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Commentary

Are facing body dyads as special as (single) faces for the human brain?

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In her thoughtful and provocative *Viewpoint* paper, Liuba Papeo summarizes a series of recent studies from her group and other researchers, to propose that visual perception of human bodies facing each other evokes effects compatible with the most robust neuro-functional markers of face-specificity in the visual cortex and that such face-to-face bodies are visually represented as a single unit, “analogously to the features of a face”. While the point is generally well taken, this view is qualified here, the specialness of (single) faces in terms of expertise at identity recognition based on holistic fine-grained representations being probably unparalleled for the human brain. As shown for faces, electrophysiological recordings may offer the most promising avenue to test the hypothesis of early integrated facing human bodies as a key unit of social recognition.

Starting with the so-called *inversion effect* in behavior, Papeo and her colleagues have shown convincingly in a number of studies that categorization of visual stimuli as (human) bodies is disproportionately disrupted by picture-plane inversion when these bodies are facing each other (Papeo et al., 2017), with a number of stringent controls excluding these effects to be due to faces alone (Papeo & Abassi, 2019) or generalized to nonbody object shapes (Strachan et al., 2019). Nevertheless, the parallel made with the face inversion effect (FIE) should be qualified since this effect is not typically defined in terms of categorizing a visual stimulus as a face, but as the significant drop of performance occurring when people have to recognize the *identity* of faces appearing upside-down (Yin, 1969), whether it is measured through the identification of famous faces, old/new recognition tasks or simultaneous matching tasks with unfamiliar faces for instance (Rossion, 2009 for review). The FIE, which,

interestingly, is not, or only weakly and inconsistently, observed in a prevalent animal model of human face recognition, the macaque monkey (Griffin, 2020), is functionally important since the physical difference between the individual faces is strictly identical across the two orientations. Hence, the FIE points to the (human-specific) reliance on experienced-based knowledge of the morphological structure of faces and of their natural variability in the environment to quickly determine how well two or more individual faces differ in a given task. However, as powerfully used by the Renaissance painter Giuseppe Arcimboldo in his reversible paintings of portraits (Hulten, 1987), there is also a clear effect of inversion on the categorization of a visual stimulus as a face (see Rossion et al., 2011); and this is where the parallel with the inversion effect of facing body dyads seems to be the most appropriate. Whether inversion would also disproportionately affect identity recognition of facing body dyads could be tested in future research. However, an obvious caveat is that identity recognition is not as good from the body as from the face, simply because, across individuals of a genetically homogeneous human population, faces convey a disproportionately large amount of morphological diversity as compared to other body parts (Sheehan & Nachman, 2014).

Similarly to Arcimboldo paintings, binarized images of faces, so-called Mooney faces, also illustrate this effect of inversion on the categorization of the stimulus as a face very well (Rossion et al., 2011). Since the perception of a face emerges from Arcimboldo/Mooney stimuli that do not have objective facial parts (this can be demonstrated by breaking these stimuli in a few spatially rearranged pieces, e.g., see Fig. 1 in Rossion et al., 2011), the percept is thought to depend on the representation of the whole stimulus configuration as a

