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Like the back of my hand:

Visual ERPs reveal a specific change detection mechanism for the bodily self

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1 ABSTRACT

2

3 The ability to identify our own body is considered a pivotal marker of self-awareness. Previous
4 research demonstrated that subjects are more efficient in the recognition of images representing
5 self rather than others' body effectors (*self-advantage*). Here, we verified whether, at an
6 electrophysiological level, bodily-self recognition modulates change detection responses. In a
7 first EEG experiment (discovery sample), event-related potentials (ERPs) were elicited by a
8 pair of sequentially presented visual stimuli (vS1; vS2), representing either the self-hand or
9 other people's hands. In a second EEG experiment (replicating sample), together with the
10 previously described visual stimuli, also a familiar hand was presented. Participants were asked
11 to decide whether vS2 was identical or different from vS1. Accuracy and response times were
12 collected. In both experiments, results confirmed the presence of the *self-advantage*:
13 participants responded faster and more accurately when the self-hand was presented. ERP
14 results paralleled behavioral findings. Anytime the self-hand was presented, we observed
15 significant change detection responses, with a larger N270 component for vS2 different rather
16 than identical to vS1. Conversely, when the self-hand was not included, and even in response
17 to the familiar hand in Experiment 2, we did not find any significant modulation of the change
18 detection responses. Overall our findings, showing behavioral self-advantage and the selective
19 modulation of N270 for the self-hand, support the existence of a specific mechanism devoted
20 to bodily-self recognition, likely relying on the multimodal (visual and sensorimotor)
21 dimension of the bodily-self representation. We propose that such a multimodal self-
22 representation may activate the salience network, boosting change detection effects specifically
23 for the self-hand.

24

25 Keywords: Bodily-self recognition; self-advantage; change detection; EEG; N270

26

1 **1. Introduction**

2 The ability to recognize the own body visually (for example from a picture or when it is
3 reflected in the mirror) has traditionally been considered as a pivotal marker of self-awareness
4 (for a recent review see e.g. Apps & Tsakiris, 2014). However, while we usually distinguish
5 other people's body by vision only, for bodily-self recognition we can rely on information
6 coming from different sensory modalities (Tsakiris, 2010). To identify own body effectors, we
7 usually resort to a wide network of sensorimotor (e.g. proprioceptive, somatosensory and
8 motor) inputs, rather than to visual features *per se* (Ehrsson, Holmes, & Passingham, 2005;
9 Frassinetti, Ferri, Maini, Benassi, & Gallese, 2011). Nonetheless, in a series of previous studies
10 employing visual-matching tasks, Frassinetti and colleagues demonstrated that subjects are
11 faster and more accurate in discriminating grey-scale pictures representing bodily-self effectors
12 as compared to others' body effectors (the so-called *self-advantage*) (Frassinetti et al., 2011;
13 Frassinetti et al., 2008; Frassinetti et al., 2009). The presence of such facilitation in participants'
14 performance has been associated with the recourse to a sensorimotor network recruited when
15 subjects had to recognize the bodily-self in "implicit" tasks (see e.g. Frassinetti et al. 2009;
16 Conson, Volpicella, De Bellis, Orefice, & Trojano, 2017; in other words, the self-recognition
17 is task-irrelevant, i.e. not explicitly required in task instructions). More specifically, the self-
18 advantage was associated with the activation of a visual-sensorimotor network including,
19 besides occipital areas, bilateral premotor cortex and right temporal cortex encompassing the
20 extrastriate body area (Ferri, Frassinetti, Ardizzi, Costantini, & Gallese, 2012). However, even
21 though the study by Ferri and colleagues revealed a direct involvement of the somatosensory
22 cortices in self-hand recognition, since a motor task (i.e., hand-rotation) was performed, it
23 cannot be excluded that the (motor) nature of the task might have contributed to the observed
24 sensorimotor activation.

1 The idea that bodily-self recognition implies the interaction between visual and sensorimotor
2 areas has been confirmed also by different lines of research that does not employ motor tasks,
3 such as those studies investigating the neural correlates of a famous illusion of body ownership
4 (i.e. the rubber hand illusion; see e.g., Botvinick & Cohen, 1998; Buccioni et al., 2016; Burin
5 et al., 2017; Della Gatta et al., 2016; Fossataro, Bruno, Giurgola, Bolognini, & Garbarini,
6 2018). During this illusion, participants, while watching a human-like rubber hand being
7 touched synchronously with their own hand hidden from view, experience the feeling that the
8 fake hand has become part of their own body. It has been demonstrated that, during this
9 procedure, the functional connectivity between visual areas (e.g. lateral occipitotemporal
10 cortex and extrastriate body area; EBA) and ventral premotor cortex is specifically modulated
11 during the embodiment (i.e. when the fake hand is attributed to themselves) (Limanowski &
12 Blankenburg, 2015; Zeller, Friston, & Classen, 2016), consistently with the fact that the illusion
13 reduces the perceived objective (visual) dissimilarities between the own and the rubber hand
14 (Longo, Schuur, Kammers, Tsakiris, & Haggard, 2009). Moreover, lesion studies of brain
15 damaged patients exhibiting an impairment of self-other hands discrimination support the
16 involvement of a visual-sensorimotor network in self-recognition. Indeed, the core lesion
17 underpinning this deficit has been identified in the subcortical white matter connecting
18 temporal areas, involved in the visual recognition of the body (i.e., the extrastriate body area,
19 EBA), with anterior multisensory areas, such as the premotor cortex (Pia et al., 2020).

20 Furthermore, the recruitment of multimodal networks (including sensorimotor areas) in self-
21 recognition is not only observed for limb discrimination, but it has been described for faces as
22 well, without the involvement of a motor task (Cardini et al., 2011; Morita et al., 2018; Sugiura,
23 2015). For example, Cardini and colleagues found that ventral premotor cortex activity differed
24 when viewing self-face as compared to another's face, thus revealing a crucial role of
25 sensorimotor areas in self-other face discrimination. Accordingly, the processing of the self-
26 face has been associated to a specific sensorimotor pattern of activations, involving sensory

1 (i.e., visual, somatosensory and interoceptive areas) and motor association cortices (i.e.,
2 premotor cortex and supplementary motor area – see Sugiura et al., 2015 for a review). Overall
3 these findings suggest the presence of different mechanisms for self- *versus* other people’s
4 body recognition (De Bellis, Trojano, Errico, Grossi, & Conson, 2017; Ferri, Frassinetti,
5 Costantini, & Gallese, 2011; Hu et al., 2016; Myers & Sowden, 2008), thus highlighting the
6 specificity of self-recognition.

7 In the present study, we investigated whether implicit (task-irrelevant), bodily-self recognition
8 has an observable electrophysiological correlate. To this aim, we exploited the repetition
9 suppression phenomenon and we asked whether it could be modulated by implicit, bodily-self
10 recognition. As widely described in the literature, event-related potential (ERP) amplitudes are
11 strongly reduced when the same stimulus is repeated at short and constant time intervals
12 (Iannetti, Hughes, Lee, & Mouraux, 2008; A. L. Wang, Mouraux, Liang, & Iannetti, 2010).
13 Amplitude modulations induced by repetition have also been observed for abstract visual
14 stimuli, such as different shapes (Y. Wang, Cui, Wang, Tian, & Zhang, 2004), and body-related
15 pictures, mainly human faces (for a recent review see Schweinberger & Neumann, 2016).
16 Importantly, the detection of a *change* within stimulus sequence is able to revert such amplitude
17 reduction due to repetition. In other words, the sudden change of one or more stimulus basic
18 features (e.g. modality, intensity, shape, or color) usually enhances the amplitude of the evoked
19 responses (Valentini, Torta, Mouraux, & Iannetti, 2011; Y. Wang et al., 2004). However, this
20 is not always the case. Through a paradigm exploiting intensity modulations of repeated painful
21 stimuli, it has been shown that intensity increases but not decreases could revert repetition-
22 related amplitude reduction (Ronga, Valentini, Mouraux, & Iannetti, 2013). The authors
23 interpreted their findings suggesting that only *salient* changes were able to induce change
24 detection-related responses.

25 Based on the above evidence, changes involving the self-hand should be considered salient by
26 the nervous system. Previous studies highlighted the specificity of self-hand recognition, which

1 seems to rely on a peculiar sensorimotor mechanism. In other words, the difference between
2 the self- *versus* other people's hand recognition, by resorting to distinct neural mechanisms,
3 may represent a *kind* rather than a *degree* property. It seems therefore likely that stimulus
4 changes involving the self-hand may elicit salience effect (i.e. the reversion of repetition
5 suppression), which are similarly described as *kind* phenomena. Indeed, as demonstrated by
6 previous studies (Ronga et al., 2013; Torta, Liang, Valentini, Mouraux, & Iannetti, 2012), the
7 change detection effects induced by salient stimuli are expressed in an *all or nothing* fashion
8 (i.e., the reversion of repetition suppression is not gradable but either present or absent).
9 Analogously, since the self-hand could be more salient than the other's hands, we should expect
10 that only the visual presentation of the self-hand may induce change detection-related
11 responses. Conversely, changes between other people's hands, and even between familiar and
12 not familiar hands, may not be salient enough to revert repetition suppression phenomena.
13 In our EEG paradigms, ERPs were recorded while participants were presented with grey-scale
14 images depicting the right hands. Hand pictures were delivered in pairs (vS1 and vS2), at a
15 constant 1-second interval, and might represent either the participant's self-hand or other
16 people's hands. *Experiment 1* was directed to explore whether the presentation of the self-hand
17 boosts the change detection mechanism, reversing the repetition suppression phenomenon. It
18 was divided into two different conditions (*scenarios*): in the *With Self* scenario, the self-hand
19 was included within the presented visual stimuli; in the *Without Self* scenario, the self-hand
20 was never presented (see 2.1.2 for a rationale description). Subjects were asked to judge
21 whether vS2 was identical or different from vS1 (*implicit recognition task*). ERPs to visual
22 stimuli, as well as accuracy and response times (RTs) were collected. *Experiment 2* specifically
23 aimed at replicating results of Experiment 1 also controlling for any familiarity bias in our
24 behavioral and EEG results. In the design of Experiment 1, the self-hand is the only hand
25 participants had some familiarity with. Therefore, in case we found any specific change
26 detection response for the self-hand, we could not disentangle whether this result was driven

1 by a mechanism specific for the body-self or by a general familiarity effect. To control for this
2 aspect, in Experiment 2 we included a third scenario, namely the *With Familiar* scenario, where
3 one of the two others' hands was familiar to the participants, by means of repeated presentation
4 of such a hand in the immediately preceding scenario.

