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Differences in cortical activity related to motor planning between experienced guitarists and non-musicians during guitar playing

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ABSTRACT

The influence of motor skill learning on movement-related brain activity was investigated using electroencephalography. Previous research has indicated that experienced performers display movement-related cortical potentials (MRCPs) of smaller amplitude and later onset compared to novices. Unfortunately, previous studies have lacked ecological validity with experimenters recording the MRCP prior to simple motor tasks and applying the results to more complex motor skills. This study replicated previous research using an ecologically valid motor skill; recording the MRCP from a group of experienced guitarists and a control group of non-musicians while they played a simple scale on the guitar. Results indicated no difference between groups in early motor planning. In contrast, the later, negative slope and motor potential components were of smaller amplitude and the negative slope began later in the experienced guitarists. The data may indicate that, for experienced guitarists, a reduced level of effort is required during the motor preparation phase of the task. These findings have implications for musical instrument learning as well as motor skill acquisition in general.

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1. Introduction

Performance of most motor skills can be improved by accurate, long-term practice. What occurs within the brain to reflect this improved performance is less clear. Electroencephalography (EEG) can be used to examine movement-related cortical activity with high temporal resolution (Luck, 2005) and, as such, is a suitable technique for investigating changes in cortical activity that may be associated with motor skill learning and performance.

In the final seconds prior to voluntary movement production there is an increase in electrical activity in the motor areas of the brain, known as the movement-related cortical potential (MRCP). One component of the MRCP, the Bereitschaftspotential (BP), is a slowly rising negativity that occurs 1–2 s prior to movement onset (Kornhuber & Deecke, 1965; for a review see Shibasaki & Hallett, 2006). The BP is followed by a steeper gradient negativity, the negative slope (NS'), which occurs at 400–500 ms prior to movement onset (Shibasaki, Barrett, Halliday, & Halliday, 1980). These components are followed by the motor potential (MP), the peak negativity occurring concomitantly to movement onset in contralateral central sites. Both the amplitude and onset times of these components vary depending on the physical and psychological characteristics of the forthcoming movement (Birbaumer, Elbert, Canavan, & Rockstroh, 1990). As such, the MRCP may reflect the cortical activity involved in planning and preparing to perform voluntary movements (Shibasaki & Hallett, 2006). A schematic representation of the pre-movement components of the MRCP is displayed in Fig. 1.

Several studies have investigated differences in the MRCP amplitude and onset times between expert and novice performers to aid our understanding of learning-related changes in brain functioning (e.g., Di Russo, Pitzalis, Aprile, & Spinelli, 2005; Fattapposta et al., 1996; Hatta, Nishihira, Higashiura, Kim, & Kaneda, 2009; Kita, Mori, & Nara, 2001). The main findings from these studies are that expert performers show smaller amplitude and later onset MRCPs than their novice counterparts, prior to task performance. This has been shown in groups of expert and novice clay target (Di Russo, Pitzalis, et al., 2005) and pistol shooters (Fattapposta et al., 1996), as well as in elite and novice kendo martial art performers (Hatta et al., 2009; Kita et al., 2001). These authors have generally concluded that experienced performers are able to plan and perform the task with reduced cortical activity compared to novices, attributing these differences to long-term training by the expert group. This body of research is supported by several studies that have used functional magnetic resonance imaging (fMRI) to study skill-related differences in cortical activity between expert and novice musicians. For example, several

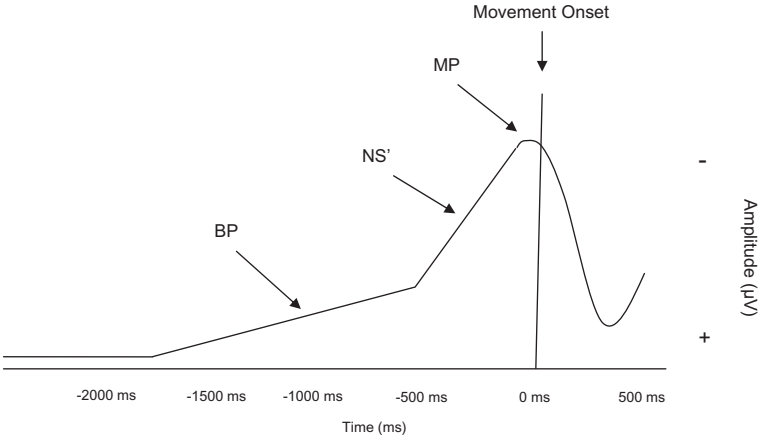

Fig. 1. A schematic representation of the movement-related cortical potential (MRCP). Time 0 ms on the horizontal axis indicates the point of movement onset. The pre-movement components, termed the Bereitschaftspotential (BP), the negative slope (NS') and the motor potential (MP) are thought to reflect the cortical activity involved in planning and preparing to perform voluntary movement.