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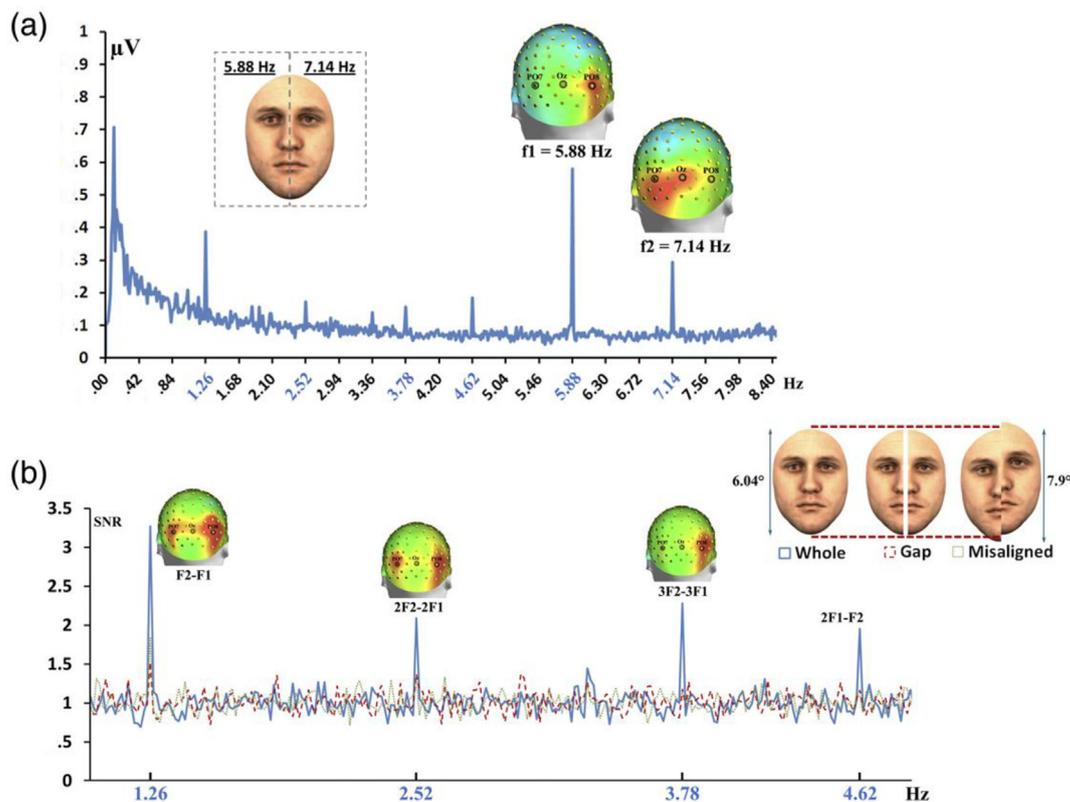


Fig. 1 – Objective evidence for neural integration of facial parts (adapted from Boremanse et al., 2013). (a). EEG spectrum (grand-averaged from 15 participants, right occipito-temporal channel PO8; μV = microvolts, SNR = signal-to-noise ratio) obtained by flickering the two halves of a face stimulus at different frequency rates ($F1 = 5.88$ and $F2 = 7.14$ cycles by second) for 60 s. The response to each face part is contralateral to the side of stimulation. (b). Intermodulation responses at the exact difference between the two fundamental stimulation frequencies (e.g., $F2 - F1 = 1.26$ Hz) and harmonics (e.g., $2F2 - 2F1 = 2.52$ Hz, etc.). These intermodulation responses are prominent over the right occipito-temporal cortex and reflect an objective signature of a holistic (i.e., unified) representation of the face. They are specifically disrupted when the two face parts are spatially separated or misaligned. Would facing body dyads lead to the same kind of neural signature, reflecting their automatic holistic integration in the visual cortex?

single unit. This holistic/configural account of the effect of inversion (either on categorization or individuation of faces) is nevertheless difficult to conceptualize in a standard hierarchical view of visual perception and, for this reason, is constantly challenged in human face recognition research (e.g., Rakover, 2013; Riesenhuber et al., 2004). Without a theoretical framework that goes beyond a hierarchical part-decomposition, it is likely that a similar account of the effect of inversion on facing dyads as advocated by Papeo and colleagues will be questioned in the years to come.

In fact, according to a strong version of the holistic/configural perception of faces, which I fully embrace, the parts (mouth, eye, nose...) of a face are not even represented independently (Rossion, 2009; Tanaka & Farah, 1993). That is, a face input is represented only as a single unit, a whole configuration in the human brain. This is not to say that parts/features cannot be processed and represented independently at various stages of the visual system (starting in the retina), but these “representations” are not category-selective and do not serve the purpose of reliable (i.e., beyond image-based differences) categorization: category-selectivity concerns only the representation of the face as a whole (Rossion, 2014).

