław Michałowski, prof. Uniwersytetu SWPS

Laboratory of Affective Neuroscience

Faculty of Psychology and Law in Poznań

SWPS University

Review report on the PhD thesis of Łucja Doradzińska entitled

Automaticity of attention capture and engagement: the role of semantic congruency and emotional relevance

Supervisor: Dr hab. Michał Bola

There is a long history of experimental research on the cognitive mechanisms underlying visual processing. This research faces the challenge of unraveling the interplay between awareness and attention, as there are strong interconnections between these two processes. Initially, this research was based on behavioral measurements. Since the rapid development of neuroscience in the 1990s, the field of cognitive and affective psychology has also begun to utilize neuroscience methods and procedures. The electroencephalography (EEG) turned out to be particularly useful in this context, as the EEG enables observing the stimulus-locked neuronal activity with a high temporal resolution. Within the EEG methodology, event-related potentials (ERPs) were proven a particularly valuable method. In her doctoral dissertation, Ms. Łucja Doradzińska tries to fill the gaps in awareness and attention research using both, the line of thoroughly designed experiments and carefully applied ERPs methodology. As a result, Ms. Doradzińska prepared a complete and scientifically valuable doctoral dissertation.

Formal evaluation

The English-language dissertation of Łucja Doradzińska consists of three thematically related scientific articles that have been published in respected journals: Consciousness and Cognition (IF = 2.4), Cerebral Cortex (IF = 3.7), Journal of Cognitive Neuroscience (IF =

3.2). The articles presented in the work are preceded by an introduction including theoretical considerations regarding awareness and selective attention, the general aims and the summary of the studies presented in the articles as well as a general discussion. The list of references included in the introduction contains 238 items. By reading the doctoral thesis, one gets the impression that its individual parts have been carefully prepared, including a clearly written Polish- and English-language summaries, in which the author outlines the theoretical background of her research, describes the research problem and summarizes the results of the presented studies.

Professional quality

In the studies presented in her doctoral thesis Łucja Doradzińska investigated whether semantic congruency and emotional salience of visual stimuli and their task relevance affects response latency and accuracy in the choice reaction time tasks or the amplitudes of the ERPs for naturalistic images. Based on these variables, the author drew conclusions about the factors influencing stimulus awareness and attention.

In the first publication she aimed to specify whether semantically incongruent pictures automatically engage and hold attention to a higher degree than the congruent ones and contrasted this congruity condition with the emotional salience condition, in which she tested the automatic attention towards disgust-eliciting vs happiness-inducing pictures. The letter categorization task performed in these two conditions was used to index attentional bias. Replicating the well-known emotional salience effect the study revealed that the response to letters was prolonged and the accuracy reduced during the presentation of disgust- when compared to happiness-eliciting pictures. Due to an increased arousal value of disgusting pictures used in this study, it is difficult to accept the suggestion of the author that this result proves a specific attentional bias towards disgusting materials. At the same time, the study did not confirm the beneficial role of incongruency in automatically attracting and holding attention, as there were no differences in response time and accuracy between stimuli presented in the context of incongruent vs congruent pictures.

In the second and third publications the author presents the behavioral and ERP results originating from a task in which pairs of faces were presented with one being replaced with a dot probe. The task was presented in two blocks: in one block it was utilized as a standard