5 From a behavioral point of view, both in Experiments 1 and 2, we expected to confirm the
6 presence of the self-advantage, i.e. higher accuracy and faster RTs any time when at least one
7 self-hand was included in the pair of visual stimuli. From an electrophysiological point of view,
8 if bodily-self recognition actually represents a unique and salient phenomenon, recruiting
9 dedicated mechanisms and neural networks, then in both experiments we should observe a
10 significant change detection effect (i.e. greater amplitude difference between responses to
11 repeated *versus* non-repeated stimuli) only for images representing the self-hand. Crucially, in
12 Experiment 2 we should observe a clear difference in the change detection responses between
13 the With Self scenario and the With Familiar scenario, with significant change detection effect
14 for the self-hand. We expect that this effect might specifically be observed on the N270
15 modulation, a component which has been systematically related to visual change detection
16 (Bennett, Duke, & Fuggetta, 2014; Scannella et al., 2016; P. Wang et al., 2018; Zhang et al.,
17 2008).

18 Alternative results, showing a similar change detection effect for self- and other people's
19 hands, would instead challenge the idea of the presence of a specific mechanism for bodily-
20 self recognition.

21

22 **2. Materials and Methods**

23

24

25 **2.1 Experiment 1 (discovery sample)**

26

27 **2.1.1 Participants**

28

1 Fifteen healthy right-handed subjects participated in the study (5 women) aged 22-26 years
2 (mean±SD: 24.1 ±1.2; years of education: 17.9 ±1.0).

3 Sample size (N=15) was a priori determined to match the number of subjects involved in
4 previous research investigating visual mismatch detection effects and exploiting the same EEG
5 analyses employed in the present study (Wang et al. 2003, N=13; Wang et al. 2004, N=15;
6 Bennet et al. 2014, N=16).

7

8 All participants gave their written informed consent to participate in the study, which
9 conformed to the standards required by the Declaration of Helsinki and was approved by the
10 Ethics Committee of the University of Torino (prot. n. 125055, 12/07/16).

11

12 **2.1.2. Stimuli and Experimental Design**

13 Visual stimuli consisted of grey-scale pictures (10x15 cm) of the dorsum of open right hands
14 belonging either to the participants or to other people. Hand pictures were taken before the
15 experiment, all in the same room, with controlled illumination conditions and were post-
16 processed. As a first step, picture background was removed and replaced with a black uniform
17 background, original color pictures were then converted in grey-scale images with the aim of
18 standardizing different skin colors. Finally, hand images were resized in order to have all
19 similar dimensions. The resulting visual stimuli were presented for 0.3s at the center of a 21-
20 inch *Sony* CRT computer screen.

21

22 The experimental paradigm (presented in Fig. 1) partially replicated the methodology proposed
23 by Frassinetti et al. (2009). However, stimulus presentation parameters (e.g. presentation mode,
24 duration, interstimulus-interval, intertrial-interval) were modified in order to realize a paradigm
25 suitable for EEG. The experiment consisted of a single session divided into two different
26 scenarios (i.e. *With Self* and *Without Self*) and four 8-minute recording blocks (2 per scenario).

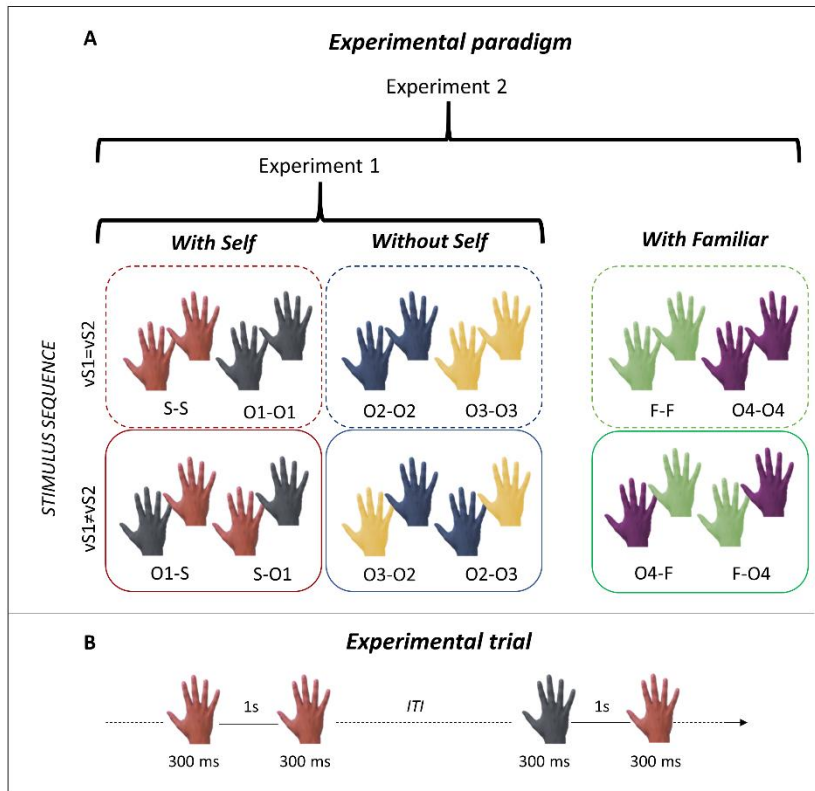
1 Each scenario was composed of 104 pairs of visual stimuli (vS1 and vS2), delivered at a
2 constant 1 s inter-stimulus interval. The time interval between each pair was randomly jittered
3 between 6 and 8 s, in a way that participants could not anticipate stimulus occurrence.

4 In both scenarios, vS1 and vS2 could be either identical or different. In the *With Self* scenario,
5 visual stimuli included participants' self-hand. Four different types of pairs were presented:
6 *Self-Self* (with both vS1 and vS2 depicting the self-hand); *Other1-Other1* (with vS1 and vS2
7 depicting the same hand belonging to a stranger – *Other1*); *Self-Other1* (with vS1 representing
8 the self-hand and vS2 *Other1*'s hand); *Other1-Self* (with vS1 representing *Other1*'s hand and
9 vS2 the self-hand).

10 In the *Without Self* scenario, the self-hand was never presented. Four different types of pairs
11 were delivered: *Other2-Other2* (with vS1 and vS2 depicting the same hand belonging to a
12 stranger – *Other2*, different from *Other1*); *Other3-Other3* (with both vS1 and vS2 depicting
13 the same hand belonging to a stranger – *Other3*, different from *Other1* and *Other2*); *Other2-*
14 *Other3* (with vS1 representing *Other2*'s hand and vS2 *Other3*'s hand); *Other3-Other2* (with
15 vS1 representing *Other3*'s hand and vS2 *Other2*'s hand). Importantly, in both scenarios the
16 others' hands were matched for the gender of participants.

17 The occurrence of each type of pair (probability of occurrence=0.25) was balanced and pseudo-
18 randomized within each block so that the maximum number of consecutive pairs of the same
19 type was two. Scenarios' presentation order was counterbalanced across subjects (i.e. With
20 Self=A; Without Self=B; one half of the subjects follows the sequence ABBA and the other
21 half BAAB).

22 With the present paradigm, it was possible to compare behavioral and electrophysiological
23 responses to pairs of identical or different visual stimuli, either when the self-hand was present
24 (*With Self* scenario) or not (*Without Self* scenario). Crucially, we decided not to intermix all
25 stimulus types (Self, *Other1*, *Other2*, *Other3*) in a single scenario to avoid making self-hand
26 stimuli rare as compared to the other stimuli, always representing strangers' hands.



1

2

3 **Figure 1 A. Experimental paradigm.** Experiment 1 was divided into two different scenarios:

4 *With Self* (where the self-hand was included), and *Without Self* (where the self-hand was never

5 presented). Experiment 2 was divided into three different scenarios: *With Self*, *Without Self*,

6 and *With Familiar* (where the familiarized hand was presented). **B. Experimental trial.** In

7 both experiments, visual stimuli (vS1 and vS2) were displayed for 300 ms and were delivered

8 at a constant 1 s inter-stimulus interval.

9

10 2.1.3 Behavioral task and EEG recording

11 During the experiment, participants were seated in a comfortable chair in a silent, dimly lit

12 room, with their chest at a distance of 55 cm from the computer screen. They were asked to

13 focus on the stimuli and look at a fixation cross, placed at the center of the screen. Subjects'

14 task was to decide whether vS2 was identical or different from vS1 by pressing, as fast as

1 possible with the right index finger, the “s” key for identical pairs and the “d” key for different
2 ones on the keyboard. Accuracy and RTs were recorded by Eprime V2.0 software (Psychology
3 Software Tools Inc., Pittsburgh, PA, USA).

4

5 The EEG was recorded using 32 Ag-AgCl electrodes placed on the scalp according to the
6 International 10-20 system and referenced to the nose. Electrode impedances were kept below
7 5 k Ω . The electro-oculogram (EOG) was recorded from two surface electrodes, one placed
8 over the right lower eyelid and the other placed lateral to the outer canthus of the right eye.
9 Signals were amplified and digitized at a sampling rate of 1,024 Hz (*HandyEEG – SystemPlus*
10 *Evolution*, Micromed, Treviso, Italy).

11

12 **2.1.4 Data Analysis**

13 *Behavioral data.* Subjects’ correct responses (i.e. *accuracy*) and *RTs* for each pair type were
14 collected and averaged. Importantly, trials with individual RTs exceeding two standard
15 deviations below or above the mean (of each specific experimental condition) as well as trials
16 with missing or wrong response were discarded from RT analysis (Conson et al., 2015; Ronga
17 et al., 2018; Sarasso et al., 2019). The average number of discarded responses per participant
18 was around 5%. In order to explore the presence of the *self-advantage* effect in our matching
19 task, we performed, on both accuracy and RTs as dependent variables, separate 2*4 repeated-
20 measures ANOVAs with two within-subject factors: “Scenario” (two levels: *With Self*
21 *scenario*; *Without Self* scenario) and “Condition” (four levels: the two pairs of identical and the
22 two pairs of different stimuli in each scenario). The normal distribution of residuals was
23 checked by using Shapiro-Wilk’s test (p always > 0.05). To explore significant interactions, ad
24 hoc planned comparisons were performed and corrected with Bonferroni’s test. Statistical
25 analyses were performed using Statistica Software (StatSoft, release 8 RRID:SCR_014213).

