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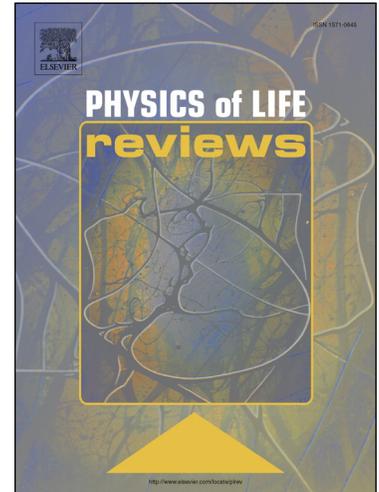Arianna Curioni, Natalie Sebanz, Günther Knoblich

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Can we identify others' intentions from seeing their movements? Comment on "Seeing mental states: An experimental strategy for measuring the observability of other minds" by Cristina Becchio et al.

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In their review, Becchio and colleagues describe the 'unobservability principle' and the 'direct social perception thesis' as two competing accounts of how people identify others' intentions (Becchio et al., 2017). The former treats intentions as private information that is hidden within individual minds. The latter treats intentions as public information that can be directly perceived from observed movements. The authors propose a new method for quantifying cues to intention from human movement, providing support for the 'direct social perception thesis' in the domain of instrumental actions. Without doubt this new approach is valuable in establishing whether there is a dissociation between the presence of movement cues in the perceptual input and people's ability to make use of these cues for identifying intentions. It is also valuable in identifying movement parameters that could be crucial for improving the planning of instrumental actions in robotic agents so that their movements become better identifiable for human observers.

What is less clear in Becchio and colleagues' review is how radical one should be in adopting the 'direct social perception thesis'. The less radical reading of their claims is that observing human movements can provide systematic cues to identifying the intentions underlying movements. Many proponents of what the authors call the 'unobservability principle' would not disagree with such a weak reading because they postulate that intentions (and other mental states) are sometimes but not always hidden from observers. The more radical reading of Becchio and colleagues' claims that is in line with ecological psychology (Gibson, 1978, Turvey & Shaw, 1995) and philosophy in the phenomenological tradition (Zahavi & Gallagher, 2008) can be stated as follows: the perception of movement cues is necessary and sufficient to identify intentions. In our commentary, we will provide three challenges for this more radical claim and conclude that the research performed by the authors so far does not (yet) support this claim.

1) Is perception of human movement necessary and sufficient for identifying intentions?

The 'direct social perception thesis' is not the only theory in Social Cognition postulating that inferential processes are not always necessary to represent others' intentions and other mental states. Developmental theories of how infants are able to distinguish agents from objects (attributing intentionality to the former but not to the latter) stress that, for identifying intentions, inference is not always necessary. However, unlike the 'direct social perception thesis', they highlight that perception alone is not sufficient. These accounts postulate that identifying intentions relies on perceptual heuristics that are biased towards cues to intentional action, such as whether an observed action is performed in an efficient way (Gergely & Csibra, 2003) or whether

an agent's movements are self-propelled (Baron-Cohen, 1994, Leslie, 1994, Premack, 1990). These basic abilities to identify intentional agents emerge long before infants are capable of reasoning about others' mental states (before they develop a Theory of Mind, Leslie et al., 2004), as early as at the age of 6.5-months (Csibra, 2008). The early onset of these abilities has been taken as evidence for a core knowledge system specialized in identifying intentionality (Spelke & Kinzler, 2007; Carey, 2009). It is assumed that this domain-specific core system does not derive entirely from experience, but has its roots in innate biases of the perceptual system. In this view, perceptual biases preferentially processing cues to an agent's intentionality are a precondition for discriminating between different intentions based on different movement patterns. This implies that early identification of intentionality relies on whether movement cues match the specifications of the core system rather than on kinematic specifications of intentions only (Runeson & Frykholm, 1983). In support of this, experiments on infants demonstrated that computing the *efficiency* of an action performed by an agent seems to be sufficient for attributing intentionality to this agent (Csibra et al., 2003). Further studies show that movement cues to agency and intentionality are not restricted to human movements as children and adults show a propensity to attribute intentions to animated objects that move in non-human ways (Abell, Happe, & Frith 2000; Heider & Simmel 1944; Isik et al., 2017). Together, the developmental evidence suggests that identifying intentions is not a purely bottom up perceptual process discriminating differences in movement patterns. A full account of how intentions are identified seems to require additional cognitive components, for instance, processes that guide perception towards relevant cues.

2) Is predicting future action outcomes sufficient for identifying intentions?

