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Using temporal order judgments to investigate attention bias toward pain and threat-related information. Methodological and theoretical issues

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ABSTRACT

Recently, Vanden Bulcke, Crombez, Durnez, and Van Damme (2015) investigated whether the attentional prioritization of a specific location due to the anticipation of pain is modality specific or multisensory. They used a temporal order judgment task in which participants judged the order of either two tactile or two visual stimuli, one presented on each hand. Additionally, participants either expected the occurrence of a painful stimulus on one hand or the absence of any pain. Results showed that participants' judgments were biased to the advantage of the stimuli, tactile or visual, presented at the location where pain was expected. The authors concluded that the anticipation of pain leads to a multisensory prioritization of information presented at the threatened spatial location. Here, we would like to question their conclusion in terms of a genuine attentional modulation of multisensory nature, based on methodological and theoretical grounds.

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Pain has an adaptive value. Therefore characterizing how a nociceptive/painful stimulus directs attention toward its location and prioritizes the processing of stimuli occurring in that location is of central interest in pain research (Legrain & Torta, 2015; Van Damme, Legrain, Vogt, & Crombez, 2010). In order to adapt behavior to physical threats, it is crucial to coordinate the mapping systems that allow perceiving the location of somatosensory stimuli on the body and those that allow perceiving the location of these threatening objects in external space. Special interest has therefore been given to study the abilities to remap nociceptive inputs from anatomical to spatial reference frames (Legrain & Torta, 2015). Temporal order judgment tasks (TOJ) are one of the most effective and commonly used experimental approaches to investigate this topic (e.g. Moseley, Gallace, & Spence, 2009; De Paepe, Crombez, & Legrain, 2015; De Paepe, Crombez, Spence, & Legrain, 2014; Sambo et al., 2013). In TOJ tasks, pairs of stimuli separated by various and randomly introduced time intervals are presented. Participants have to judge which of the two stimuli is perceived as presented first. This paradigm allows characterizing biases indexed by a shift of the judgment to the advantage of one of the two stimuli (Spence & Parise, 2010). Using the TOJ paradigm, perceptual biases triggered by pain-related information were recently investigated by a study of Vanden Bulcke, Crombez, Durnez, and Van Damme (2015). In that study, participants were asked to judge the temporal order of two consecutive tactile stimuli applied to either hand, or of two visual stimuli presented in the space close to either hand. Each trial was preceded by one out of two signals. One signal warned the participants that the forthcoming pair of tactile or visual stimuli could be

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occasionally (10%) replaced by a painful electrical shock on one hand (*threat condition*). The other signal informed them that the pair would not be replaced by any painful stimulus (*control condition*). In other words, before each trial (i.e., 1.5 s before the stimulation pair), participants knew whether a painful stimulus could eventually occur or would certainly not occur. Results showed that participants judged more often as occurring first the stimuli, tactile or visual, presented at the location where the painful shock could be delivered. Importantly, this was only the case when the potential occurrence of the threat was actually cued (threat condition) and not in the control condition. On the basis of these findings, the authors concluded that *the anticipation of pain results in multisensory prioritization of information at the threatened body location*, meaning that participants biased positively the perception of stimuli, whatever their sensory modality, to the side of space where pain was expected.

Although these results might be of potential interest, at the current stage, we feel that some methodological issues dampen the interpretation of the findings, making them not compelling enough to fully support the authors' conclusion. Indeed, we believe that despite the fact that Vanden Bulcke et al. (2015) interpreted their results in terms of an attentional modulation at the perceptual level, it is possible that the effects are explained by response and/or decisional biases, and that such a potential decisional bias might have been influenced by the experimenters' instruction.