26

1 Electrophysiological data. ERPs triggered by vS1 and vS2 were pre-processed and analyzed
2 using Letswave v.6 (www.letswave.org) (Mouraux & Iannetti, 2008). Continuous EEG data
3 were segmented into epochs using a time window ranging from 0.5 s before vS1 to 1 s after
4 vS2 (total epoch duration: 3.1 s), and band-pass filtered (1-30 Hz) using a fast Fourier transform
5 filter. Each epoch was baseline corrected using the interval from -0.5 to 0 s as reference. Filter
6 and baseline correction were chosen according to previous studies investigating repetition
7 suppression/change detection paradigms (Galigani et al., under review; Ronga et al., 2013;
8 Torta et al., 2012; Y. Wang et al., 2004; Y. Wang et al., 2003). Artifacts due to eye blinks or
9 eye movements were subtracted using a validated method based on an Independent Component
10 Analysis (ICA – Jung et al. 2000). Finally, epochs belonging to the same pair kind (i.e. 26
11 epochs) were averaged time-locked to the onset of vS1. Thus, for each subject, eight average
12 waveforms (Self-Self; Other1-Other1; Self-Other1; Other1-Self; Other2-Other2; Other3-
13 Other3; Other2-Other3; Other3-Other2) were obtained.

14
15 Statistical analyses on ERPs. The analysis of electrophysiological data was performed on the
16 second stimulus, focusing on the amplitude modulation of the N270 component, which is
17 elicited around 270 ms after stimulus onset, in response to the detection of a mismatch in a pair
18 of visual stimuli (see also § *Introduction*). Following the same methodology exploited by
19 previous research investigating visual mismatch detection responses (Bennett et al., 2014;
20 Scannella et al., 2016; P. Wang et al., 2018), ERP waveform amplitudes in the time window
21 between 230 and 320 ms after the onset of vS2 were averaged and the resulting value was the
22 object of further analyses. According to previous research (Bennett et al., 2014), mean
23 amplitudes were extracted from four different clusters of electrodes (frontal: F3/Fz/F4; central:
24 C3/Cz/C4; parietal: P3/Pz/P4; occipital: O1/Oz/O2). Importantly, despite the N270 is maximal
25 at fronto-central electrodes (Li, Wang, Wang, Cui, & Tian, 2003; Scannella et al., 2016), we
26 chose to analyse also central, parietal, and occipital clusters in order to have a broad picture of

1 the scalp, as well as to verify that the source of the observed effects matched those described
2 in previous studies. For each cluster, a single mean amplitude value was obtained by averaging
3 each electrode mean amplitude.

4 With the aim of investigating change detection mechanisms for visual stimuli depicting self-
5 versus other people's hands, the mean amplitudes of N270 extracted from frontal, central,
6 parietal and occipital electrodes were used as dependent variables and entered in four identical
7 statistical models (one for each cluster), i.e. a 2*4 repeated measures ANOVA with two within-
8 subject factors: "Stimulus Sequence" (two levels: vS1=vS2, vS1≠vS2); and "Stimulus
9 Identity" of vS2 (four levels: Self, Other1, Other2, Other3). The normal distribution of
10 residuals was checked by using Shapiro-Wilk's test (p always > 0.06). Post hoc comparisons
11 were performed by means of Bonferroni's test. Statistical analyses were performed using
12 Statistica Software (StatSoft, release 8 RRID:SCR_014213).

13

14 **2.2 Experiment 2 (replicating sample and control for familiarity bias)**

15 **2.2.1 Participants**

16 Fifteen healthy right-handed subjects participated in the study (10 women) aged 19-30 years
17 (mean±SD: 24.88±3.1; years of education: 18.1±2.7). None of them participated to Experiment
18 1. Sample size (N=15) was a priori determined to match the sample of Experiment 1.

19 All participants gave their written informed consent to participate in the study, which
20 conformed to the standards required by the Declaration of Helsinki and was approved by the
21 Ethics Committee of the University of Torino (prot. n. 125055, 12/07/16).

22

23 **2.2.2. Stimuli and Experimental Design**

24 General procedures were identical to the Experiment 1, with the following exceptions. In the
25 experimental paradigm (Fig. 1) we included a third scenario, i.e. the *With Familiar* scenario.
26 In this scenario, we presented two others' hands. Importantly, one of these hands was familiar

1 for the participant (i.e. the *Familiar hand*), since it had already been repeatedly presented in
2 the immediately preceding scenario (which, depending on the specific sequence assigned to
3 subject, might either be the *With Self* or the *Without Self* scenario). Four different pair types
4 were presented: *Familiar-Familiar* (with both vS1 and vS2 depicting the familiarized hand);
5 *Other4-Other4* (with vS1 and vS2 depicting the same hand belonging to a stranger – *Other4*);
6 *Familiar-Other4* (with vS1 representing the familiarized hand and vS2 *Other4*'s hand);
7 *Other4-Familiar* (with vS1 representing *Other4*'s hand and vS2 the familiarized hand). The
8 occurrence of each pair type ($p=.25$) was matched across conditions and pseudo-randomized
9 within each block, so that the maximum number of consecutive pairs of the same type was two.
10 The presentation of the scenarios was counterbalanced, except for the *With Familiar* scenario
11 that was always presented immediately following the scenario including the other's hand with
12 which participants familiarized (i.e. *With Self*=A; *Without Self*=B; *With Familiar*=C; subjects
13 may be administered with one of the following sequences: ACB; BAC; BCA; ABC).

14 Furthermore, in order to exclude that any possible negative results observed in Experiment 1
15 (such as the absence of a significant change detection effect in the *Without Self* scenario) were
16 due to a signal to noise ratio problem rather than to a genuine absence of modulation, we
17 doubled the number of trials in Experiment 2 (i.e. 52 trials per condition). Each scenario was
18 therefore composed of 208 pairs of visual stimuli (vS1 and vS2), delivered at a constant 1 s
19 inter-stimulus interval. The time interval between each pair was randomly jittered between 3
20 and 4 s, in a way that participants could not anticipate stimulus occurrence. The whole
21 experiment was divided into six 8-minute recording blocks (2 per scenario).

22

23 **2.1.3 Behavioral task and EEG recording**

24 All procedures were identical to those of Experiment 1.

25

26 **2.1.4 Data Analysis**

1 Behavioral data. Subjects' correct responses (i.e. *accuracy*) and *RTs* for each pair type were
2 collected and averaged. Importantly, trials with individual *RTs* exceeding two standard
3 deviations below or above the mean (of each specific experimental condition) as well as trials
4 with missing or wrong response were discarded (Bruno, Ronga, Fossataro, Capozzi, &
5 Garbarini, 2019; Bruno et al., 2020; Conson et al., 2015; Fossataro, Bucchioni, et al., 2018;
6 Ronga et al., 2018; Sarasso et al., 2018). The average number of discarded responses per
7 participant was around 5%. In order to explore the presence of the *self-advantage* effect in our
8 matching task, we performed, on both accuracy and *RTs* as dependent variables, two 3*4
9 repeated-measures ANOVA with two within-subject factors: "Scenario" (three levels: *With*
10 *Self* scenario; *Without Self* scenario; *With Familiar* scenario) and "Condition" (four levels: the
11 two pairs of identical and the two pairs of different stimuli in each scenario). The normal
12 distribution of residuals was checked by using Shapiro-Wilk's test (p always > 0.05). To
13 explore significant interactions, ad hoc planned comparisons were performed and corrected
14 with Bonferron's test. Statistical analyses were performed using Statistica Software (StatSoft,
15 release 8 RRID:SCR_014213).

16

17 Electrophysiological data. All the preprocessing of ERP data was identical to that of
18 Experiment 1, except for the following. We obtained 52 epochs for each pair that were averaged
19 time-locked to the onset of vS1. Thus, for each subject, twelve average waveforms (Self-Self;
20 Other-Other; Self-Other; Other-Self; Other1-Other1; Other2-Other2; Other2-Other1; Other1-
21 Other2; Familiar-Other3; Other3-Other3; Ohter3-Familiar; Familiar-Other3) were obtained.
22 The normal distribution of residuals was checked by using Shapiro-Wilk's test (p always $>$
23 0.06). Post hoc comparisons were performed by means of Bonferroni's test. Statistical analyses
24 were performed using Statistica Software (StatSoft, release 8 RRID:SCR_014213).

25

1 Statistical analyses on ERPs. The analysis of electrophysiological data replicated that of
2 Experiment 1. The mean amplitudes of N270 extracted from frontal, central, parietal and
3 occipital clusters were used as dependent variables and entered in four identical statistical
4 models (one for each cluster), i.e. 2x6 repeated measures ANOVAs with two within-subject
5 factors: “Stimulus Sequence” (two levels: vS1=vS2, vS1≠vS2); and “Stimulus Identity” of vS2
6 (six levels: Self, Other1, Other2, Other3, Other4, Familiar). The normal distribution of
7 residuals was checked by using Shapiro-Wilk’s test (p always > 0.07). Post hoc comparisons
8 were performed by means of Bonferroni’s test. Statistical analyses were performed using
9 Statistica Software (StatSoft, release 8 RRID:SCR_014213).

10

11 **3. Results**

12

13 **3.1 Experiment 1 (discovering sample)**

14 **3.1.1 Behavioral results**

15 Behavioral results are presented in Figure 2. Note that, overall are in line with our predictions,
16 participants showed a more accurate and faster behavioral performance anytime the self-hand
17 was included in the pair, thus indicating the presence of the *self-advantage* effect also in our
18 sample.

