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Letter

Characterizing the Third Visual Pathway for Social Perception

David Pitcher[1,*]

To understand the behaviour and intentions of other people we use visual cues generated by the movements and actions of their faces and bodies. These include facial expressions, eye-gaze, body movements, and the audio-visual integration of speech. Explaining the neural processes that enable us to see, process, and respond to these signals is a fundamental aim of psychology. In pursuit of this goal, we recently proposed the existence of a visual pathway specialised for social perception [1]. This pathway projects from V1 into the posterior banks of the superior temporal sulcus (STS), via the motion-selective area V5/MT. In response, Weiner and Gomez [2] have raised salient questions about the third pathway, which I welcome the opportunity to address here.

The Role of V5/MT

The authors point out that there are alternate cortico-cortical pathways into the macaque STS that do not include MT. These are shown in detail in the anatomical diagram presented in Figure 2 of our original paper [1]. Our intention was not to deny the importance of these connections, but rather to highlight the role of motion in the third pathway. V5/MT is the most heavily studied motion-selective area in the brain, and our conception of the third pathway is predicated on its fundamental role in biological motion perception. But other visual areas, including V1, also respond to motion [3]. The direct connection from V1 to the banks of the STS that the authors discuss may contribute to the full representation of the visual field that has been reported for moving faces in the macaque and human STS [4,5]. This full visual field representation is integral to the functional role of the third pathway, because social interactions often depend on simultaneously processing multiple sources of biological motion across the entire visual field [1].

The Role of Motion

As stated earlier, motion is a fundamental component in our proposal of the third pathway. In their response, the authors rightly state that many areas in the vicinity of

Box 1. Dr Leslie G. Ungerleider (1946–2020)

Dr Leslie Ungerleider passed away in December 2020 (Figure I). Her profound scientific impact has been detailed in the many obituaries and tributes that have been published over the past months. The two visual pathway model [12] transformed our understanding of cortical organisation and served as a blueprint for mapping the visual functions of the primate brain. Leslie was a true pioneer in this field. While always remaining a non-human primate researcher at heart, she became a leader in the human neuroimaging revolution that started in the 1990s. In her laboratory she investigated the neural basis of cognition across species and across methods.

Our model of the third visual pathway [1] came from the countless scientific conversations I was fortunate enough to enjoy with her over 10 years. Leslie had a detailed knowledge of neuroanatomy and brain function, but that was not enough. She would ask 'What does it mean? For her it was essential to explain data and theories in the widest possible scientific context to facilitate understanding across disciplines. Leslie was generous and kind, while simultaneously demanding clarity of thought and scientific precision. Her loss is deeply felt by her former mentees, colleagues, and many friends across the neuroscientific community.

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Figure I. Leslie Ungerleider (1946–2020).

V5/MT, and the face-selective area in the human posterior STS (pSTS), also respond to static visual stimuli. This is indeed the case, multiple face-selective areas in the STS do respond to static stimuli, but dynamic stimuli produce a substantially greater neural response [6]. By contrast, motion does not increase the neural response to faces in face-selective areas on the ventral surface of the brain like the fusiform face area. Our intention was to argue that biological motion is essential to understanding the functional role of the third pathway and it is this dissociation (between static and dynamic stimuli) that should be used to characterise functional differences across the pathways in future studies.

Third Pathway or Lateral Pathway?

It is not clear that we are talking about the same brain areas when we each refer to the third pathway. The STS, which is at the heart of our proposed pathway, is not referenced in any of the studies the authors report in Figure 1. For example, the STS is not included in the resting-state fMRI data [7] detailed in their Figure 1A. In addition, the cortical parcellation data shown in Figure 1D appears to show a cortico-cortical pathway projecting along the middle temporal gyrus (MTG), not the STS. The authors refer to this pathway as the lateral stream [8] and they have previously defined this pathway using flashing checkerboard bars, not moving face videos as we have used [4]. Our conceptualisation of the third visual pathway is that face and body movement processing is fundamental to its function. We also suggested that the third pathway might be right-lateralised in the future questions of our original paper [1]. By contrast, others have proposed an MTG pathway for action observation and object representation [9] that is left-lateralised [10]. Fully characterising the functional responses of these lateral brain areas across hemispheres will open up many exciting opportunities for future research. This is particularly important given the preferential role of the left hemisphere in language and the representation of concepts [10].

Across Species, across Modalities, and across Methods

I wholeheartedly agree with the important questions the authors raise concerning the extent to which we can compare the third pathway across species and its role in haptic sensory processing. In addition, Grossman has recently offered a fascinating developmental perspective on the third pathway [11]. The broad scope of the visual pathway model originally proposed by Ungerleider and Mishkin [12] has enabled researchers to describe the cognitive operations of the brain at a level that can encompass different species [5,6], different stages of development [8,11], and different experimental methods [4,7] (Box 1). The third visual pathway updates this model [1]. Our intention was to create a common cognitive framework capable of integrating novel data and theories seeking to bridge sensory neuroscience and social cognition.

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[1]Department of Psychology, University of York, Heslington, York, YO10 5DD, UK

*Correspondence:
david.pitcher@york.ac.uk (D. Pitcher).
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References

1. Pitcher, D. and Ungerleider, L.G. (2021) Evidence for a third visual pathway specialized for social perception. *Trends Cogn. Sci.* 25, 100–110
2. Weiner, K.S. and Gomez, J. (2021) Third visual pathway, anatomy, and cognition across species. *Trends Cogn. Sci.* (in press)
3. Snowden, R.J. *et al.* (1991) The response of area MT and V1 neurons to transparent motion. *J. Neurosci.* 11, 2768–2785
4. Pitcher, D. *et al.* (2020) The human posterior superior temporal sulcus samples visual space differently from other face-selective regions. *Cereb. Cortex* 30, 778–785
5. Bruce, C. *et al.* (1981) Visual properties of neurons in a polysensory area in superior temporal sulcus of the macaque. *J. Neurophysiol.* 46, 369–384
6. Pitcher, D. *et al.* (2019) A functional dissociation of face-, body- and scene-selective brain areas based on their response to moving and static stimuli. *Sci. Rep.* 9, 8242
7. Haak, K.V. and Beckmann, C.F. (2018) Objective analysis of the topological organization of the human cortical visual connectome suggests three visual pathways. *Cortex* 98, 73–83
8. Gomez, J. *et al.* (2019) Development of population receptive fields in the lateral visual stream improves spatial coding amid stable structural-functional coupling. *Neuroimage* 188, 59–69
9. Kilner, J.M. (2011) More than one pathway to action understanding. *Trends Cogn. Sci.* 15, 352–357
10. Wurm, M.F. and Caramazza, A. (2021) Action and object representation in the ventral "what" stream. *PsyArXiv* Published online April 1, 2021. https://doi.org/10.31234/osf.io/af65s
11. Grossmann, T. (2021) Developmental origins of the pathway for social perception. *Trends Cogn. Sci.* Published online March 16, 2021. https://doi.org/10.1016/j.tics.2021.03.003
12. Ungerleider, L.G. and Mishkin, M. (1982) Two cortical visual systems. In *Analysis of Visual Behavior* (Ingle, D.J. *et al.*, eds), pp. 549–586, MIT Press