dot-probe task where the location of dots had to be detected (detection task) and in the other block participants had to identify the face that was replaced by the dot (face identification task). The idea to present faces as targets or distractors with the same experimental procedure enabled to test the endogenous and exogenous attention towards faces. Moreover, in the study the author manipulated two other important variables. First, the pairs of faces included various combinations of fearful and neutral faces which enabled to control the level of emotional salience of the presented materials. Second, the pairs of faces were presented either masked with scrambled neutral faces or unmasked, which enabled to control the level of stimulus awareness. In her first publication, the authors analyzed the standard target response parameters as well as the ERPs for face images. The response parameters confirmed that the unmasked faces were correctly identified. The same was true for the masked faces, even though their discrimination was lower. As to the ERPs, several components were sensitive to the emotional salience of faces but if this effect was observed, it was significant only for the unmasked condition. In the early time window (EPN and N2pc) this effect was observed for exogenous and endogenous attention and in the later time window (SPCN and P3b) it was only visible for task-relevant faces (i.e. for exogenous attention). The author suggests that these findings speak against the idea that threat-related stimuli can be preconsciously perceived (e.g. Phelps, 2006; LeDoux and Brown, 2017). In the third publication, the data from the same experiment were used to disentangle the awareness and selective attention effects using the ERP signatures of perceptual awareness, as indexed by the component called Visual Awareness Negativity (VAN), which was shown to be more pronounced for stimuli that were consciously presented when compared to those that remained undetected or unconscious (Koivisto and Revonsuo, 2010). Thus, in this publication the author analyzed the ERPs in the VAN-specific sensor cluster in early and late VAN time windows. The results of these analyses revealed that the amplitude of VAN was predominantly enhanced by selective attention. The early VAN was completely suppressed when endogenous attention was manipulated indicating that this portion of VAN is not necessary for awareness. Most importantly for the main research question, the amplitude of early and late VAN was observed to respond to attentional manipulation in the absence of stimulus awareness. The latter results undermine the assumption that VAN is sufficient for conscious experience to occur and indicate that this component is strongly related to attentional prioritization.

I have an overall positive impression of the presented thesis. First of all, the author clearly proves that she has the most important features of a good researcher - the ability to develop a logical research strategy and the patience in implementing it. In this case, the strategy involved looking for the factors influencing selective attention for semantically and emotionally significant materials. The first step in implementing this research strategy was to conduct a behavioral study that aimed at comparing the selective attention towards semantically incongruent materials with the one towards emotionally relevant stimuli. This type of comparison allowed the author to use a well-known emotion-related attentional bias as a basis for verifying her hypotheses about the less-known effects of semantic incongruency. The second step undertaken by the author to answer her strategic questions aimed at investigating whether aversive stimuli can be prioritized for sensory processing even though they are presented outside of awareness. In this study, the author supplemented the behavioral assessments with electrophysiological data, which enriched the interpretative power of the study. The PhD student also proved that she knows the classic methods of EEG signal processing and analysis (she perfectly describes the individual steps of signal reduction and analysis) and uses innovative analysis methods. What is noteworthy is the precision with which the PhD student applied the research procedure, e.g. balancing masked and unmasked conditions, emotion-related and neutral faces as well as conditions of exogenous vs. endogenous attention towards facial expressions. It has to be noted that the research material and the procedure were prepared expertly in both studies, e.g. picture selection was based on their emotional significance and physical properties, responses with right and left hands were counterbalanced, presentation of conditions was blocked, self-paced breaks were introduce to allow participants to regain their cognitive resources, awareness of pictures was controlled with SDT parameters, etc. Also, both studies were conducted on samples with appropriate number of participants, which was planned with a priori sample size estimations based on previous studies with similar procedures. This approach is consistent with current social research methodology and challenges in the replication crisis.

In general, it is difficult to find any significant weaknesses in the presented articles, because the studies and the text were prepared exhaustively and extremely carefully. The whole dissertation follows a clear logic and the narrative style is friendly. The multi-aspect nature of the presented research deserves special attention: the analysis and interpretation of the collected data required the PhD student to possess the knowledge and skills in psychology,

psychophysiology and advanced statistics. In her publications, the author has undoubtedly demonstrated that she has the most important feature of a good researcher - perseverance in implementing a logical research strategy. I also appreciate the ability of the author to conduct an in-depth discussion of the results with valuable references to the literature as well as thoughtful methodological considerations (e.g. regarding the backward masking procedure with scrambled faces, duration of SOAs or ITIs, etc.) and interesting explanatory hypotheses.

The above-mentioned advantages of the dissertation outweigh some minor uncertainties in terms of research methodology and interpretation of the results. Even if many potential methodological shortcomings of the presented studies were identified and discussed by the author, a few of them would require broader discussion. First, the behavioral results of the second study suggest that the identification task was fairly difficult and it was contaminated by stimulus selection: d`-context was moderate and criterion values were positive. Second, the ERP waveforms and topographic maps raise doubts whether the temporal and (especially) spatial features of the P1 have been correctly identified. Third, as already mentioned above, arguing for the specificity of disgust-relevant images after comparing two stimulus categories that differ in their baseline arousal seems an over-interpretation. If subjective arousal ratings have been collected from the sample, additional analyzes could probably be performed to allow for more justified interpretations. My other concerns are raised by a certain theoretical issue: In several places the author seems to claim that her results question the theory of LeDoux indicating that people are able to prioritize the processing of threatening stimuli which they are unaware. Although the author's results indeed indicate that such stimuli are not selectively processed in visual processing brain areas, there are numerous evidences for their prioritized processing at the lower (subcortical) level, which the author was unable to verify.