19

20 *Accuracy*

21 The 2*4 repeated measures ANOVA performed on accuracy values revealed a significant
22 Scenario*Condition Interaction ($F_{3,42}=4.967$; $p=0.004$; $\eta^2=0.262$), showing that the factor
23 Condition was significantly modulated only in the *With Self* scenario. To further explore this
24 interaction, four planned comparisons were run in the *With Self* scenario to compare identical
25 pairs (*Self-Self* vs *Other1-Other1*), different pairs (*Other1-Self* and *Self-Other1*) and each
26 identical pair with the corresponding different pair (*Self-Self* vs *Other1-Self*; *Other1-Other1* vs

1 *Self-Other1*). By applying Bonferroni's correction, alpha value was set at 0.012. Crucially,
2 planned comparisons revealed that accuracy values of the *Self-Self* pair (mean±SEM= 93.71 ±
3 2.09 %) were higher, even though it did not reach the significance level after Bonferroni's
4 correction (p=0.012), than those of *Other1-Other1* pair (mean±SEM= 83.64±3.81 %), whereas
5 the accuracy rate of *Other1-Self* pair (mean ± SEM= 94.59±1.71 %) and *Self-Other1* pair
6 (mean±SEM=89.64±2.79 %) were not significantly different (p=0.048). Moreover, the
7 percentage of accuracy response were higher in *Self-Other1* pair as compared to *Other1-Other1*
8 pair, even though the difference did not reach the significance level (p=0.014), but no
9 significant differences emerged comparing *Self-Self* pairs to *Other1-Self* pair (p=0.683). This
10 suggests the presence of a higher accuracy anytime the self-hand was included in the pair.

11

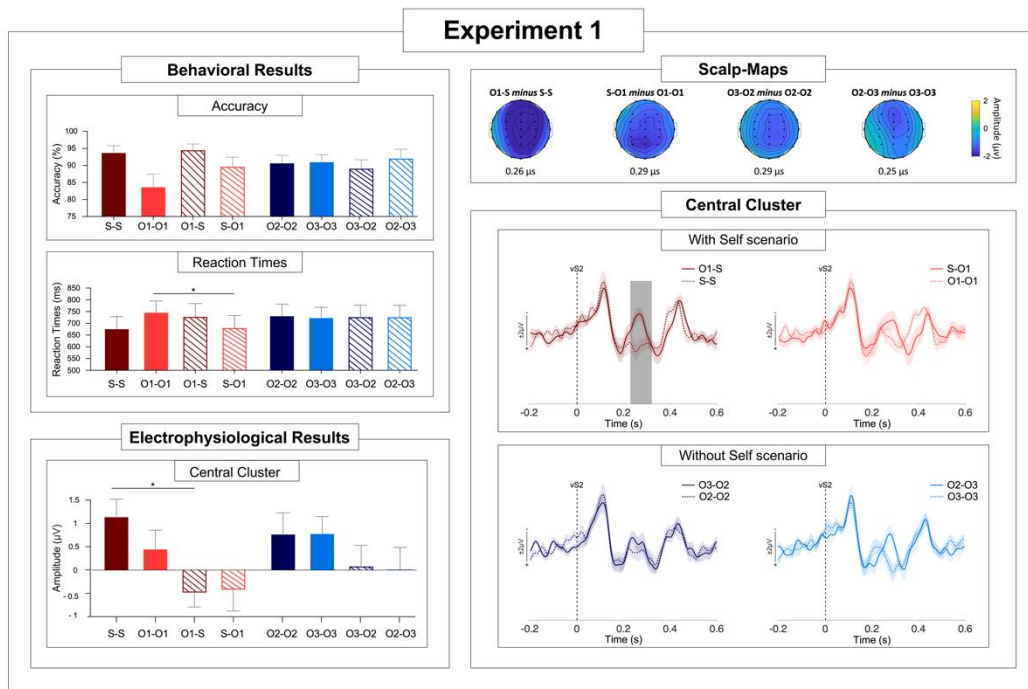
12 *Response Times (RTs)*

13 The 2*4 repeated measures ANOVA performed on RTs revealed a significant
14 Scenario*Condition Interaction ($F_{3,42}=3.820$; $p=0.016$; $\eta^2=0.214$). Crucially, as for the
15 accuracy, the factor Condition was modulated only in the *With Self* scenario and it was further
16 explored with four planned comparisons (see above). Faster RTs were found in *Self-Self* pair
17 (mean±SEM= 675.42±52.50 ms) as compared to *Other1-Other1* pair (mean±SEM= 745.72
18 ±49.25 ms), even though the difference did not reach the significance level (p=0.017), whereas
19 RTs of *Other1-Self* pair (mean±SEM= 727.64± 56.2 ms) and *Self-Other1* pair (mean±SEM=
20 680.16±52.78 ms) were not significantly different (p=0.057). Moreover, behavioral
21 performance was significantly faster in *Self-Other1* pair as compared to *Other1-Other1* pair
22 (p=0.0119), but no significant differences emerged comparing *Self-Self* pair to *Other1-Self* pair
23 (p=0.102). Overall, the RT results parallel the accuracy results, showing the presence of a faster
24 response anytime the self-hand was included in the pair.

25

26

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3

4 **Figure 2. Experiment 1: behavioral and electrophysiological results.** The top left panel
5 represents the accuracy values (in percentages) and the subjects' RTs. Note that subjects'
6 performance was more accurate and faster anytime the self-hand was presented. The bottom
7 left panel represents the mean of ERP amplitudes in the range between 230 and 320 ms post
8 vS2 onset (i.e. the window including N270 component). Y axis: the mean voltage amplitude
9 (μ V); X axis: experimental conditions. Note that the *With Self* scenario is represented in red,
10 while the *Without Self* scenario is represented in blue. The top right panel represents the scalp
11 map distribution of change response peaks (the latency corresponds to the peak of the
12 subtraction waves). Maps are obtained by subtracting the response to vS2 of identical pairs
13 from the response to vS2 of different pairs. The bottom right panel represents ERP waveforms
14 in response to the vS2 at the central cluster (mean of the electrodes composing the cluster). Y
15 axis: amplitude (μ V); X Axis: time (s). Waveforms in dotted lines represent pairs of identical
16 stimuli ($vS1=vS2$), waveforms in solid lines represent pairs of different stimuli ($vS1\neq vS2$).

1 Shaded areas correspond to ERP sem (standard error of the mean). Significant differences are
2 highlighted in grey. The top panel represents ERP waveforms in the *With Self* scenario. The
3 bottom panel represents ERP waveforms in the *Without Self* scenario.

4

5 **3.1.2 ERP results**

6 Electrophysiological results for the central cluster are presented in Figure 2. Results for all the
7 other clusters are presented in the Supplementary materials.

8 Note that, as expected, the contrast between pairs of identical stimuli ($vS1=vS2$) and pairs of
9 different stimuli ($vS1\neq vS2$) revealed a greater differential amplitude of the N270 in the *With*
10 *Self* scenario when $vS2$ represented the self-hand (i.e. *Self-Self* vs. *Other1-Self*).

11

12 *Frontal cluster*

13 The 2*4 repeated measures ANOVA revealed a main effect of Sequence ($F_{1,14}= 6.949$;
14 $p=0.019$; $\eta^2=0.331$), with overall larger ERP amplitudes for different as compared to identical
15 $vS2$ ($vS1=vS2$: $\text{mean}\pm\text{SEM}= 0.16\pm 0.29 \mu\text{V}$; $vS1\neq vS2$: $\text{mean}\pm\text{SEM}= -0.60\pm 0.33 \mu\text{V}$). A
16 significant Sequence*Identity interaction ($F_{3,42}= 2.974$; $p=0.042$; $\eta^2=0.175$) was observed,
17 suggesting that the difference between identical and different pairs was greater when $vS2$
18 represented the self-hand. Crucially, post-hoc analyses showed that only the *Self-Self* vs
19 *Other1-Self* comparison was significantly different in the N270 time window, with a larger
20 amplitude for the different as compared to the identical pair ($p<0.001$). All other comparisons
21 were ≥ 0.60 .

22

23 *Central cluster*

24 The 2*4 repeated measures ANOVA revealed a main effect of Sequence ($F_{1,14}= 13.926$;
25 $p=0.002$; $\eta^2=0.499$), with overall larger ERP amplitudes for different as compared to identical

1 vS2 (vS1=vS2: mean±SEM= 0.76±0.34 μ V; vS1≠vS2: mean±SEM= -0.18±0.35 μ V). A
2 significant Sequence*Identity interaction ($F_{3,42}= 3,067$; $p=0.038$; $\eta^2=0.180$) was found. As for
3 the frontal cluster, post-hoc comparisons showed that only *Self-Self* vs *Other1-Self* was
4 significant, with a larger amplitude for the different as compared to the identical pair ($p<0.001$).
5 All other comparisons were ≥ 0.08 .

6

7 *Parietal cluster*

8 The 2*4 repeated measures ANOVA revealed a main effect of Sequence ($F_{1,14}= 14.705$;
9 $p=0.002$; $\eta^2=0.512$), with overall larger ERP amplitudes for different as compared to identical
10 vS2 (vS1=vS2: mean±SEM= 1.27±0.32 μ V; vS1≠vS2: mean±SEM= 0.51±0.29 μ V).
11 Moreover, no significant Sequence*Identity interaction was found ($F_{3,42}= 2,822$; $p=0.051$;
12 $\eta^2=0.168$).

13

14 *Occipital cluster*

15 The 2*4 repeated measures ANOVA revealed a main effect of Sequence ($F_{1,14}= 5.106$;
16 $p=0.040$; $\eta^2=0.267$), with overall larger ERP amplitudes for different as compared to identical
17 vS2 (vS1=vS2: mean±SEM= 1.60 ± 1.56 μ V; vS1≠vS2: mean±SEM= 1.05±0.38 μ V).
18 Moreover, no significant Sequence*Identity interaction was found ($F_{3,42}= 2.686$; $p=0.059$;
19 $\eta^2=0.161$).

20

21 **3.2 Experiment 2 (replicating sample and control for familiarity)**

22 **3.2.1 Behavioral results**

23 Behavioral results are presented in Figure 3. Note that behavioral results replicate the results
24 of Experiment 1, showing a more accurate and faster performance anytime the self-hand was
25 presented.