Attentional effects on TOJ are based on prior-entry theories that propose that attended stimuli are perceived earlier than unattended ones (see Spence & Parise, 2010 for a review). Typically, in prior-entry related TOJ tasks, the point of subjective simultaneity (PSS) is measured, which corresponds to the amount of time by which one stimulus has to precede or follow the other in order to be perceived as occurring simultaneously. One of the key issues of TOJ tasks is to characterize how the PSS is influenced by changes in perceptual processing of the stimuli following an attentional modulation, and to minimize the contribution of response and decisional-level biases. Indeed, the PSS is, of course, often found around the smallest time delays between the two competing stimuli of the pair, that is, the time delays for which the participants are susceptible to be most uncertain about which of the two stimuli is actually presented first. In versions of the task that are particularly devoted to study spatial perception abilities, it is therefore possible that participants, when unsure about the exact temporal order, decide to report the location they guess to be the most task-relevant, i.e., the side of space they were instructed to attend, even though the stimulus presented in this location was actually not perceived as occurring first (the response bias account, as discussed in e.g. Frey, 1990; Jaskowski, 1993; Scharlau, 2004; Shore, Spence, & Klein, 2001). This potentially confounding effect of a decisional bias can be minimized by using a response organization that is orthogonal to the spatial dimension of the stimuli, as well as by using blocks of stimulation during which participants have to judge which of the two stimuli is perceived second, instead of first (e.g. Scharlau, 2004; Shore et al., 2001; Spence, Shore, & Klein, 2001; Yates & Nicholls, 2009). Under such control conditions, an attentional effect can be evidenced in case of reversed judgments in the '*which is second*' conditions relative to the '*which is first*' conditions. On the contrary, in the case of a decisional bias, participants would report more likely the same stimulus, irrespective of the fact that they have to respond to the questions '*which is first?*' or '*which is second?*'. These potential confounds can be also minimized by using a simultaneity judgment rather than an order judgment (e.g. Zampini, Shore, & Spence, 2005), or by combining both tasks (e.g. Zampini et al., 2007; but see Spence & Parise, 2010, and Weiβ & Scharlau, 2011 for a discussion). Another interesting possibility could be the use of TOJ models that explicitly consider response biases by including decisional parameters, with the aim to distinguish directly attentional effects from response and/or decisional ones (e.g. García-Pérez & Alcalá-Quintana, 2012a, 2012b). However, none of these strategies were used in the present study (nor in previous works of the authors, Vanden Bulcke, Crombez, Spence, & Van Damme, 2014; Vanden Bulcke, Van Damme, Durnez, & Crombez, 2013).

Considering this potential decisional bias, the results of the study could be accounted for by the fact that participants reported more often the side of space they had been instructed to attend, that is, the side of the *threat*, instead of a genuine bias of temporality perception. Indeed, participants were told before the beginning of each block which of the two hands could receive the painful shock. In other words, before each block, they knew in which location could appear the painful stimulus, and that this location wouldn't change during the entire block. Before each trial they were warned whether the painful stimulus could be actually applied. It is therefore possible that participants' judgments were shifted toward that location because, in situations of uncertainty about the actual temporal order, participants might have simply reported the stimulus occurring at the location they guessed to be the most relevant, that is, the side of the *threat*. For this reason, we believe that a decisional bias might have been introduced by the fact that participants were explicitly instructed to attend one side of space and to expect the potential occurrence of a painful stimulus on that side. In the absence of any of the control conditions detailed in the previous paragraph, it appears therefore difficult to disentangle whether the anticipation of pain at one side of space modified the perceptual processing of any stimuli occurring at that same location, or whether participants simply resolved temporal uncertainty by choosing the side of space they expected to be the most task-relevant, i.e., the side of space where the threatening stimulus was likely to appear. Unfortunately, this confounding effect could also be present in previous studies by the authors (Vanden Bulcke et al., 2014), in which, based on the results from a similar paradigm, they suggested that the prioritization of somatosensory inputs could not be *limited to the exact location where pain was anticipated*, *but rather generalized to any somatosensory stimuli presented on the same side of the body*. This potential confound is not specific to these particular studies, but could be applied to many earlier TOJ studies, where participants' attention is manipulated along the same spatial dimension that they use to respond.

As a consequence, the methodological issues raised here provide caveats to the interpretation of Vanden Bulcke et al.'s data in terms of *multisensory prioritization of sensory stimuli induced by the anticipation of pain*. In addition, we would like

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