Summary

The responsibilities of a reviewer of a doctoral dissertation include determining whether the dissertation can be considered as an original solution of a scientific problem and whether the author of the dissertation has demonstrated sufficient theoretical knowledge within a given scientific discipline and a good ability to independently conduct scientific work. Both the theoretical and empirical part of the reviewed dissertation of Ms. Łucja Doradzińska can be evaluated very positively. Regardless of a few critical comments mentioned above, the PhD student has proven that she has the research competences expected of people applying for

PhD. Therefore, I declare that **the doctoral dissertation meets the conditions set out in Article 187 of the Act of 20 July 2018. Law on Higher Education and Science (Journal of Laws of 2023, item 742, as amended). In view of the above, I request the Scientific Council of the Nencki Institute of Experimental Biology to admit mgr Łucja Doradzińska to the further stages of the proceedings on the conferment of the doctoral degree.**

Evaluation of the dissertation "*Automaticity of attention capture and engagement: the role of semantic congruency and emotional relevance*" authored by Łucja Doradzińska (Supervisor Dr. Michał Bola, Ph.D., D.Sc.)

Evaluation by Dr. Hab. Robert van der Lubbe, Ph.D.

The dissertation of Łucja Doradzińska consists of five major parts, followed by three first-author publications in high quality journals in the field of Cognitive Neuroscience. The three publications form the basis of the major parts described in the initial five parts of the thesis. In this document, comments to various parts of the thesis are provided in separate footnotes. The most relevant comments are summarized in bullet points at the end of this document.

The first part of the thesis presents a general introduction to the topic of automaticity of attention capture. A theoretical perspective is taken according to which attention acts as a cognitive mechanism that guides the allocation of perceptual resources. The general idea (1.) is that attention biases the competition between different stimuli by increasing the activity related to relevant stimulus information and decreasing activity related to other stimuli [1].

In the thesis an important distinction is made between endogenous attention and exogenous attention, which relates to the voluntarily and involuntarily allocation of attention, the latter induced by external signals. Involuntary attention is thought to operate as soon as after ~100 ms after the onset of a stimulus. Subsequently, it is argued that the automatic allocation of attention includes two components, an attentional shift to the relevant stimulus location, and attentional engagement, which refers to the processing of a stimulus and the inability to disengage attention, following the proposal of Posner et al. (1987) [2].

---

[1] This view is not very novel, and according to my opinion might have deserved more discussion as other proposals have been forwarded that do not consider attention as having a major function in better recognition of relevant stimuli as it duplicates the function of eye movements (e.g., see Van der Heijden, 1992). Instead, several authors have argued that the main function of selection might be at the level of action rather than perception (e.g., see Cisek, 2007).

[2] The idea that attention concerns both the selection of a relevant stimulus and stimulus processing creates a bit ambiguous picture on the function of attention, which is still quite common in the current scientific literature. The PhD candidate seems to acknowledge this by mentioning that "together [they] allow for efficient processing

In the next section of the introduction (1.1), the PhD candidate argues that the use of simple stimuli to examine attentional capture, for example by using one stimulus with a deviant feature amongst other non-unique stimuli, does not provide us with "the full extent of attentional mechanisms that take part in naturalistic perception." In other words, the PhD candidate doubts the ecological relevance of these "artificial" approaches. One aspect that has been mentioned in the literature is that semantically incongruent objects should benefit from attentional prioritization. Furthermore, automatic attentional prioritization may especially concern emotionally relevant stimuli. This has been related to their crucial role for survival, but whether this attentional prioritization occurs outside of awareness is a point of discussion [3,4].

In the following section of the introduction (1.2) the relation between attention and consciousness is discussed. A part of the famous quote of James (1890) is mentioned "focalization, concentration of consciousness are of its essence " which is taken as support for the close relation between attention and consciousness, but the PhD candidate underlines that attention may very well be attracted to stimuli although observers have no conscious experience of these stimuli [5].