1

2 *Accuracy*

3 The 3*4 repeated measures ANOVA performed on accuracy values revealed a significant
4 Scenario*Condition Interaction ($F_{6,84}=5.130$; $p<0.001$; $\eta^2=0.268$), showing that the factor
5 Condition was modulated only in the *With Self* scenario. As for the Experiment 1, to further
6 explore this interaction, four planned comparisons were run in the *With Self* scenario to
7 compare identical pairs (*Self-Self* vs *Other1-Other1*), different pairs (*Other1-Self* and *Self-*
8 *Other1*) and each identical pair with the corresponding different pair (*Self-Self* vs *Other1-Self*;
9 *Other1-Other1* vs *Self-Other1*). By applying Bonferroni's correction, alpha value was set at
10 0.012. Planned comparisons revealed that accuracy values of the *Self-Self* pair (mean \pm SEM=
11 96.60 \pm 1.04 %) were significantly higher ($p<0.001$) than those of *Other1-Other1* pair
12 (mean \pm SEM= 85.57 \pm 2.18 %), whereas the accuracy rate of *Other1-Self* pair (mean \pm SEM=
13 89.46 \pm 2.36 %) and *Self-Other1* pair (mean \pm SEM=92.09 \pm 2.34 %) were not significantly
14 different ($p=0.266$). Moreover, the percentage of accuracy response were significantly higher
15 in *Self-Other1* pair as compared to *Other1-Other1* pair ($p<0.001$) and in *Self-Self* pair as
16 compared to *Other1-Self* pair, even if it did not reach the significance level ($p=0.012$),
17 suggesting that the greater the accuracy the greater the presence of self-hand in the pair.

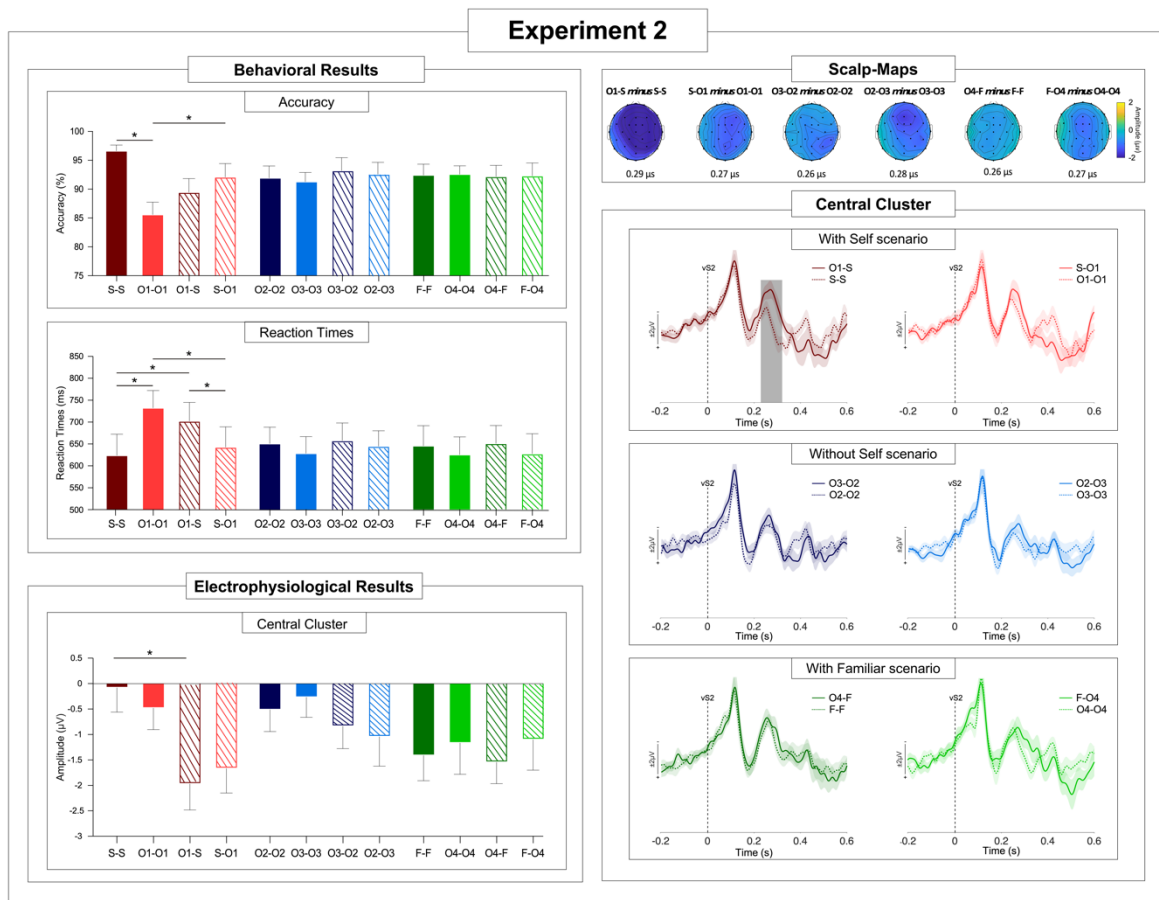
18

19 *Response Times (RTs)*

20 The 3*4 repeated measures ANOVA performed on accuracy values revealed a significant
21 Scenario*Condition interaction ($F_{6,84}=5.555$; $p<0.001$; $\eta^2=0.284$), showing that, as for the
22 accuracy, the factor Condition was modulated only in the *With Self* scenario. All planned
23 comparisons performed in the *With Self* scenario were significant here, revealing that RTs of
24 the *Self-Self* pair (mean \pm SEM= 623.81 \pm 48.34 ms) were significantly faster ($p=0.003$) than
25 those of *Other1-Other1* pair (mean \pm SEM= 732.31 \pm 39.78 ms) and that RTs in *Self-Other1*

1 pair (mean±SEM= 642.16±46.37 ms) were significantly faster ($p<0.001$) as compared to
 2 *Other1-Self* pair (mean± SEM=702.17±42.74 ms). Moreover, RTs were significantly faster in
 3 *Self-Other1* pair as compared to *Other1-Other1* pair ($p<0,001$) and in *Self-Self* pair as
 4 compared to *Other1-Self* pair ($p=0.010$), suggesting that the behavioral performance was faster
 5 whenever the self-hand was present in the pair and it was depicted as the first stimulus.

6
7



8
9
10

11 **Figure 3. Experiment 2: behavioral and electrophysiological results.** The top left panel
 12 represents the accuracy values (in percentages) and the subjects' RTs. Note that subjects'
 13 performance was more accurate and faster anytime the self-hand was presented. The bottom
 14 left panel represents the mean of ERP amplitudes in the range between 230 and 320 ms post
 15 vS2 onset (i.e. the window including N270 component). Y axis: the mean voltage amplitude
 16 (μV); X axis: experimental conditions. Note that the *With Self* scenario is represented in red,

1 while the *Without Self* scenario is represented in blue, and the *With Familiar* scenario in green.
2 The top right panel represents the scalp map distribution of change response peaks (the latency
3 corresponds to the peak of the subtractions waves). Maps are obtained by subtracting the
4 response to vS2 of identical pairs from the response of vS2 of different pairs. The bottom right
5 panel represents ERP waveforms in response to the vS2 at the central cluster (mean of the
6 electrodes composing the cluster). Y axis: amplitude (μV); X Axis: time (s). Waveforms in
7 dotted lines represent pairs of identical stimuli ($vS1=vS2$), waveforms in solid lines represent
8 pairs of different stimuli ($vS1\neq vS2$). Shaded areas correspond to ERP sem (standard error of
9 the mean). Significant differences are highlighted in grey. The top panel represents ERP
10 waveforms in the *With Self* scenario. The middle panel represents ERP waveforms in the
11 *Without Self* scenario. The bottom panel represents ERP waveforms in the *With Familiar*
12 scenario.

13 Notably, overall present results confirmed the findings of Experiment 1.

14

15 **3.2.2 ERP results**

16 Electrophysiological results for the central cluster are presented in Figure 3. Results for all the
17 other clusters are presented in the Supplementary materials.

18 Note that, as in Experiment 1, the contrast between pairs of identical ($vS1=vS2$) and different
19 stimuli ($vS1\neq vS2$) revealed a significant modulation of the N270 only in the *Whit Self* scenario
20 when vS2 represented the self-hand.

21

22 *Frontal cluster*

23 The 2*6 repeated measures ANOVA revealed a main effect of Sequence ($F_{1,14}=15,013$;
24 $p=0.002$; $\eta^2=0.517$), with overall larger ERP amplitudes for different as compared to identical
25 vS2 ($vS1=vS2$: $\text{mean}\pm\text{SEM}= -0.54\pm 0.25 \mu\text{V}$; $vS1\neq vS2$: $\text{mean}\pm\text{SEM}= -1.35\pm 0.29 \mu\text{V}$). A

1 significant Sequence*Identity interaction was found ($F_{5,70}= 4.895$; $p<0.001$; $\eta^2=0.259$).
2 Crucially, post-hoc comparisons showed that only vS2s belonging to *Self-Self* vs *Other1-Self*
3 pairs were significantly different in the N270 time window, with a significantly larger
4 amplitude for the different as compared to the identical pair ($p<0.001$). All other comparisons
5 were ≥ 0.08 .

6

7 *Central cluster*

8 The 2*6 repeated measures ANOVA revealed a main effect of Sequence ($F_{1,14}=12.186$;
9 $p=0.004$; $\eta^2=0.465$), with overall larger ERP amplitudes for different as compared to identical
10 vS2 (vS1=vS2: mean \pm SEM= -0.38 ± 0.34 μ V; vS1 \neq vS2: mean \pm SEM= -1.15 ± 0.39 μ V). A
11 significant Sequence*Identity interaction was found ($F_{5,70}= 3.621$; $p=0.006$; $\eta^2=0.201$).
12 Crucially, post-hoc comparisons showed that only S2s belonging to *Self-Self* vs *Other1-Self*
13 pairs were significantly different in the N270 time window, with a significantly larger
14 amplitude for the different as compared to the identical pair ($p<0.001$). All other comparisons
15 were ≥ 0.71 .

16

17 *Parietal cluster*

18 The 2*6 repeated measures ANOVA revealed a main effect of Sequence ($F_{1,14}=11.462$; $p=.004$;
19 $\eta^2=0.450$), with overall larger ERP amplitudes for different as compared to identical vS2
20 (vS1=vS2: mean \pm SEM= 0.26 ± 0.36 μ V; vS1 \neq vS2: mean \pm SEM= -0.38 ± 0.43 μ V). No
21 significant Sequence*Identity interaction was found ($F_{5,70}= 2.154$; $p=0.069$; $\eta^2=0.133$).

22

23 *Occipital cluster*

24 The 2*6 repeated measures ANOVA revealed a main effect of Sequence ($F_{1,14}=9.257$; $p=0.009$;
25 $\eta^2=0.398$), with overall larger ERP amplitudes for different as compared to identical vS2

1 (vS1=vS2: mean±SEM= -0.07±0.51 μ V; vS1≠vS2: mean±SEM= -0.66±0.63 μ V). No
2 significant Sequence*Identity interaction was found ($F_{5,70}= 0.677$; $p=0.642$; $\eta^2=0.046$).

