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Research report

Do meditators have higher awareness of their intentions to act?

Han-Gue Jo [a,b], Thilo Hinterberger [c], Marc Wittmann [d] and Stefan Schmidt [a,b,*]

[a] Department of Psychosomatic Medicine, University Medical Center Freiburg, Freiburg, Germany
[b] Institute for Transcultural Health Studies, European University Viadrina, Frankfurt (Oder), Germany
[c] Research Section of Applied Consciousness Sciences, Department of Psychosomatic Medicine, University Medical Center Regensburg, Regensburg, Germany
[d] Institute for Frontier Areas of Psychology and Mental Health, Freiburg, Germany

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ABSTRACT

Intuitively, being aware of one's inner processes to move should be crucial for the control of voluntary movements. However, research findings suggest that we are not always aware of the processes leading to movement execution. The present study investigated induced first-person access to inner processes of movement initiation and the underlying brain activities which contribute to the emergence of voluntary movement. Moreover, we investigated differences in task performance between mindfulness meditators and non-meditators while assuming that meditators are more experienced in attending to their inner processes. Two Libet-type tasks were performed; one in which participants were asked to press a button at a moment of their own decision, and the other one in which participants' attention was directed towards their inner processes of decision making regarding the intended movement which lead them to press the button. Meditators revealed a consistent readiness potential (RP) between the two tasks with correlations between the subjective intention time to act and the slope of the early RP. However, non-meditators did not show this consistency. Instead, elicited introspection of inner processes of movement initiation changed early brain activity that is related to voluntary movement processes. Our findings suggest that compared to non-meditators, meditators are more able to access the emergence of negative deflections of slow cortical potentials (SCPs), which could have fundamental effects on initiating a voluntary movement with awareness.

* *Corresponding author*. Department of Psychosomatic Medicine, University Medical Center Freiburg, Hauptstraße 8, 79104 Freiburg, Germany.
E-mail address: stefan.schmidt@uniklinik-freiburg.de (S. Schmidt).
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1. Introduction

A self-initiated movement is considered as *voluntary* if one experiences her or his own volition preceding a movement, which is not directly determined by any external stimulation. The generation of such a voluntary movement is, therefore, strongly related to an individual's internal states. An internal starting point for a movement could be an *inner impulse* or urge, which can be described as a pre-conceptual movement of the mind. Such an inner impulse may be possible to access with awareness as a certain "taste" of a mind movement, but it is unspecified and not conceptualized at first (Jo, Wittmann, Borghardt, Hinterberger, & Schmidt, 2014). This impulse may be occasionally so strong that it is hard to restrain from action execution (e.g., addictive behaviors or autonomic behaviors to avoid imminent danger to life). But sometimes it may be so subtle that it is hard to be experienced. Such inner impulses might be taken up and combined with a personal goal forming an *intention*. Whether to commit to this intention can be determined by a final *decision* process, which is also known as 'late whether decision' of human volition in the model by Haggard (2008). Thus, becoming aware of an inner impulse might be the first stage where people can realize that they are about to execute a voluntary movement (a theoretical framework of the inner process of voluntary movement is illustrated in Fig. 1). In the present study we focus on the inner process of voluntary movement, especially becoming aware of such an inner process (i.e., inner impulse or intention) and its correlates with the neural dynamics that are relevant to the emergence of conscious intention to act.

Human volitional movement has been studied by using the Libet task, in which participants were asked to perform a spontaneous finger movement driven by their own urge, desire, or decision (Libet, Gleason, Wright, & Pearl, 1983). Interestingly enough, participants are often not aware of having moved even after having been trained to introspectively attend to their movements (Keller & Heckhausen, 1990). Moreover, a recent study showed that participants sometimes initiate a voluntary movement while their mind is wandering or while they are thinking about something else (Schneider, Houdayer, Bai, & Hallett, 2013). That is, they were not aware of their inner state of voluntary movement or of a preparation of this voluntary movement, while the brain progressively builds up neural activity that could lead to the emergence of conscious intention (Desmurget, 2013). Those studies recorded Electroencephalography (EEG) to investigate neural representations of the temporal course of volitional movement. Especially the negative deflections of the slow cortical potentials (SCPs), i.e., the so called readiness potential (RP) and the contingent negative variation (CNV) depend on the task demands (Birbaumer, Elbert, Canavan, & Rockstroh, 1990), are of interest as they are indicative of movement preparation. Although the causal relationship between the RP and conscious decision-making is questioned, a common understanding of the RP is that a negative potential shift before a self-initiated movement creates decision processes related to voluntary action (Shibasaki & Hallett, 2006). Here we thus presume that the negative deflections of SCPs might be relevant to the inner process of voluntary movement initiation, even if not a decision-making process (Jo, Hinterberger, Wittmann, Borghardt, & Schmidt, 2013).

Recent evidence shows that a voluntary movement is more likely initiated during negative deflections of SCPs, resulting in an averaged negative potential before movement onset (Jo et al., 2013; Schurger, Sitt, & Dehaene, 2012). Averaging these negative potentials over trials leads to the characteristic signature of the RP. In addition, it was demonstrated that a conscious intention to act is paralleled by ongoing negative deflections of SCPs, showing that RP-like negative potentials are found when participants are aware of an inner impulse or

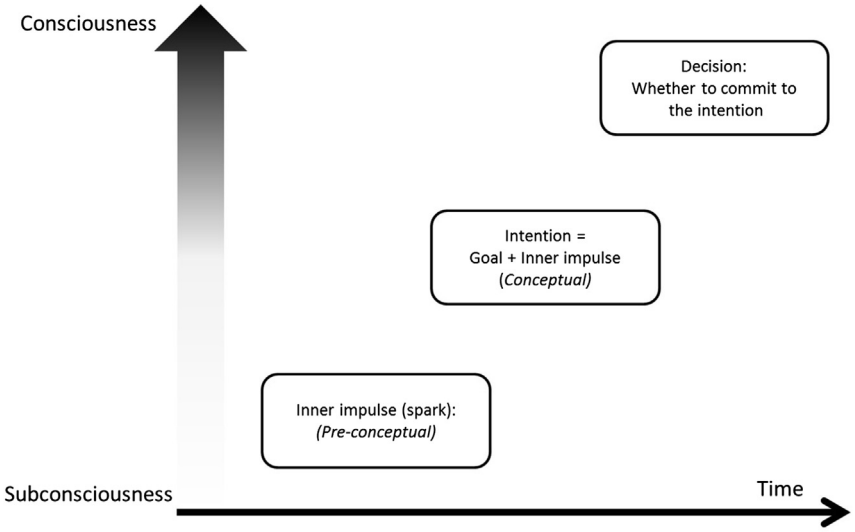

Fig. 1 – A gradual phenomenon of consciousness during an immediate voluntary movement process. An *inner impulse* that is a pre-conceptual movement of the mind can be considered as the spark, initiating a behavior in accordance with one's goals and plans. The inner impulse is conceptualized by taken up and combined with a personal goal, leading to from an *intention*. Whether to commit this intention can be determined by a final *decision* process.