In the second part of the thesis (2.) the general aim is presented, which was "to investigate how and under which circumstances two constituents of perceptual saliency – namely semantic congruency and affective relevance – capture and engage exogenous attention". The first study

---

of information under different conditions." Nevertheless, it might have been a good idea to indicate that this also creates confusion on what the precise function of attention actually is, is it for selecting relevant information, or for processing relevant information, or are these different aspects that actually better would require different terms, or, maybe this points to some circularity in our reasoning on what the function of attention actually is (e.g., see Hommel et al., 2019).

[3] In this section, the PhD candidate might have reflected a bit more on the supposed dichotomy of exogenous and endogenous orienting. According to some authors, they are controlled by partly different brain regions (Corbetta & Shulman, 1998), while a study of Peelen et al. (2004) argued that their data support a brain network that is identical for both orienting mechanisms. Furthermore, some stimuli that might be considered related to endogenous orienting appear to have exogenous orienting properties (e.g., see Tipples, 2002).

[4] Some studies in the past indicated that emotional relevance is detected outside of awareness, but these studies are not mentioned (Murphy & Zajonc, 1993; Almeida et al., 2013), but they seem to have some implications that could have been discussed here.

[5] No definition of consciousness is given, which seems understandable on the one hand, but, on the other hand it might at least have been useful to mention and shortly discuss nowadays popular views on consciousness such as the ideas of Dehaene et al. (2006) and alternative views proposed by Van Gaal & Lamme (2012).

aimed to examine whether semantically incongruent objects automatically engage and hold exogenous attention [6].

The aim of the second study was to focus on attentional prioritization of threats more specifically. Facial stimuli (neutral or fearful) were presented briefly and were made invisible by using a backward masking technique. The focus was on ERPs as measures for unconscious attentional prioritization [7].

The third study focused on the influence of attention on the "putative neural mechanisms of perceptual consciousness". This was done by simultaneously exploring the difference between consciously and unconsciously perceived events and examining the influence of attentional selection [8].

In the third part of the thesis (3.), the research is described containing both additional background information and the acquired results. The first section (3.1) focuses on the study on semantic congruency and provides some additional details [9, 10].

---

[6] Semantic congruency implies that all stimulus information must be processed at a relatively high (semantic) level, and depends a lot on previous experience that may differ between participants, is that not a crucial difference with the common pop-out displays and emotional faces? Furthermore, exogenous orienting effects commonly lead to a fast disengagement in the case of peripheral exogenous cues, but here the focus is on continued engagement that may occur with emotional stimuli, is that not a bit counterintuitive? The underlying theoretical implications of a specific pattern of results are not clear.

[7] At this point of the thesis, it is unclear how ERPs might provide information on the attentional prioritization of fearful faces, given the fact that the interpretation of ERP components as markers of specific processes is a point of discussion. For example, according to some authors the visual P1 component reflects the initial perceptual processing of a visual stimulus, whereas it has also been argued that the P1 component reflects inhibition (see Klimesch et al., 2011, Van der Lubbe et al., 2016).

[8] Here, it could be relevant to point out some potential issues mentioned by Van Rullen (2011). Especially Mistake #3 seems highly relevant.

[9] Why is there the choice of presenting the target letter after the possibly incongruent displays? Will this onset not overrule any preceding attentional effects? There are quite some studies showing that exogenous orienting effects can easily overrule endogenous orienting or at least can be independent from each other, even in crossmodal settings (e.g., see Van der Lubbe & Postma, 2005). The comparison of the displayed two semantic congruent and incongruent stimuli seemed to me a bit unlucky, what if the interpretation of the oven is just a cabinet, then there is no incongruency at all. According to me, these stimuli require quite some processing up to a semantic level, thereby lowering the possibility of automatic attentional allocation and engagement.

[10] I really appreciate the fact that this study was conducted in a registered report format, this should be done more often as too regularly, null results remain unpublished.

The second section (3.2) focuses on the study of affective relevance. It was mentioned that many studies investigating attentional reactions to unconsciously perceived threat signals did not test for awareness of these stimuli. In the reported study, in one task participants had to report on the identity of the faces that were masked, while in the other study they had to perform a respond to a dot-probe [11]. EEG results are reported for an EPN [12] and the N2pc component. The N2pc related to the location of the fearful stimulus was only observed in the unmasked condition [13].