3

4 **4. Discussion**

5 The present paper, focused on bodily self-identification, explores whether the recognition of
6 our physical identity has an observable electrophysiological correlate. More specifically, we
7 exploited the amplitude modulation following different *vs* identical stimulation to verify
8 whether implicit bodily-self recognition is able to modulate change detection responses, in a
9 pair of sequentially presented visual stimuli. Importantly, previous literature investigating
10 body-related change detection within the visual domain has mainly concentrated on face
11 discrimination (Schweinberger & Neumann, 2016). Crucially, face visual features are
12 extremely salient, since they are systematically employed for individual recognition. Still, self-
13 face recognition seems to rely on sensorimotor representations, exploiting multisensory cues,
14 such as speech processing (Cardini et al., 2011; Sugiura, 2015; Tsakiris, 2008). Not
15 surprisingly, therefore, face changes induced change detection responses in visual evoked
16 potentials. Conversely, the present study focuses on body effectors (right hands), whose visual
17 features are not equally relevant for their discrimination. However, similarly to faces, the self-
18 hand representation is supposed to recruit not only visual, but also sensorimotor brain networks
19 (Apps & Tsakiris, 2014; Conson et al., 2017; Ferri et al., 2012; Limanowski & Blankenburg,
20 2015). Thus, thanks to this multimodal representation, we hypothesized that self-hand visual
21 recognition should still entail a special change detection mechanism, inducing greater
22 electrophysiological responses than those elicited by others' hands discrimination.

23 In the following paragraphs we (1) outline our behavioral findings as supporting evidence of
24 the *self-advantage* effect and (2) discuss our ERPs results, which seem to confirm the salience
25 of bodily-self stimuli, which are able to boost identity recognition and change detection both

1 at behavioral and at electrophysiological levels. Importantly, the results highlighted in
2 Experiment 1 (our discovering sample) were fully confirmed and extended in Experiment 2,
3 which, besides controlling for a possible familiarity bias in our change detection effect, can be
4 considered as a measure of internal replicability.

5

6 *The self-advantage and visual ERPs*

7 Our behavioral results highlighted the relevance of self-advantage (Frassinetti et al., 2009) in
8 a repetition suppression paradigm, thus confirming the presence of such an effect for detection
9 tasks, even though self-recognition is not explicitly required by experimental instructions.

10 In both experiments, participants' accuracy rate was modulated selectively in the *With Self*
11 scenario (as indicated by the significant interaction between the factors Sequence and Identity
12 in Experiments 1 and 2 - § *Results* 3.1.1; 3.2.1), where participants' performance was overall
13 more accurate whenever the self-hand was included in the pair. The statistical analyses on RTs
14 paralleled accuracy results, thus revealing a significant modulation only in the *With Self*
15 scenario. In both experiments, we observed a comparable pattern of results, showing a
16 complete replicability of our findings. Interestingly, in the RT analysis of Experiment 2, likely
17 because of the increased number of trials included in this second experiment, all the planned
18 comparisons were significant, thus showing RT facilitation anytime the self-hand was the first
19 stimulus of the pair. To explain this result, we can hypothesize that the self-hand, when
20 presented as the first stimulus, boosted subjects' working memory and thanks to its relevance
21 for the system reduced the cognitive load and facilitated the active maintenance of the stimulus
22 memory trace in order to solve the task (Scannella et al., 2016).

23 Taken together, both accuracy and RTs point out a clear self-advantage effect in our behavioral
24 results, with overall faster and better performance when the self-hand was included in the pair.

25

1 From an electrophysiological point of view, as indicated by previous literature (Iannetti et al.,
2 2008; Ronga et al., 2013), we hypothesized a significantly different ERP amplitude modulation
3 between repeated and non-repeated conditions, highlighting, at least in the *With Self* scenario,
4 a specific change detection mechanism. The present ERP data confirm our hypothesis (see
5 below). Still, electrophysiological results in a way paralleled our behavioral findings, since in
6 both experiments all significant modulations were selectively observed in the *With Self*
7 scenario, thus pointing out the relevance of bodily-self recognition both from a behavioral and
8 an electrophysiological point of view.

9

10 *A specific change detection mechanism for self-hands is revealed by N270 amplitude*
11 *modulation*

12 From an electrophysiological point of view, in both experiments, we found a main effect of
13 Stimulus Sequence, thus confirming also in the present samples the sensitivity of N270
14 component in revealing sudden mismatches in a stream of visual stimuli (Y. Wang et al., 2004;
15 Y. Wang et al., 2003). Ferrari, Bradley, Codispoti, and Lang (2010), by employing an oddball
16 task with picture sequences, showed that N270 amplitude dramatically decreased already after
17 the first stimulus repetition and immediately increased for novel pictures, thus confirming
18 results by Y. Wang et al. (2004) obtained with stimulus pairs. Furthermore, the presence of
19 overall greater N270 amplitudes when vS2 was different rather than identical to vS1, is in line
20 with earlier evidence, proposing the N270 as an electrophysiological biomarker of conflict
21 detection in a sequence of incoming visual stimuli (Enriquez-Geppert, Konrad, Pantev, &
22 Huster, 2010; Folstein & Van Petten, 2008).

23 More crucially for the present study, we also found a significant interaction between the factors
24 Sequence and Identity, thus indicating that N270 amplitude was selectively modulated in the
25 *With Self* scenario. Post-hoc comparisons revealed that the amplitude modulation between
26 identical vs different pairs (i.e. *change detection*) was significant only for stimuli representing

1 the self-hand. Notably, this effect was found mainly over frontal and central electrodes, where
2 in both experiments it was fully significant. For the parietal and occipital clusters, we found no
3 significant modulations in both Experiment 1 and 2. These results are fully consistent with
4 source localization studies, showing a fronto-central distribution of the N270 component (Li et
5 al., 2003; Scannella et al., 2016).

6 The confinement of significant change detection effects to the *With Self* scenario is a crucial
7 finding since, as expected, it demonstrates that a reversion of repetition suppression mechanism
8 within the N270 time window are not automatically elicited by the system anytime a change in
9 the stimulation pattern occurs. Instead, mismatch detection responses emerge only when
10 stimulation changes are valued as salient (Ronga et al., 2013). Importantly, our results confirm
11 that the salience of the self-hand, as demonstrated by its ability to revert repetition suppression
12 effectively, represents a *kind* rather than a *degree* property expressed by *all or nothing* effects.
13 Interestingly, such salience of self-recognition turns up even when entailing the (task-
14 irrelevant) identification of body effectors, selectively through their visual appearances.
15 Apparently, recognizing our own body seems to represent an *aprioristic* relevant matter for the
16 individual, independently from specific task instructions.

17

18 A similar line of research, focused on investigating the electrophysiological signatures of self
19 and other's face recognition, reported that the amplitude of an occipito-temporal negative
20 component, peaking around 250 ms post stimulus onset, appeared larger in response to familiar,
21 rather than unfamiliar faces (Schweinberger & Neumann, 2016; Tanaka & Pierce, 2009). Even
22 though such a component was emerging from different neural sources as compared to our
23 fronto-central N270 (see e.g., Caharel, d'Arripe, Ramon, Jacques, & Rossion, 2009), results of
24 Experiment 1 cannot exclude that the familiarity of the self-hand could somehow contribute to
25 N270 modulation in the *With Self* scenario. To explore this possible familiarity-related effect
26 and confirm the results of Experiment 1, we run Experiment 2, where a scenario with a familiar

1 hand was added in the experimental paradigm. Importantly, and as supporting evidence of the
2 specificity of our effect for the self-hand, we found that presenting a familiarized hand did not
3 boost change detection responses (as demonstrated by the absence of any behavioral and
4 electrophysiological modulations in the *With Familiar* scenario – see 3.2.1 and 3.2.2). This
5 finding seems to indicate that the enhancement of change detection mechanisms is driven by a
6 self-specific effect and not by a mere familiarity effect, even though we cannot rule out that
7 the special familiarity acquired by the self-hand somehow contributed to the observed effect.
8 Overall, it may be challenging to distinguish specific self-recognition driven effects from
9 familiarity-driven effects and previous studies present controversial evidence. Butler and
10 colleagues (Butler, Mattingley, Cunnington, & Suddendorf, 2013) found similar
11 electrophysiological signatures of self-face and highly familiar faces (i.e., those of dizygotic
12 twins), suggesting that self-bodies, when compared to other bodies with a similar exposure, do
13 not involve unique featural encoding. On the other hand, Alzueta, Melcon, Poch, and Capilla
14 (2019) recorded EEG activity while participants performed a facial recognition task, where
15 they had to discriminate between their own face, a friend’s face, and an unknown face.
16 Crucially, authors pinpointed a specific modulation (within the time window of P200),
17 distinctive of the processing of self-face, suggesting that self-body parts have dedicated
18 processing mechanisms, clearly distinguishable from the detection of others’ familiar bodies.
19 We believe that our results, revealing a selective modulation of N270 component only when
20 the self-hand was presented, may be considered as a supporting evidence of the tenet that self
21 and other body parts have different neural representations (see below).

22

23 Overall the present findings suggest that, in a visual detection task, self- and only self-hand
24 changes are salient enough to reverse repetition suppression mechanism. In other words, self-
25 hand recognition, similarly to other sensory stimulation valued as relevant by the system, might
26 trigger the activity of the “salience network” (mainly including multimodal, associative

1 cortices, such as the anterior cingulate cortex and the insula) (Legrain, Iannetti, Plaghki, &
2 Mouraux, 2011; Mouraux, Diukova, Lee, Wise, & Iannetti, 2011), thus boosting the mismatch
3 detection effect. However, this possible mechanism does not explain how the system
4 recognizes the self-hand. Previous studies showed that the nervous system may employ a
5 number of different strategies to recognize the bodily self, entailing the identification of visual
6 features and/or the sensorimotor information (Ferri et al., 2012; Frassinetti et al., 2011;
7 Tsakiris, 2010).