While this holistic representational mode provides substantial advantages (e.g., in face stimulus completion), it would certainly be detrimental to represent human bodies only as (facing) dyads in body-selective areas of the visual cortex for instance. Moreover, the usual relative distance between facing bodies is certainly modulated by many factors, including cultural factors, and can change over time (e.g., with social distance increasing following the coronavirus pandemic), making such representations more flexible rather than being based on holistic templates derived from experience to a number of individual faces.

Regarding the attentional advantage for facing body dyads, I am not aware of experiments showing that categorization of a face among nonfaces is faster than the opposite, but studies indicate indeed that faces pop-out in visual displays (Hershler & Hochstein, 2005) and are detected automatically (i.e., without volitional control; e.g., Crouzet et al., 2010). In this latter study, even when human subjects have to saccade to a nonface object, the simultaneously presented face stimulus is a powerful attractor of automatic early saccades. Although a fraction of these effects has been attributed to low-level physical cues contained in the stimulus amplitude spectrum

(Crouzet & Thorpe, 2011; VanRullen, 2006), such low-level cues are unlikely to account for the effects reported by Papeo and colleagues for facing body dyads given that the exact same body shapes are used across conditions in these studies.

Turning to the parallel drawn between the representation of (single) faces and facing body dyads at the neural level, the question of the selectivity of cortical regions is key. Faces are associated with a large specialized cortical network in primates, with right hemispheric dominance in humans (Grill-Spector et al., 2017). Modulation of (some) of these regions by the degree of interaction of body shapes (Abassi & Papeo, 2019) is fascinating and undoubtedly questions/extends the functional role of these regions (although face-selective regions might be equally modulated by facing faces only). However, contrary to what is found for isolated faces, there is no evidence of entire cortical regions/clusters responding selectively to facing body dyads over all other kinds of stimuli, including nonfacing body dyads, or of a clear hemispheric specialization. Moreover, the origin of the specialness of faces for the human brain comes from the observation of patients who, following focal brain damage at adulthood, present with a profound selective inability to recognize the identity of faces (prosopagnosia, Bodamer, 1947; see Rossion, 2018 for review). A similar selective acquired impairment in visual recognition of facing body dyads only has not been shown, and is highly unlikely.

Finally, beyond the lesion method, and among all methodologies of human cognitive neuroscience, electroencephalography (EEG) or even intracranial EEG (iEEG) may well offer the most promising avenue to pursue the original research program outlined by Liuba Papeo in her Viewpoint paper, for two reasons. First, the high temporal resolution of EEG may be key to demonstrate that facing dyads constitutes the earliest rudimentary representation of social interaction in the visual cortex. Indeed, relating to the first section of Papeo's Viewpoint paper, attributing effects to (visual) perception is virtually impossible with behavioral performance alone since (even in speeded visual search or near-threshold stimulus detection) these behavioral effects necessarily reflect a mixture of attentional and decisional processes. This is the main reason why a number of scientists in the face research community even consider, strangely enough in my view, that behavioral effects based on powerful visual illusions such as the composite effect (which is abolished by inversion; Young et al., 1987) may have an attentional and/or decisional basis (see Rossion, 2013). Therefore, to capture rudimentary perceptual representations of social interaction, direct measures of neural activity over, or within, the visual cortex may be required during tasks that do not involve an explicit judgement on visual pictures of human bodies. Second, (i)EEG coupled with relatively fast periodic visual stimulation is able to neatly isolate neural representations of facial parts, for instance of the left and right halves of a face tagged at different stimulation frequencies F1 and F2 in the frequency domain. Most importantly, this frequency-tagging approach can identify objective measures of parts integration in terms of nonlinear intermodulation components (e.g., f_1+f_2 or f_1-f_2) in the (i) EEG spectrum (Boremanse et al., 2013, Fig. 1).

In future studies, inspired by research on human face perception, this highly sensitive approach may be used in a

straightforward manner to provide objective evidence that face-to-face bodies are indeed represented as a grouped unit, and distinguish this representation from representations of the human bodies alone, significantly extending this exciting research program on social perception.

