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## What is *abstract* about seeing social interactions?

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Social vision is a branch of vision science investigating the visual processing of socially relevant stimuli, primarily people. The focus of this research has recently moved from individuals (faces/bodies and their actions) to groups (two faces/bodies and their interactions). This new focus has revealed that the visual system is particularly sensitive to information that signals social interaction, or an agent's social engagement. McMahan and Isik [1] propose that the visual system uses this information to generate abstract representations of social interaction on an "exciting middle ground" that goes beyond the input structure, but precedes cognitive processes such as theory of mind. A hierarchical organization that supports increasingly abstract levels of representation is common to many large-scale brain networks [2], and is probably a good model to understand the processing of social interaction. The mapping of different representational levels into the visual cortex however is more uncertain than McMahan and Isik suggest.

In the perception of two bodies, the visual system sees distance, relative positioning (facing/non-facing), postural relations, synchrony, and possibly other relational properties (or *social primitives*) that distinguish related/interacting from unrelated/non-interacting people. Face-to-face interacting dyads (Figure 1A) are processed faster and better than non-interacting dyads [3]. McMahan and Isik argue that the computation of social primitives along the visual hierarchy results in the abstract representation of social interaction in regions such as the extrastriate body area (EBA) and the posterior superior temporal sulcus (pSTS). This representation would capture the structure of the input-event beyond the specific visual features, enabling category-level generalization, i.e., the recognition of a structure that is common to, say, all instances of *helping*, and that distinguishes *helping* from *hindering* events. Current results however show that the response to social interactions in those regions lacks the quality of generality that defines abstract representation, and remains compatible with the representation of visual correlates of social interaction.

Neurons in EBA and pSTS show selectivity for bodies/body parts and body motion, respectively. Both regions also respond more strongly to face-to-face interacting, than non-interacting dyads. Consistent with the functional properties of neurons in these regions, EBA shows an effect for both static and dynamic body dyads, pSTS only for dynamic dyads [4-6].