8 The specificity observed for self-hand recognition in our data suggests that the self has a
9 systematic processing advantage, likely related to its inherent multimodal dimension.
10 Differently from images depicting others' bodies, which cannot be felt, visual stimuli
11 representing the bodily-self have immediate access also to sensorimotor information, thus
12 enriching their representation and salience. The present results, therefore, are compatible with
13 the idea of an integrated, multisensory network devoted to the recognition of the bodily-self
14 (Limanowski & Blankenburg, 2015, 2016; Zeller et al., 2016). The visual representation of
15 body effectors, besides primary visual cortices, may activate a circuit of sensorimotor areas
16 (including the ventral-premotor cortex) and of extrastriate, associative visual cortices (such as
17 the extrastriate body area – EBA – in the temporal lobe) (Ferri et al., 2012; Frassinetti et al.,
18 2011; Limanowski, Sarasso, & Blankenburg, 2018). However, how can this multimodal
19 activity be observed? Recently, a novel EEG paradigm has been specifically designed to
20 highlight the sensorimotor activity in response to visual body recognition (Galvez-Pol, Calvo-
21 Merino, & Forster, 2020). EEG responses to bodily-self visual information should be recorded
22 either in isolation (*visual-only condition*) or in combination with task-irrelevant motor and
23 somatosensory events (*multimodal condition*). Then, the activation recorded in visual-only
24 condition should be subtracted from the multimodal condition. This subtraction should
25 highlight the supposed contribution of sensorimotor activity in response to bodily-self images.
26 In the present study, we demonstrate that the implicit self-body recognition boosts the change

1 detection and we postulate that this enhanced mechanism is related to the activation of a
2 multimodal sensorimotor network devoted to the recognition of the bodily-self. If our
3 hypothesis is correct, future studies should exploit such a multimodal EEG paradigm in the
4 context of visual mismatch detection protocols, thus uncovering the neural mechanisms
5 underlying the enhancement of change detection effects for the bodily-self.

6

7 **Author contribution**

8 Mattia Galigani: conceptualization, methodology, software, formal analysis, investigation,
9 writing and original draft, visualization.

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24 **Open practices**

25 The datasets generated during this study, the experiment code, and the experimental stimuli are
26 available at Mendeley <https://data.mendeley.com/datasets/rz6gcc29dj/draft?a=e8a769c7->

1 c293-4839-bc95-75a86e427156. The present experiments and analyses were not pre-
2 registered. In our methodological section, we report how we determined our sample size, all
3 data exclusions, all inclusion/exclusion criteria, whether inclusion/exclusion criteria were
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5

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References

- 1
2
3 Alzueta, E., Melcon, M., Poch, C., & Capilla, A. (2019). Is your own face more than a highly
4 familiar face? *Biol Psychol*, *142*, 100-107. doi: 10.1016/j.biopsycho.2019.01.018
- 5 Apps, M. A., & Tsakiris, M. (2014). The free-energy self: a predictive coding account of self-
6 recognition. *Neurosci Biobehav Rev*, *41*, 85-97. doi: 10.1016/j.neubiorev.2013.01.029
- 7 Bennett, M. A., Duke, P. A., & Fuggetta, G. (2014). Event-related potential N270 delayed and
8 enhanced by the conjunction of relevant and irrelevant perceptual mismatch.
9 *Psychophysiology*, *51*(5), 456-463. doi: 10.1111/psyp.12192
- 10 Botvinick, M., & Cohen, J. (1998). Rubber hands 'feel' touch that eyes see. *Nature*, *391*(6669),
11 756. doi: 10.1038/35784
- 12 Bruno, V., Ronga, I., Fossataro, C., Capozzi, F., & Garbarini, F. (2019). Suppressing
13 movements with phantom limbs and existing limbs evokes comparable electrophysiological
14 inhibitory responses. *Cortex*, *117*, 64-76. doi: 10.1016/j.cortex.2019.02.024
- 15 Bruno, V., Ronga, I., Fossataro, C., Galigani, M., Sacco, K., & Garbarini, F. (2020). Long-
16 term limb immobilization modulates inhibition-related electrophysiological brain activity.
17 *Neuroimage*, *218*, 116911. doi: 10.1016/j.neuroimage.2020.116911
- 18 Bucchioni, G., Fossataro, C., Cavallo, A., Mouras, H., Neppi-Modona, M., & Garbarini, F.
19 (2016). Empathy or Ownership? Evidence from Corticospinal Excitability Modulation during
20 Pain Observation. *J Cogn Neurosci*, *28*(11), 1760-1771. doi: 10.1162/jocn_a_01003
- 21 Burin, D., Garbarini, F., Bruno, V., Fossataro, C., Destefanis, C., Berti, A., & Pia, L. (2017).
22 Movements and body ownership: Evidence from the rubber hand illusion after mechanical limb
23 immobilization. *Neuropsychologia*, *107*, 41-47. doi: 10.1016/j.neuropsychologia.2017.11.004
- 24 Butler, D. L., Mattingley, J. B., Cunnington, R., & Suddendorf, T. (2013). Different neural
25 processes accompany self-recognition in photographs across the lifespan: an ERP study using
26 dizygotic twins. *PLoS One*, *8*(9), e72586. doi: 10.1371/journal.pone.0072586

1 Caharel, S., d'Arripe, O., Ramon, M., Jacques, C., & Rossion, B. (2009). Early adaptation to
2 repeated unfamiliar faces across viewpoint changes in the right hemisphere: evidence from the
3 N170 ERP component. *Neuropsychologia*, 47(3), 639-643. doi:
4 10.1016/j.neuropsychologia.2008.11.016

5 Cardini, F., Costantini, M., Galati, G., Romani, G. L., Ladavas, E., & Serino, A. (2011).
6 Viewing one's own face being touched modulates tactile perception: an fMRI study. *J Cogn*
7 *Neurosci*, 23(3), 503-513. doi: 10.1162/jocn.2010.21484

8 Conson, M., Errico, D., Mazzarella, E., De Bellis, F., Grossi, D., & Trojano, L. (2015). Impact
9 of body posture on laterality judgement and explicit recognition tasks performed on self and
10 others' hands. *Exp Brain Res*, 233(4), 1331-1338. doi: 10.1007/s00221-015-4210-3

11 Conson, M., Volpicella, F., De Bellis, F., Orefice, A., & Trojano, L. (2017). "Like the palm of
12 my hands": Motor imagery enhances implicit and explicit visual recognition of one's own
13 hands. *Acta Psychol (Amst)*, 180, 98-104. doi: 10.1016/j.actpsy.2017.09.006

14 De Bellis, F., Trojano, L., Errico, D., Grossi, D., & Conson, M. (2017). Whose hand is this?
15 Differential responses of right and left extrastriate body areas to visual images of self and
16 others' hands. *Cogn Affect Behav Neurosci*, 17(4), 826-837. doi: 10.3758/s13415-017-0514-z

17 Della Gatta, F., Garbarini, F., Puglisi, G., Leonetti, A., Berti, A., & Borroni, P. (2016).
18 Decreased motor cortex excitability mirrors own hand disembodiment during the rubber hand
19 illusion. *Elife*, 5. doi: 10.7554/eLife.14972

20 Ehrsson, H. H., Holmes, N. P., & Passingham, R. E. (2005). Touching a rubber hand: feeling
21 of body ownership is associated with activity in multisensory brain areas. *J Neurosci*, 25(45),
22 10564-10573. doi: 10.1523/JNEUROSCI.0800-05.2005

23 Enriquez-Geppert, S., Konrad, C., Pantev, C., & Huster, R. J. (2010). Conflict and inhibition
24 differentially affect the N200/P300 complex in a combined go/nogo and stop-signal task.
25 *Neuroimage*, 51(2), 877-887. doi: 10.1016/j.neuroimage.2010.02.043

1 Ferrari, V., Bradley, M. M., Codispoti, M., & Lang, P. J. (2010). Detecting novelty and
2 significance. *J Cogn Neurosci*, *22*(2), 404-411. doi: 10.1162/jocn.2009.21244

3 Ferri, F., Frassinetti, F., Ardizzi, M., Costantini, M., & Gallese, V. (2012). A sensorimotor
4 network for the bodily self. *J Cogn Neurosci*, *24*(7), 1584-1595. doi: 10.1162/jocn_a_00230

5 Ferri, F., Frassinetti, F., Costantini, M., & Gallese, V. (2011). Motor simulation and the bodily
6 self. *PLoS One*, *6*(3), e17927. doi: 10.1371/journal.pone.0017927

7 Folstein, J. R., & Van Petten, C. (2008). Influence of cognitive control and mismatch on the
8 N2 component of the ERP: a review. *Psychophysiology*, *45*(1), 152-170. doi: 10.1111/j.1469-
9 8986.2007.00602.x

10 Fossataro, C., Bruno, V., Giurgola, S., Bolognini, N., & Garbarini, F. (2018). Losing my hand.
11 Body ownership attenuation after virtual lesion of the primary motor cortex. *Eur J Neurosci*,
12 *48*(6), 2272-2287. doi: 10.1111/ejn.14116

13 Fossataro, C., Bucchioni, G., D'Agata, F., Bruno, V., Morese, R., Krystkowiak, P., &
14 Garbarini, F. (2018). Anxiety-dependent modulation of motor responses to pain expectancy.
15 *Soc Cogn Affect Neurosci*. doi: 10.1093/scan/nsx146

16 Frassinetti, F., Ferri, F., Maini, M., Benassi, M. G., & Gallese, V. (2011). Bodily self: an
17 implicit knowledge of what is explicitly unknown. *Exp Brain Res*, *212*(1), 153-160. doi:
18 10.1007/s00221-011-2708-x

19 Frassinetti, F., Maini, M., Romualdi, S., Galante, E., & Avanzi, S. (2008). Is it mine?
20 Hemispheric asymmetries in corporeal self-recognition. *J Cogn Neurosci*, *20*(8), 1507-1516.
21 doi: 10.1162/jocn.2008.20067

22 Frassinetti, F., Pavani, F., Zamagni, E., Fusaroli, G., Vescovi, M., Benassi, M., . . . Farne, A.
23 (2009). Visual processing of moving and static self body-parts. *Neuropsychologia*, *47*(8-9),
24 1988-1993. doi: 10.1016/j.neuropsychologia.2009.03.012

25 Galigani, M., Ronga, I., Bruno, V., Castellani, N., Rossi Sebastiano, A., Fossataro, C., &
26 Garbarini, F. (under review). Saliency effects on visual change detection: face-like

1 configurations modulate electrophysiological mismatch responses *European Journal of*
2 *Neuroscience*.

