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Meta-analysis

Simulating social interactions for the experimental investigation of joint attention

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ABSTRACT

Social interactions are, by their nature, dynamic and reciprocal – your behaviour affects my behaviour, which affects your behaviour in return. However, until recently, the field of social cognitive neuroscience has been dominated by paradigms in which participants passively observe social stimuli from a detached "third person" perspective. Here we consider the unique conceptual and methodological challenges involved in adopting a "second person" approach whereby social cognitive mechanisms and their neural correlates are investigated within social interactions (Schilbach et al., 2013). The key question for researchers is how to distil a complex, intentional interaction between two individuals into a tightly controlled and replicable experimental paradigm. We explore these issues within the context of recent investigations of joint attention – the ability to coordinate a common focus of attention with another person. We review pioneering neurophysiology and eye-tracking studies that have begun to address these issues; offer recommendations for the optimal design and implementation of interactive tasks, and discuss the broader implications of interactive approaches for social cognitive neuroscience.

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Humans are innately social creatures with a biological imperative for social interaction (Baumeister and Leary, 1995). We seek social interactions to share information, to accomplish shared goals, and to enjoy shared interests. As social cognitive neuroscientists, our aim is to understand the cognitive and neural mechanisms that underlie these vital social behaviours, their emergence during development, and the ways in which they may diverge from the norm in conditions such as autism, schizophrenia, and various forms of acquired or degenerative brain injury. Until recently, research in this field has relied on paradigms in which participants are presented with social stimuli (e.g., faces or videos of social interactions) that they view and respond to from a detached "third person" perspective. However, as Schilbach et al. (2013) have cogently argued, the cognitive and neural mechanisms involved in completing such tasks are not necessarily the same as those engaged in everyday social interactions where individuals must process information from a "second person" (i.e., you and I) perspective embedded *within* the interaction. Accordingly, the challenge for social cognitive neuroscientists is to develop interactive paradigms that achieve this ecological validity, whilst at the same time maintaining close experimental control. At the forefront of such efforts have been recent studies (including our own) investigating the neural correlates of joint attention. Our objective in this paper is to extract the key lessons from this nascent field of research and draw out the broader implications for social cognitive neuroscience.

The term "joint attention" refers to our ability to simultaneously coordinate attention between a social partner and an object or event of interest (Bruner, 1974). In a typical joint attention episode, one person initiates joint attention (IJA) by intentionally directing their social partner to a particular location via eye gaze, head turns, gesture (e.g., pointing), or vocalization. The other person must recognise these behaviours as having communicative intent, and respond to the joint attention bid (RJA) by attending to the same location. Finally, at least one individual must determine whether they have been successful in achieving joint attention (Tomasello, 1995). We refer to this third component as evaluating the achievement of joint attention (EAJA).[1] These behaviours emerge during reciprocal and ongoing social interactions, and are greater than (or at least different to) the combined behaviours of each individual acting alone (Hobson, 2008). As such, joint attention can *only* be experienced from within a face-to-face interaction involving at least two people. Therefore, a "second person" approach is essential to the measurement and investigation of joint attention.

To date, most research on joint attention has been conducted by developmental psychologists. It has been established that infants begin to display RJA behaviours at approximately six months of age when they reflexively follow the gaze of others around them (Mundy et al., 1994). Initiating behaviours appear somewhat later, typically between six and twelve months of age (Mundy et al., 1994). These emerging abilities are considered to be a key component of children's social and cognitive development, playing a crucial role in language development, and learning in general (Adamson et al., 2009; Baron-Cohen, 1995; Charman, 2003; Mundy et al., 1990, 2009; Murray et al., 2008; Tomasello, 1995). For instance, if a parent describes or names an object whilst directing an infant's attention to that object, and the infant responds by attending to the same object, then he or she has an opportunity to form associations between the visual, lexical, and semantic representations of the object (Baldwin, 2014). Furthermore, elay in the development of joint attention is strongly associated with autism spectrum disorders. It is one of the earliest recognisable symptoms of the condition (Lord et al., 2000) and reliably predicts the severity of social and linguistic impairments that autistic children experience (Charman, 2003; Dawson et al., 2004; Lord et al., 2000; Mundy et al., 1990; Stone et al., 1997).

Yet despite its importance in both typical and atypical development, little is currently known about the underlying cognitive and neural mechanisms that support joint attention. Models of joint attention have been proposed (e.g., Baron-Cohen, 1995; Mundy et al., 2009), but these are largely descriptive, lack detail, and are yet to be rigorously tested. The superficial nature of our current understanding is due, at least in part, to the inherent challenges in creating adequate experimental measures of joint attention. Standardized observational protocols, such as the Early Social Communication Scales (Mundy et al., 2003) and the Autism Diagnostic Observation Schedule (Lord et al., 2000), can reliably measure joint attention behaviours in young children; however, these scales do not allow for the experimental manipulations or large number of trials necessary for investigating the underlying cognitive or neural mechanisms. Until recently, experimental studies of "joint attention" were largely restricted to variations of the Posner-cueing paradigm (Posner, 1980) in which response times to a visual target are influenced by the image of a pair of eyes looking either towards or in the opposite direction of the target. However, this paradigm taps low-level "reflexive" orienting of attention (Friesen and Kingstone, 1998) and studies of autistic individuals have failed to find consistent evidence of impairment, in contrast to the findings from more naturalistic measures (Leekam, 2015; Nation and Penny, 2008). The challenge, therefore, is to develop controlled experimental tests that capture the intentional, mutual, and communicative aspects of joint attention.

Taking up this challenge, in 2010, researchers in the United States, Japan and Germany independently published three studies that effectively kick-started the field of second person neuroscience (Redcay et al., 2010; Saito et al., 2010; Schilbach et al., 2010). Each study used functional magnetic resonance imaging (fMRI) to investigate the neural correlates of joint attention. Subsequent fMRI studies (including our own) have built on and refined the methodological innovations in these three pioneering studies. In the following section of this paper, we review this growing body of research. Our focus is less on the particular findings of these studies (see Pfeiffer et al., 2013 for a comprehensive review) and more upon the tasks themselves. In particular, we consider how the three components of joint attention (RJA, IJA, and EAJA) have been operationalised and (critical to any fMRI study) the baseline conditions with which they have been contrasted.

In the second half of the paper, we provide a synthesis of the critical issues affecting the measurement of joint attention using a second-person approach. In particular, we consider the importance of realistically complex interactions, the intentional nature of the interaction, and the question of whether participants need to interact with (or believe they are interacting with) a real person. In addition to the fMRI studies, we include insights from recent eye-tracking and electroencephalography (EEG) studies that have addressed these questions directly. We conclude by considering directions for future research.

1. fMRI studies of joint attention

1.1. Responding to joint attention bids

As noted above, the field of second person neuroscience arguably began with three fMRI studies of joint attention published

[1] Emery (2000) argues that when two people are mutually aware that they have achieved joint attention, this becomes a separate social phenomenon called "shared attention". However, in the existing experimental literature most researchers have continued to use the term "joint attention" when describing EAJA during social interactions (cf. Pfeiffer et al., 2013).