In the third section (3.3) of the third part of the thesis, the focus is on attentional modulation of neural correlates of consciousness. It is first clarified that a component that has often been related to conscious visual perception, the Visual Awareness Negativity (VAN), can only be considered as a proper neural correlate of consciousness (NCC) if it can be demonstrated that it is not reflecting other mechanisms such as selective attention. The data of the second study were reanalyzed but now the focus was on establishing whether an early and late part of the VAN are affected by 1) exogenous attention capture and engagement of the presented affective stimuli, and 2) the impact of attention related to the task relevance of the presented stimuli [14]. The early VAN appeared to be absent when stimuli are non-salient or task-irrelevant. The late VAN appeared to be present but was modulated by exogenous and endogenous orienting. Together, these findings suggested that the VAN may at least partly reflect attentional prioritization of presented stimuli.

---

[11] It is argued that participants were unconscious regarding the identity of faces in the case of backward masking. As the type of trial is blocked, this might have induced a strategy shift, participants may decide to give up after some trials, what is the candidate's opinion on this? Another aspect seems also relevant, as there might be something like perceptual learning taking place. For example, in a study of Szumka et al. (2016) it was observed that perceptual thresholds decrease over time. How might this have affected the results?

[12] This component was not defined at this stage, and I don't know what it reflects.

[13] Here, one could argue that the attentional orienting response simply got disrupted by the onset of the masks, so, the absence of an N2pc relative to the side of the threatful face does not prove that attention was attracted in the first place. Might it not have been better to use backward masks with different SOAs intermixed thereby reducing the perceptual differences between the crucial conditions (e.g., see Jaśkowski et al., 2002)?

[14] The common way to compute the VAN is to contrast trials with conscious and without conscious perception. However, here there seems to be an additional difference between these trial types as trials without conscious perception have masks while trials with conscious perception have no masks. Why is this difference not a confounding for the VAN?

In the fourth part of the thesis (4.) it is mentioned that "our findings suggest that unlike simple physical features, semantic regularities embedded in natural scenes do guide attention automatically"[15]. Later, it was concluded that "the discrepancies between previous findings and data obtained in our study can be attributed to the fact that they measured different attentional mechanisms [16]. The results of the second study confirmed several previous studies by showing that threat-related stimuli automatically capture and engage attention[17]. Importantly, these effects were not observed in the condition with masks. These findings conflict with several findings reported in the literature [18]. The results of the third study indicate that the early VAN is not necessary for awareness. It is argued that the current findings contradict recurrent processing theory (RPC).[19]

In the fifth part of the thesis (5.) a summary and overall conclusions were provided. The argument was made that more research may be needed with stimuli with higher ecological validity (study 1), threatening stimuli may attract attention automatically, but only when presented supraliminal (study 2), and there seems to be an interdependency between attention and awareness (study 3) [20].

---

[15] I do not understand this sentence, is there a mistake, I expected to read "semantic irregularities … do not engage attention". Maybe our findings refer to Furtak et al. (2020) instead of the work presented in this thesis?

[16] This is not really an explanation, if the eyes are longer directed at incongruent objects this seems a reflection of an attentional preference. Many studies observed a close relation between covert and overt orienting, are there no alternative explanations (see previous comment 9). The fact that there is an effect with disgust stimuli may just indicate that this type of stimuli implies a stronger incentive as compared to the incongruent semantic stimuli, which may not be so surprising as they simply require more advanced processing.

[17] As this concerns a discussion, I thought we might read here a bit more, now the discussion of these results is just descriptive.

[18] It seems that the PhD candidate implicitly assumes that the other observed effects are due to inefficient masking procedures. However, it may also be proposed that the current masking procedure was too effective to induce any processing. Many studies revealed that there is further processing of information that participants are not aware of, which was checked in separate tests. So, is this conclusion not a bit over-hasty?

[19] A rejection of RCP seems indeed very relevant. I expected to read subsequently more about other theoretical possibilities. Maybe we must conclude that we still don't know what consciousness is? In this respect, it might be relevant to focus on alternatives, like Information Integration theory (Tononi, 2012), fame in the brain (Dennett, 1991), etc.