From a radical reading of Becchio and colleagues' claims, according to which perceiving movement cues is necessary and sufficient for identifying intentions, it follows that categorizing specific movement patterns should be sufficient to identify the intentions driving an observed action. However, it is questionable whether the phenomena addressed in Becchio and colleagues' research require identifying the intention behind an action, or whether predicting the action outcome or end state of an action sequence is sufficient. Observers in Becchio and colleagues' studies may simply compute how likely a certain action outcome is (e.g. grasping to drink) given the available perceptual information (e.g. reaching for a bottle with a characteristic movement). Although predicting action outcomes can provide important cues to the intentions underlying actions, it is not necessary and sufficient to identify intentions.

To illustrate, imagine two friends sitting at a table in a bar. Aysche does not want her friend Eszter to notice that she does not like the bottle of wine Eszter has ordered for the two of them. She reaches for the glass of wine in front of her, grasps it, and moves it to her mouth pretending to drink without actually drinking. A radical version of the direct social perception thesis predicts that movement cues should be sufficient for Eszter to tell that Aysche only pretends to be drinking. In contrast, the 'unobservability principle' holds that movement cues alone do not allow Eszter to

identify Aysche's intention of concealing her opinion about the wine by pretending to drink. Identifying this intention would require that Aysche shares her inner states through verbal communication or other appropriate means.

If the authors wanted to defend a radical version of the direct social perception thesis they would need to demonstrate that movement cues to intentions such as pretending or deceiving can overrule movement cues that point to the particular outcomes of instrumental actions. At present, their approach seems to equate intention identification with predicting action outcomes. This limits generality and restricts the approach to the domain of instrumental actions where different intentions behind the same actions can lead to identifiable differences in movement patterns. It leaves open the question of how more 'private' intentions are identified and integrated in the processing of the observed actions. These involve pretense, deception, and other aspects of inner mental life that do not necessarily show up in the outcomes of instrumental actions.

3) Is the observability principle sufficient for identifying intentions in social interactions?

Identifying intentions from others' movements is a key component to success in a wide range of social interactions. The authors' 'observability principle' exclusively focuses on movement cues about others' intentions that are available in the here and now. This is illustrated by Becchio and colleagues' model, where perceptual evidence is *accumulated* during action perception towards identifying one of two possible intentions of an observed agent.

However, identifying intentions in social contexts draws on factors that go beyond the currently perceived movements such as the shared interaction history of the individuals involved. This implies that identifying intentions may crucially depend on factors that are prior or external to the processing of movement information in the here and now. For instance, a prior interaction history that two or more individuals share might narrow or expand the space of possible intentions they assign to each other. Imagine sitting at the dinner table with a friend who you know is training for a marathon. When she reaches towards a corner of the table where you can see a bowl of salad and some lasagna, this knowledge is likely to play a key role in identifying her intention as grabbing the lasagna rather than the salad, as you know she needs highly caloric food, even if movement cues suggest otherwise. In such a scenario, the most effective way to predict her intention seems to involve finding a good balance between your knowledge of your friend's future intention (Pacherie, 2008) to run a marathon and the currently accumulating movement information in the perceptual system. The specific context of where and when an interaction takes place may provide further cues to the range of intentions that are potential drivers of individual behavior.

Even if one focuses on cues to intention available in the here and now of a specific interaction there are many other perceptual cues to a person's potential intention than the ones available from a person's movement. For instance, research on person perception has shown that social biases, stereotypes, and prejudices can strongly influence our processing of observed actions, often in an implicit manner (Greenwald et al., 1998; Devine, 1989). Like interaction histories and interaction contexts, such cues can play a major role in determining the range of potential intentions an

observer is considering. The range of intentions a police officer considers when she sees an individual reaching for something in her bag will possibly differ a lot depending on whether the individual is a Black or White person, as a result of stereotypes that translate into perceptual racial biases (Correl et al., 2006). Social neuroscience research has revealed the neural basis of processes in person perception that modulate how others' behaviors are perceived and which underlying intentions are attributed (Amodio, 2014; Cikara, 2015). This raises the challenge for the authors' purely bottom up approach based on discrimination of movement patterns to explain how perceptual information derived from movement patterns can be combined with other sources of information, such as categorizing individuals as members of certain groups or knowing about the long- term plans of a conversation partner.

Conclusion

Becchio and colleagues provide a new and principled method of quantifying movement cues to intention that goes beyond descriptive accounts of the experienced immediacy of identifying intentions that often characterize 'direct social perception' accounts (Gallagher, 2008). However, demonstrating that movement cues enable people to discriminate between (two) possible intentions driving instrumental actions is not sufficient to rule out the 'unobservability principle'. Inference and other cognitive processes may still play a key role in identifying intentions and other mental states. After all, people can identify intentions from movement cues provided by non-intentional agents such as artifacts (cars, robots) and attribute intentions even in the absence of movement cues as in the case of imagined agents (such as gods and ghosts).

Acknowledgments

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