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4 Critically, static body dyads do not yield pSTS activity. If it doesn't even generalize between static  
5 and dynamic stimuli, in what sense is the representation of social interaction in pSTS abstract?  
6 Other effects that are interpreted as high-level feature representation in pSTS [1], can be  
7 explained by fine-tuning to kinematic aspects of the stimuli. In particular, neural patterns in pSTS  
8 discriminate between *helping* and *hindering* events, as depicted in coordinated motion patterns  
9 of two agents [7]. Before representation of social-goal compatibility (cooperation vs. competition),  
10 discrimination could concern those motion patterns: in *helping* the two agents move along the  
11 same trajectory, in *hindering* they move in opposite directions (Figure 1B). Key evidence for  
12 abstraction of features as high-level as goal compatibility, would be that the pSTS response to  
13 *helping* in one situation (climbing up a hill) generalizes to a different situation (opening a box).  
14 This kind of evidence is missing.  
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20 In EBA, increased response to both static and dynamic social interaction could suggest  
21 abstraction. However, such general response would also be found if EBA responds to each static  
22 snapshot that forms a motion sequence, as appears to be the case [8]. In effect, the response to  
23 body dyads in EBA does not even generalize to dyads of faces: EBA responds more to facing (vs.  
24 non-facing) bodies, but does not show a comparable effect for facing (vs. non-facing) faces [9].  
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28 If we dismiss the hypothesis of abstraction, discrimination between categories of social  
29 interactions (e.g., arguing vs. celebrating) in EBA (Figure 1C) [10], may reveal so-far uncharted  
30 visual sensitivities to relational properties of facing/related bodies [11-12]. For instance, recent  
31 work shows that EBA, like pSTS, is sensitive to alignment/synchrony between facing individuals  
32 [11] (Figure 1D). Thus, rather than categorization, discrimination of social interactions (arguing vs.  
33 celebrating) could capture consistent variations in the level of synchrony/alignment between  
34 stimuli.  
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38 It is an empirical fact that the superior/middle temporal cortex is a hub for social-information  
39 processing, where the boundaries between perception and cognition become blurred. Measuring  
40 brain response during the presentation of large sets of naturalistic events—a trend in the field—is  
41 highlighting the extent of this territory. However, research on algorithmically controllable stimuli is  
42 still needed to define which features, and to what extent, give rise to an individual's *perception* of  
43 social interaction. This painstaking work can benefit computer vision, where bottom-up models  
44 have already seen improvements towards human-level social-interaction recognition, with the  
45 introduction of visual *social primitives* in the inputs [1]. It can also help isolate truly abstract  
46 representations of social interactions in the brain, those that might or might not correlate with the  
47 visual properties of the stimuli, but are independent from them and from the objects that instantiate  
48 the interaction, generalizing across features, exemplars and stimulus modalities.  
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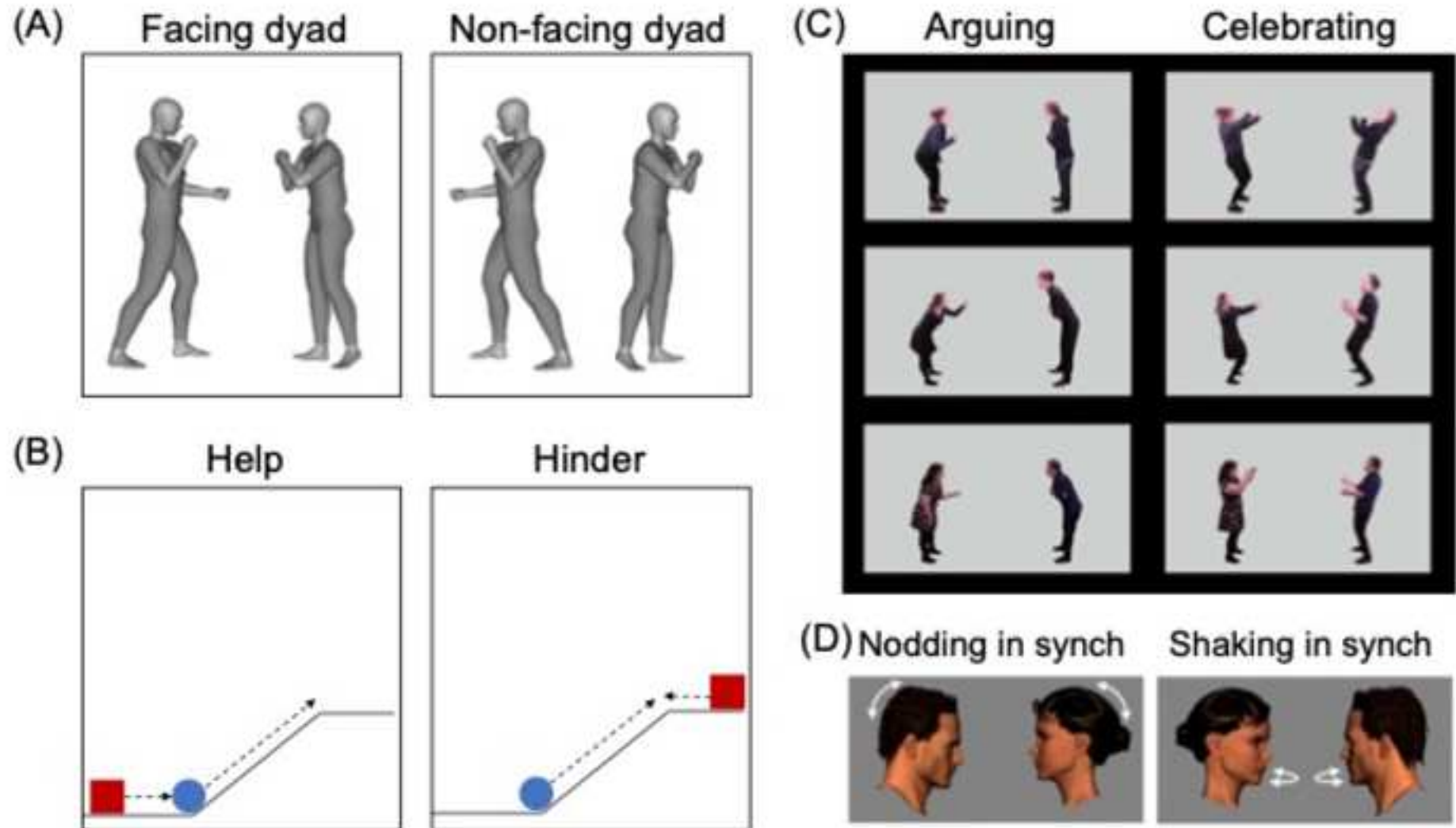
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4 **Figure legend**  
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8 **Figure 1. Effects of social interaction perception in the lateral occipito-temporal visual areas are**  
9 **observed with stimuli that can be discriminated based on high-level as well as lower-level visual**  
10 **features.** (A) In the posterior superior temporal sulcus (pSTS) and extrastriate body area (EBA),  
11 the stronger response to interacting (vs. non-interacting) bodies can be reduced to the effect of  
12 spatial positioning: a stronger response to facing –seemingly interacting– than non-facing bodies  
13 [4,6,9]. (B) The pSTS responds to animated shapes that act as social agents, and discriminates  
14 between events differing for goal-compatibility (helping vs. hindering) as well as motion patterns  
15 (same trajectories vs. opposite and colliding trajectories) [7]. (C) In the EBA, discrimination  
16 between social interaction categories (arguing vs. celebrating) [10] remains compatible with the  
17 effect of systematic visual differences, for instance, in postural relations, alignment and synchrony.  
18 (D) Recent findings show sensitivity to postural alignment and/or synchrony of face-to-face  
19 individuals, in EBA and pSTS [11].  
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