[20] Here, and in the previous part I thought some potential next steps might have been proposed, what questions remain to be addressed given the current results? What are the theoretical implications?

The first published article deals with study 1, as mentioned above. Many participants were measured, and together with the simulation results, it can be concluded that the sample-size was well chosen. The discussion of the results seems very thorough [21]. The second published article deals with study 2. The EPN is now shortly described, and the sample size seems appropriate. The results are thoroughly discussed. It is now mentioned that the backward masking procedure with the scrambled faces may have been too conservative. Nevertheless, the authors conclude that this challenges one of the key predictions of the low-road hypothesis [22, 23]. The third article, which has been accepted for publication, involves the same participants as in study 2. In the abstract, it is indicated that there was a single-trial ERP analysis [24]. In the discussion, it is indicated that there were two methodological limitations. It was acknowledged that awareness is not the only difference between the masked and unmasked conditions. The argument why it is unlikely that observed effects are due to a confounding is mainly based on the observed polarity changes [25].

---

[21] Nevertheless, I still miss more discussion on the processing requirements to enable to establish semantic incongruence (see previous point 6).

[22] According to my opinion, this conclusion is a bit premature, what about all the other findings that support this hypothesis? A single study does not seem enough, and here, as the authors suggested themselves, the masking procedure may have been to conservative, or too strong. It is not a surprise that with short presentation and strong masking no effects remain, as there was simply insufficient sensory activation. Can this explanation be excluded?

[23] At several points, the authors equate unconscious with masked and conscious wit unmasked, I think this is not appropriate, an experimental manipulation cannot be equated with a perceptual experience…

[24] This mention is rather confusing, indeed single trial ERP analyses have been performed, for example, by using Woody filtering searching for P3 components in single trial data, but here, I don't see anything like this. What do the authors intend to say with single-trail ERP analysis?

[25] I do not find this argument fully convincing. There are quite some indications that overlapping ERPs to stimuli are not just additive effects, but likely interactions. The interaction with emotional expression, however, seems not easy to be explained by this aspect, nevertheless, it implies that the VAN is not the typical VAN. Could the authors suggest an alternative approach based on the current data?

In this section, I will summarize my main questions for the PhD candidate.

- The theoretical perspective chosen is not novel, already in the 1990's several authors argued that "selection" is for action, and not perception, can you think of consequences when following this alternative theoretical perspective?
- What do you consider to be the function of "consciousness"?
- What are necessary processing elements required to enable semantic (in)congruency, and what may be the implications?
- Do exogenous orienting effects not often overrule earlier effects? If so, what does that mean for the results of study 1?
- What are disadvantages of a blocked masking procedure, and why was SOA not manipulated instead of using a masked and unmasked block?
- Masking ≠ unconscious processing, mostly, and for good reasons other approaches are used to determine the VAN, why this choice?
- Was masking not too effective to demonstrate relevant effects with fearful stimuli?
- What view on consciousness does the candidate prefer after rejecting RCP and why?
- Covert and overt orienting are considered as different, but are there no alternative ways to look at the observed data?
- Was the VAN really a VAN?

According to my opinion, the thesis of the PhD candidate demonstrates the candidate's general theoretical knowledge in the discipline of Cognitive Neuroscience and clearly shows the ability to conduct research independently. Furthermore, the subject matter of the doctoral dissertation is an original approach to different scientific problems: (1) what attracts and engages our attention automatically, (2) is unconscious processing of fearful stimuli automatic, and (3) is the VAN a proper index for visual awareness?

My evaluation of this dissertation is very positive, and I recommend that the PhD candidate be admitted to the subsequent stage of doctoral defense. I also think that the thesis quality is beyond the standard and deserves to be distinguished for the following reasons: high quality of experimental design, analytical procedures, statistical procedures, theoretical aspects that are especially discussed in the published papers, and the fact that they concern three first-author publications in high-quality scientific journals. Furthermore, the candidate was also (co-)author

of five additional publications in high-quality scientific journals although this is not part of the current thesis.

Yours sincerely,
Rob van der Lubbe

Prof. UAM dr hab.
Laboratory of Vision Science and Optometry
Faculty of Physics
Adam Mickiewicz University, Poznań, Poland

Associate Professor
Cognition, Data, and Education
Faculty of Behavior, Management, and Social Sciences
University of Twente, Enschede, The Netherlands