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Reviews and perspectives

Why we may not find intentions in the brain

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ABSTRACT

Intentions are commonly conceived of as discrete mental states that are the direct cause of actions. In the last several decades, neuroscientists have taken up the project of finding the neural implementation of intentions, and a number of areas have been posited as implementing these states. We argue, however, that the processes underlying action initiation and control are considerably more dynamic and context sensitive than the concept of intention can allow for. Therefore, adopting the notion of 'intention' in neuroscientific explanations can easily lead to misinterpretation of the data, and can negatively influence investigation into the neural correlates of intentional action. We suggest reinterpreting the mechanisms underlying intentional action, and we will discuss the elements that such a reinterpretation needs to account for.

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1. Introduction

Actions are generally thought to be the result of a preceding intention to act. You intend to grasp the cup in front of you, and subsequently (and consequently) you grasp the cup. Upon being asked why you grasped the cup, you will probably reply by stating

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your further intentions concerning the cup, e.g. drinking from it, or putting it in the dish washer. Our daily communicative practices are full of 'intention talk'. By formulating intentions we can describe, explain and predict our own behavior and that of others. This 'folk psychological' use of the concept of intention conceives of intentions as clearly identifiable, relatively simple mental states, free from context-specific details, that are the originating causes of subsequent action planning and motor movement. As such, the notion of intention figures in a variety of contexts, including psychology (Meltzoff, 1995), and philosophical theories of action (Bratman, 1987; Davidson, 1963). More recently, the folk conception of intention has been adopted in neuroscientific studies into willed action. For example, Haggard summarizes the role the notion plays in computational neuroscience as follows: "In computational motor control, for example, actions begin with a relatively simple description of a goal (e.g. 'I will stand up'). The brain must expand this task-level representation into an extremely detailed movement pattern [and] specify the precise kinematics of all participating muscles and joints. Generating this information is computationally demanding. The brain's solution to the problem may lie in the hierarchical organization of the motor system. Details of movement are decided at the lowest level of the motor system possible" (Haggard, 2005).

Attempts to localize the neural correlates of intentions, however, yield diverging results. For example, Lau, Rogers, Haggard and Passingham (2004) asked subjects to attend to their own intentions while performing an action, and found increased activation in the pre-SMA region of the medial prefrontal cortex. Haynes et al. (2007) report finding neural activation specific to subjects' intentions to either subtract or add in the medial prefrontal cortex (more anterior than Lau et al. reported), as well as lateral prefrontal cortex (see Section 5 for a discussion of these findings). As a last example, Carota et al. (2010) report that Broca's area and parietal areas control the intention to speak. If intentions are indeed context-free, amodal and high-level states, as suggested by Haggard's quote above, it is rather puzzling that they are reported to be localized in such wide-ranging areas, which seem to be related to the modality of the subsequent action.

There are also a variety of different reports about the time-course of intentions and their relation to action. Libet (1985) famously showed the existence of an action-related readiness potential 300 ms prior to the reported conscious intention. More recently, Soon, Brass, Heinze and Haynes (2008) were able to predict a decision to make a left or right index finger movement from MRI data up to 10 s prior to the reported time of decision. But if intentions are supposed to be the direct causes of actions, it is not clear why they should exhibit such a broad range of temporal relationships to the actions they are posited to cause.

If each of these investigations is looking for the same thing – namely, discrete intentions – then they produce seemingly conflicting anatomical and temporal localizations for the same type of mental state. We suggest that the disagreement is an effect of the assumption that a discrete state is responsible for the subsequent actions. This assumption is, we believe, based on two ideas. First, the consequences of action control – i.e. actions – also have an apparently[2] discrete nature. It is therefore assumed that the mechanisms responsible for this output must also make use of discrete states. Second, there is the, perhaps implicit, idea that the way in which we conceptualize intentions in our daily descriptions and explanations of behavior, capture the basic properties of the neurophysiological states implementing them.

However, a conceptual taxonomy utilized for daily social interaction ('folk psychology') need not offer a valid framework for research in cognitive neuroscience. Moreover, as we will argue throughout, the presence of seemingly discrete outputs from a process does not mean that the process itself contains or involves discrete internal states. In this paper we argue that investigations of intentional action at the neural level should consider intentions as considerably more dynamic and context dependent than our everyday manner of speaking about them suggests. We will discuss evidence that action control, specifically as implemented in the prefrontal cortex, is based on dynamic processes that are continuously updated and deeply sensitive to perceptual and motor context, and we will argue that these characteristics are incompatible with discrete intentions.

Consequently, our view suggests a substantively different approach to a neuroscience of willed action. Instead of using discrete states as part of the explanation of action control, it becomes cognitive neuroscience's project to explain how states that are stable enough to plan and control action can occur in a dynamic and context-sensitive structure. We will briefly sketch the outlines of such an alternative approach. To begin, however, we will briefly discuss the properties of the folk notion of intention, and its philosophical counterparts.

2. The folk notion of intention and its characteristics

The notion of 'intention' plays an important part in our folk psychology, our everyday framework of explaining the behaviors of ourselves and others (Anscombe, 1957; Davies & Stone, 1995; Haselager, 1997; Stich, 1983). There has been intense philosophical debate about the theoretical status of folk psychology in general (e.g. Churchland (1989), Fodor (1987), Greenwood (1991)). Here, we attempt a slightly different approach, by focusing mainly on the supposed evidence for a folk psychological category – intention – and examining whether the empirical data provide genuine support for such a notion. We will therefore not discuss the philosophical literature on the topic in detail. Two characteristics of the folk notion of intention are important for our project: Intentions are generally conceived of as being (1) context-independent, and (2) discrete states. We will discuss these two properties in more detail below.

2.1. Context-independence

Pacherie (2008), Searle (1983), and Bratman (1987) argue that the content of a particular intention is independent of the perceptual, affective, and cognitive context in which it is implemented, and therefore each particular intention needs to be subsequently embedded into a context in order to cause an appropriate action. This is not to say that these philosophers claim that the *forming* of an intention is always independent of a context: a specific context, say seeing fruits in the supermarket, can help bring about an intention to eat an apple (for instance, by causing a desire for an apple). What is meant is that the content of the intention 'I will eat an apple' is the same irrespective of the color or shape of the apples one intends to grasp, or the particular perceptual surroundings at the time or the reason for grasping them.[3] This context-independence allows one to form intentions

[2] We say 'apparently discrete', because what is taken to be 'the action' in an ongoing stream of behavior is also a matter of interpretation (see also Barker (1963)).

[3] It is also possible that one could encode specific properties of the intended outcome. One might form the intention, for example, to grasp a red apple at the Acme next Thursday. (cf. the 'neurotic planner' in Pacherie and Haggard (2010). One could, however, form this intention at any time, and it remains unchanged regardless of, e.g., the properties of the apple one eventually decides to grasp, or the room one is in when entertaining the intention. The important point is that

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