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**Probing the neural representations of body-related stimuli: a reply to Tame &  
Longo's commentary**

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The processing of body-related stimuli (e.g., images of bodies) elicits activations in visual and sensorimotor brain regions (Molenberghs et al., 2012; Hardwick et al., 2018). This activity can be observed over the scalp as a mixture of event-related potentials (ERPs), yet, such a mix obstructs the discrete inspection of the underlying neuronal generators. Accordingly, in Galvez-Pol et al., (2020a), we described a method that dissociates these scalp-recorded neural signals. In their constructive and well-thought commentary, Tame and Longo (2020) highlight three aspects of this work that need to be clarified: i) whether there is a natural border between body and non-body related stimuli; ii) whether neural signals from diverse neuronal sources can be discerned by our method; and iii) whether such a method can be used with other types of stimuli.

### **1. Body or non-body-related stimuli, that is the question**

Tame and Longo (2020) raise the question of what visually perceived stimuli can be considered as ‘body-related’. We agree with them in acknowledging that given the role of our bodies in everyday activities, nearly anything can be seen as body-related. Specifically, we stress that these stimuli likely possess one or more of the following attributes: they are graspable, manipulable, and/or it is possible to reproduce an aspect of their form (e.g., outline, motion) by using one’s body (see e.g., Schubotz, 2007; de Wit et al., 2017; Romano et al., 2019). In these cases, our bodies likely mediate how we relate to the stimuli in the environment. Through statistical regularities, we learn about these stimuli and just their perception might activate our body representation in the brain (Niedenthal, 2007; Rizzolatti and Sinigaglia, 2010; De Vignemont, 2011; Galvez-Pol et al., 2020b). In a sense, our idea of body-related stimulus resembles the classical concept of affordance coined by (Gibson, 1979) as perceivable action possibilities with the environment..

As Tame and Longo (2020) suggest, all stimuli, including the examples described above, fall onto a point on a continuum that ranges from null to full body-relatedness. Yet, this

point largely depends on the person's experience (e.g., Calvo-Merino et al., 2006; Vannuscorps and Caramazza, 2016). The research question should determine what body/non-body stimulus categories are contrasted. For instance, we compared neural responses to stimuli that are as distant as possible on the continuum of body-relatedness while controlling perceptual parameters Galvez-Pol et al., 2018, Galvez-Pol et al., 2020. Specifically, we used images of hands in different positions and with no symbolism and polygonal shapes based on matching the hands in outline, colour, and size. Also, we ensured that these stimuli were equally matched in discriminability. Further studies could employ types of stimuli that land at different points within the body-related category (e.g., comparing images of hands vs. tools), and contribute to a better understanding of the properties and boundaries of the body-related continuum.

## **2. On the dissociation of sensorimotor and visual coexisting activity**

The method described in Galvez-Pol et al., (2020) dissociates ERPs, due to the processing of body-related images, by subtracting trials with visual evoked potentials from trials containing a mixture of visual and sensorimotor evoked potentials; as expressed in the equation:  $[(VEP \& SEP) - VEP = SEP \text{ only}]$ . Tame and Longo (2020) raise a stimulating point: this subtraction might hold if unimodal visual and sensorimotor activities are independent and with no shared activity. We recognise that some common activity might be shared when stimulating individual sensory modalities (e.g., Gondan and Röder, 2006; Mouraux and Iannetti, 2009). In our case, if we assume common activity "c" in every unimodal stimulation [i.e.  $(VEP_c \& SEP_c) - VEP_c = SEP_c$ ] subtracting of visual ( $VEP_c$ ) from visual and somatosensory evoked potentials ( $VEP_c \& SEP_c$ ) would get rid of the double up common activity in visual and somatosensory evoked potential trials leaving us with SEPs including common activity. Yet, it is important to highlight that the 'SEP only' on the right-hand side of the equation should not be conceptualised as a regular unimodal SEP. Modulations of activity in such evoked potentials

are not due to changes in task-irrelevant tactile or motor stimulations but to controlled variations in visually perceived stimuli (e.g., task-relevant images of bodies vs. not bodies).

Finally, the authors suggest that one of the embodiment effects found in our work could be a by-product of prominent common activity in the time range of ~200-300ms after stimulus onset. Here, it is essential to note that we also found effects in earlier and later ERP components (Supp. materials Galvez-Pol et al., 2020a). These modulations should not be expected if they were merely an overall by-product.

### **3. On the fundamentals of dissociating sensory-evoked activity**

In their third strand, Tame and Longo (2020) indicate that the method in Galvez-Pol et al., (2020a) could be applied to other stimuli and sensory domains. Despite that this work is based on research examining the processing of visually perceived body-related stimuli, many of the underlying notions could be applied in akin studies. For this to happen, it is important to consider that most stimuli can elicit bodily associations and sensorimotor activity regardless of the sense used to acquire the information (e.g., perceiving actions through vision or hearing; Kohler et al., 2002). Given such supramodal processing, bodily stimuli are closely related to symbolic associations/semantic categories. Considering these matters, it is easy to conceive a study that includes auditory-evoked potentials elicited by the sound of bodily actions (e.g., sounds of clapping or tap dance are likely associated to the hands and feet, respectively). Importantly, regardless of the nature of the stimuli, sensorimotor activity needs to be revealed through task-irrelevant stimulation. This stimulation is understood as the ‘ping’ of a sonar, where through echoed activity, the impulse reveals changes in sensorimotor cortices due to the sensory processing of the task-relevant stimuli (Sel et al., 2014; Galvez-Pol et al., 2018a, 2018b; Arslanova et al., 2019).

### **Author contributions**

A.G-P: Conceptualization, Investigation, Methodology, Writing original draft, Writing - review & editing. B.C-M and B.F: Conceptualization, Investigation, Methodology, Writing - review & editing.

### **Declaration of competing interest**

The authors declare no competing interests.

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