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Brain correlates of subjective freedom of choice

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ABSTRACT

The subjective feeling of free choice is an important feature of human experience. Experimental tasks have typically studied free choice by contrasting free and instructed selection of response alternatives. These tasks have been criticised, and it remains unclear how they relate to the subjective feeling of freely choosing. We replicated previous findings of the fMRI correlates of free choice, defined objectively. We introduced a novel task in which participants could experience and report a graded sense of free choice. BOLD responses for conditions subjectively experienced as free identified a postcentral area distinct from the areas typically considered to be involved in free action. Thus, the brain correlates of subjective feeling of free action were not directly related to any established brain correlates of objectively-defined free action. Our results call into question traditional assumptions about the relation between subjective experience of choosing and activity in the brain's so-called voluntary motor areas.

1. Introduction

Debates over whether humans have the capacity to make free choices have been ongoing for several centuries (Libet, 1999; Thomas, 1894; Wegner, 2002). In contrast, there is wider consensus about the existence of a *subjective experience* of acting freely (Sarkissian et al., 2010). We often have the impression that our internal conscious decisions drive our behaviour. In other words, we feel that our decisions and actions are not simple determined by the immediate environment, but rather expressions of our "agentic self" (Kane, 2005; Schüür & Haggard, 2011).

According to one view, these subjective experiences are illusory (Wegner, 2002), and the "conscious will" is merely a retrospective inference, rather than a direct readout of brain activity associated with action selection or action generation. The experimental studies supporting this view largely used behavioural methods to identify "illusions of will" (Wegner & Wheatley, 1999), and to manipulate their intensity (Vohs & Schooler, 2008). Further support for this view comes from electrophysiological and neurophysiological recordings (Libet, Gleason, Wright, & Pearl, 1983; Soon, Brass, Heinze, & Haynes, 2008). These studies show that the onset of the neural events associated with free decisions precede the reported onset of the awareness of intention, and suggest that conscious intention cannot be a causal factor for free decisions. Interestingly, however, few studies have investigated where in the brain this alleged illusion arises.

Neuroscientific studies have often defined volition by drawing a distinction between the information-processing underlying free and instructed actions. Because this definition makes no appeal to subjective experience, it has proved particularly useful in studies with animals (Thaler, Chen, Nixon, Stern, & Passingham, 1995). In this operationalization, instructed actions

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are fixed, yet possibly arbitrary, associations of stimuli with movements. Typically in instructed actions, both the timing and type of action are explicitly specified (the *when* and *what* of action (Brass & Haggard, 2008)). In contrast, free actions leave either the "what" or the "when" dimension of action underspecified ("when" (Libet et al., 1983; Thaler et al., 1995), "what" (Krieghoff, Brass, Prinz, & Waszak, 2009; Waszak et al., 2005)). Thus, free actions are those which do not entirely depend on explicit external signals, but depend more strongly on hypothesised internal sources. However, specifying precisely what these internal sources actually are has proved difficult and controversial (Nachev, Kennard, & Husain, 2009; Schüür & Haggard, 2011). They may include action goals (Gollwitzer, 1996), or memories (Tanji, 2001). As such, free actions cannot, by definition, be strongly related to any *single* environmental event, although they may be weakly related to a wide range of environmental inputs (Schüür & Haggard, 2011).

Support for the free vs. instructed account of volition comes partly from primate neuroanatomical evidence (Goldberg, 1985; Passingham, 2007). Lateral portions of the premotor cortices are responsible for instructed or reactive actions driven by explicit external signals, while medial premotor areas, notably the supplementary motor area (SMA), are responsible for free, self-generated or "projectional" action. For example, Thaler et al. (1995) showed that removal of the medial premotor cortex in monkeys impaired their ability to make learnt arbitrary arm movements at their own pace, in order to receive a food reward. The same monkeys showed less impairment to make the same movement following an external auditory cue.