3 Galvez-Pol, A., Calvo-Merino, B., & Forster, B. (2020). Revealing the body in the brain: An
4 ERP method to examine sensorimotor activity during visual perception of body-related
5 information. *Cortex*, *125*, 332-344. doi: 10.1016/j.cortex.2020.01.017

6 Grill-Spector, K., Henson, R., & Martin, A. (2006). Repetition and the brain: neural models of
7 stimulus-specific effects. [Review]. *Trends Cogn Sci*, *10*(1), 14-23. doi:
8 10.1016/j.tics.2005.11.006

9 Hu, C., Di, X., Eickhoff, S. B., Zhang, M., Peng, K., Guo, H., & Sui, J. (2016). Distinct and
10 common aspects of physical and psychological self-representation in the brain: A meta-
11 analysis of self-bias in facial and self-referential judgements. *Neurosci Biobehav Rev*, *61*, 197-
12 207. doi: 10.1016/j.neubiorev.2015.12.003

13 Iannetti, G. D., Hughes, N. P., Lee, M. C., & Mouraux, A. (2008). Determinants of laser-
14 evoked EEG responses: pain perception or stimulus saliency? [Research Support, Non-U.S.
15 Gov't]. *J Neurophysiol*, *100*(2), 815-828. doi: 10.1152/jn.00097.2008

16 Jung, T. P., Makeig, S., Humphries, C., Lee, T. W., McKeown, M. J., Iragui, V., & Sejnowski,
17 T. J. (2000). Removing electroencephalographic artifacts by blind source separation. [Clinical
18 Trial
19 Research Support, Non-U.S. Gov't
20 Research Support, U.S. Gov't, Non-P.H.S.]. *Psychophysiology*, *37*(2), 163-178. doi:
21 10.1111/1469-8986.3720163

22 Legrain, V., Iannetti, G. D., Plaghki, L., & Mouraux, A. (2011). The pain matrix reloaded: a
23 salience detection system for the body. [Research Support, Non-U.S. Gov't
24 Review]. *Prog Neurobiol*, *93*(1), 111-124. doi: 10.1016/j.pneurobio.2010.10.005

1 Li, L., Wang, Y., Wang, H., Cui, L., & Tian, S. (2003). Event-related potential N270 and its
2 distribution in adults and school-age children. *Brain Dev*, 25(7), 507-513. doi: 10.1016/s0387-
3 7604(03)00059-7

4 Limanowski, J., & Blankenburg, F. (2015). Network activity underlying the illusory self-
5 attribution of a dummy arm. *Hum Brain Mapp*, 36(6), 2284-2304. doi: 10.1002/hbm.22770

6 Limanowski, J., & Blankenburg, F. (2016). That's not quite me: limb ownership encoding in
7 the brain. *Soc Cogn Affect Neurosci*, 11(7), 1130-1140. doi: 10.1093/scan/nsv079

8 Limanowski, J., Sarasso, P., & Blankenburg, F. (2018). Different responses of the right
9 superior temporal sulcus to visual movement feedback during self-generated vs. externally
10 generated hand movements. *Eur J Neurosci*, 47(4), 314-320. doi: 10.1111/ejn.13824

11 Longo, M. R., Schuur, F., Kammers, M. P., Tsakiris, M., & Haggard, P. (2009). Self awareness
12 and the body image. *Acta Psychol (Amst)*, 132(2), 166-172. doi: 10.1016/j.actpsy.2009.02.003

13 Morita, T., Saito, D. N., Ban, M., Shimada, K., Okamoto, Y., Kosaka, H., . . . Naito, E. (2018).
14 Self-Face Recognition Begins to Share Active Region in Right Inferior Parietal Lobule with
15 Proprioceptive Illusion During Adolescence. *Cereb Cortex*, 28(4), 1532-1548. doi:
16 10.1093/cercor/bhy027

17 Mouraux, A., Diukova, A., Lee, M. C., Wise, R. G., & Iannetti, G. D. (2011). A multisensory
18 investigation of the functional significance of the "pain matrix". [Research Support, Non-U.S.
19 Gov't]. *Neuroimage*, 54(3), 2237-2249. doi: 10.1016/j.neuroimage.2010.09.084

20 Mouraux, A., & Iannetti, G. D. (2008). Across-trial averaging of event-related EEG responses
21 and beyond. [Research Support, Non-U.S. Gov't
22 Review]. *Magn Reson Imaging*, 26(7), 1041-1054. doi: 10.1016/j.mri.2008.01.011

23 Myers, A., & Sowden, P. T. (2008). Your hand or mine? The extrastriate body area.
24 *Neuroimage*, 42(4), 1669-1677. doi: 10.1016/j.neuroimage.2008.05.045

1 Pia, L., Fossataro, C., Burin, D., Bruno, V., Spinazzola, L., Gindri, P., . . . Garbarini, F. (2020).
2 The anatomo-clinical picture of the pathological embodiment over someone else's body part
3 after stroke. *Cortex*, *130*, 203-219. doi: 10.1016/j.cortex.2020.05.002

4 Ronga, I., Sarasso, P., Fossataro, C., Salatino, A., Garbarini, F., Ricci, R., & Neppi-Modona,
5 M. (2018). Everything is illuminated: Prismatic adaptation lowers visual detection threshold in
6 normal subjects. *J Exp Psychol Hum Percept Perform*, *44*(10), 1619-1628. doi:
7 10.1037/xhp0000559

8 Ronga, I., Valentini, E., Mouraux, A., & Iannetti, G. D. (2013). Novelty is not enough: laser-
9 evoked potentials are determined by stimulus saliency, not absolute novelty. [Research
10 Support, Non-U.S. Gov't]. *Journal of Neurophysiology*, *109*(3), 692-701. doi:
11 10.1152/jn.00464.2012

12 Sarasso, P., Ninghetto, M., Salatino, A., Ronga, I., Bongiardina, A., Iarrobino, I., . . . Ricci, R.
13 (2018). Everything is (still) illuminated: Dual right cathodal-left anodal tDCS of PPC prevents
14 fatigue on a visual detection task. *Brain Stimul*. doi: 10.1016/j.brs.2018.09.017

15 Sarasso, P., Ronga, I., Pistis, A., Forte, E., Garbarini, F., Ricci, R., & Neppi-Modona, M.
16 (2019). Aesthetic appreciation of musical intervals enhances behavioural and
17 neurophysiological indexes of attentional engagement and motor inhibition. *Sci Rep*, *9*(1),
18 18550. doi: 10.1038/s41598-019-55131-9

19 Scannella, S., Pariente, J., De Boissezon, X., Castel-Lacanal, E., Chauveau, N., Causse, M., . .
20 . Pastor, J. (2016). N270 sensitivity to conflict strength and working memory: A combined
21 ERP and sLORETA study. *Behav Brain Res*, *297*, 231-240. doi: 10.1016/j.bbr.2015.10.014

22 Schweinberger, S. R., & Neumann, M. F. (2016). Repetition effects in human ERPs to faces.
23 *Cortex*, *80*, 141-153. doi: 10.1016/j.cortex.2015.11.001

24 Sugiura, M. (2015). Three faces of self-face recognition: potential for a multi-dimensional
25 diagnostic tool. *Neurosci Res*, *90*, 56-64. doi: 10.1016/j.neures.2014.10.002

1 Tanaka, J. W., & Pierce, L. J. (2009). The neural plasticity of other-race face recognition. *Cogn*
2 *Affect Behav Neurosci*, 9(1), 122-131. doi: 10.3758/CABN.9.1.122

3 Torta, D. M., Liang, M., Valentini, E., Mouraux, A., & Iannetti, G. D. (2012). Dishabituation
4 of laser-evoked EEG responses: dissecting the effect of certain and uncertain changes in
5 stimulus spatial location. *Experimental Brain Research*. doi: 10.1007/s00221-012-3019-6

6 Tsakiris, M. (2008). Looking for myself: current multisensory input alters self-face
7 recognition. *PLoS One*, 3(12), e4040. doi: 10.1371/journal.pone.0004040

8 Tsakiris, M. (2010). My body in the brain: a neurocognitive model of body-ownership.
9 *Neuropsychologia*, 48(3), 703-712. doi: 10.1016/j.neuropsychologia.2009.09.034

10 Valentini, E., Torta, D. M., Mouraux, A., & Iannetti, G. D. (2011). Dishabituation of laser-
11 evoked EEG responses: dissecting the effect of certain and uncertain changes in stimulus
12 modality. [Research Support, Non-U.S. Gov't]. *J Cogn Neurosci*, 23(10), 2822-2837. doi:
13 10.1162/jocn.2011.21609

14 Wang, A. L., Mouraux, A., Liang, M., & Iannetti, G. D. (2010). Stimulus novelty, and not
15 neural refractoriness, explains the repetition suppression of laser-evoked potentials.
16 [Comparative Study
17 Research Support, Non-U.S. Gov't]. *J Neurophysiol*, 104(4), 2116-2124. doi:
18 10.1152/jn.01088.2009

19 Wang, P., Tan, C. H., Li, Y., Zhang, Q., Wang, Y. B., & Luo, J. L. (2018). Event-related
20 potential N270 as an index of social information conflict in explicit processing. *Int J*
21 *Psychophysiol*, 123, 199-206. doi: 10.1016/j.ijpsycho.2017.03.005

22 Wang, Y., Cui, L., Wang, H., Tian, S., & Zhang, X. (2004). The sequential processing of visual
23 feature conjunction mismatches in the human brain. *Psychophysiology*, 41(1), 21-29. doi:
24 10.1111/j.1469-8986.2003.00134.x

1 Wang, Y., Tian, S., Wang, H., Cui, L., Zhang, Y., & Zhang, X. (2003). Event-related potentials
2 evoked by multi-feature conflict under different attentive conditions. *Exp Brain Res*, *148*(4),
3 451-457. doi: 10.1007/s00221-002-1319-y

4 Zeller, D., Friston, K. J., & Classen, J. (2016). Dynamic causal modeling of touch-evoked
5 potentials in the rubber hand illusion. *Neuroimage*, *138*, 266-273. doi:
6 10.1016/j.neuroimage.2016.05.065

7 Zhang, X., Ma, L., Li, S., Wang, Y., Weng, X., & Wang, L. (2008). A mismatch process in
8 brief delayed matching-to-sample task: an fMRI study. *Exp Brain Res*, *186*(2), 335-341. doi:
9 10.1007/s00221-008-1285-0

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