REFERENCES

- Abassi, E., & Papeo, L. (2019). The representation of two-body shapes in the human visual cortex. *The Journal of Neuroscience*, 40, 852–863.
- Bodamer, J. (1947). Die-Prosop-agnosie. *Arch. Psychiatr. Nervenkrankh* 179, 6–54. Partial English translation by Ellis HD and Florence M. (1990). *Cognitive Neuropsychology*, 7, 81–105.
- Boremanse, A., Norcia, A. M., & Rossion, B. (2013). An objective signature for visual binding of face parts in the human brain. *Journal of Vision*, 11(6), 1–18.
- Crouzet, S. M., Kirchner, H., & Thorpe, S. J. (2010). Fast saccades toward faces: Face detection in just 100 ms. *Journal of Vision*, 16, 1–17.
- Crouzet, S. M., & Thorpe, S. J. (2011). Low-level cues and ultra- fast face detection. *Frontiers in Psychology*, 2, 342.
- Griffin, J. W. (2020). Quantifying the face inversion effect in nonhuman primates: A phylo- genetic meta-analysis. *Animal Cognition*, 23, 237–249.
- Grill-Spector, K., Weiner, K. S., Kay, K., & Gomez, J. (2017). The functional neuroanatomy of human face perception. *Annual Review of Vision Science*, 3, 167–196.
- Hershler, O., & Hochstein, S. (2005). At first sight: A high-level pop out effect for faces. *Vision Research*, 45(13), 1707–1724.
- Hulstn, P. (1987). *The Arcimboldo effect*. London: Thames and Hudson.
- Papeo, L., & Abassi, E. (2019). Seeing social events: The visual specialization for dyadic human–human interactions. *Journal of Experimental Psychology. Human Perception and Performance*, 45, 877–888.
- Papeo, L., Stein, T., & Soto-Faraco, S. (2017). The two-body inversion effect. *Psychological Science*, 28, 369–379.
- Rakover, S. S. (2013). Explaining the face-inversion effect: The face-scheme incompatibility (FSI) model. *Psychonomic Bulletin & Review*, 20, 665–692.
- Riesenhuber, M., Jarudi, I., Gilad, S., & Sinha, P. (2004). Face processing in humans is compatible with a simple shape-based model of vision. *Proceedings in Biological Sciences*, 271(Suppl. 6), S448–S450.
- Rossion, B. (2009). Distinguishing the cause and consequence of face inversion: The perceptual field hypothesis. *Acta Psychologica*, 132, 300–312.
- Rossion, B. (2013). The composite face illusion: A window to our understanding of holistic face perception. *Visual Cognition*, 121, 139–253.
- Rossion, B. (2014). Understanding face perception by means of prosopagnosia and neuroimaging. *Frontiers in Bioscience (Elite Ed.)*, 6, 308–317.
- Rossion, B. (2018). Damasio's error-Prosopagnosia with intact within-category object recognition. *Journal of Neuropsychology*, 12, 357–388.
- Rossion, B., Dricot, L., Goebel, R., & Busigny, T. (2011). Holistic face categorization in higher-level cortical visual areas of the normal and prosopagnosic brain: Towards a non-hierarchical view of face perception. *Frontiers in Human Neuroscience*, 4, 225.
- Sheehan, M. J., & Nachman, M. W. (2014). Morphological and population genomic evidence that human faces have evolved to signal individual identity. *Nature Communications*, 5, 4800.
- Strachan, J. W., Sebanz, N., & Knoblich, G. (2019). The role of emotion in the dyad inversion effect. *Plos One*, 14, 7.

Tanaka, J. W., & Farah, M. J. (1993). Parts and wholes in face recognition. *Quarterly Journal of Experimental Psychology*, 46, 225–245.

VanRullen, R. (2006). On second glance: Still no high-level pop-out effect for faces. *Vision Research*, 46, 3017–3027.

Yin, R. K. (1969). Looking at upside-down faces. *Journal of Experimental Psychology*, 81, 141–145.

Young, A. W., Hellawell, D., & Hay, D. C. (1987). Configurational information in face perception. *Perception*, 16, 747–759.

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