This account of free choice has been supported by several human neuroimaging studies. The contrast between free and instructed movement choices has been consistently associated with increased BOLD signal in the SMA and preSMA, the rostral cingulate zone (RCZ) and the dorsolateral prefrontal cortex (DLPFC) (Cunnington, Windischberger, Robinson, & Moser, 2006; Lau, Rogers, Haggard, & Passingham, 2004; Lau, Rogers, & Passingham, 2006), (see Krieghoff, Waszak, Prinz, and Brass (2011) for a review). In particular, Mueller, Brass, Waszak, and Prinz (2007) have suggested that RCZ is mainly involved in selecting the "what" component, in the context of a given task (Desmet, Fias, Hartstra, & Brass, 2011); whilst preSMA participates in selecting the "when" component of actions. In addition, Thimm, Weidner, Fink, and Sturm (2012) have recently shown that the BOLD activations generally associated with free choice need not be associated with overt movement. Covert unrestricted choices between objects also elicited comparable BOLD activations to free selection of motor responses, centred on the medial frontal cortex regions.

This tradition has therefore capitalised on objective experimental design factors which allow instructed and free choice to be defined in terms of information that is provided by external cues, or is not so provided. This definition bypasses the subjective experience of free choice. However, understanding the neural basis of the common feeling of acting freely is important. On the one hand, if free choice is indeed illusory, understanding the mechanism underlying illusions has long been a productive approach in psychological research. On the other hand, if free choice is not illusory then the neural bases of the subjective experience of free choice may be relevant to understanding how and where free choices occur in the brain.

The scientific tradition reviewed above operationalizes voluntary action based on objective criteria. This tradition implicitly assumes that voluntary action operationalized in this objective way captures the subjective feeling of acting intentionally. However, this important implicit assumption has never been appropriately validated. If the assumption is correct, and there is a correspondence between objective and subjective accounts of free action, then the neural correlates of free and instructed choices defined objectively should roughly match with those defined subjectively. We therefore devised an experimental task in which actions were defined either on the basis of an objective definition, or on the basis of subjective experience. We then investigated the brain correlates associated with free choices under each of the two possible definitions.

Here we use and extend the classic distinction between instructed and free choice to investigate the neural correlates of *subjective* voluntariness. Importantly, we also consider that external guidance can come in varying degrees; so that the instructed/free distinction is not a simple dichotomy between two exclusive categories, but rather represents two extremes of a continuum. On this view, generating an action can involve both internal and external factors. For example, when a driver brakes or accelerates in response to a traffic signal, they are responding both to the external event of the signal's colour, but their action also depends on an arbitrary rule that they have acquired, and chosen to follow. For our purposes, we consider freedom of choice as a *graded* measure of how independent an action is from an external stimulus. When an action is strongly determined by an external stimulus, it will be "less free" than when it is not. We may then ask whether people subjectively experience degrees of voluntariness underlying individual action decisions, and whether this graded experience originates from graded levels of activation in particular brain areas.

We have adapted the classic task of random number generation (Jahanshahi, Dirnberger, Fuller, & Frith, 2000) to allow both an objective, graded continuum of integration of stimulus information, and also a graded continuum of subjective experience of voluntariness regarding action choice. Random number generation tasks have been used before in relation to volition, but for rather different reasons from ours. In particular, many free selection studies involve asking participants to produce balanced numbers of responses, while avoiding obvious patterns such as alternation. These tasks have been interpreted as covertly asking participants to generate apparently random response sequences (Roepstorff & Frith, 2004). For example, human positron emission tomography (PET) studies during random number generation tasks have suggested a critical involvement of the left dorsolateral prefrontal cortex (DLPFC), the anterior cingulate cortex, the bilateral superior parietal cortex, and the right inferior frontal cortex (Daniels, Witt, Wolff, Jansen, & Deuschl, 2003; Jahanshahi et al., 1995). These areas partially overlap with those identified with free selection tasks (Jahanshahi et al., 1995). In our case, a modified random