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A kinematic analysis of the association between impulsivity and manual aiming control

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ABSTRACT

Two characteristics usually found in impulsive behavior are deficits in response inhibition and the inability to delay gratification. The former behavior is called motor impulsivity, and the second is called cognitive impulsivity. This study investigates the association of motor and cognitive impulsivity with manual aiming control. We administered two neuropsychological tests to 81 healthy participants to measure their levels of motor and cognitive impulsivity. A manual aiming motor task was also applied. Subsequently, from the initial group of 81 participants, two subgroups of 27 individuals were selected by their scores on (1) motor impulsivity and (2) cognitive impulsivity, and their motor performances were compared. While a group was comprised by the top 33.3% high-impulsive participants, the other was comprised by the bottom 33.3% low-impulsives participants. The results indicate that motor impulsivity is more related to motor control than cognitive impulsivity. Differences between motor impulsivity groups were found in the duration of the primary submovement, peak velocity, score of response inhibition errors and incorrect hits score. It was found that in situations in which the temporal and spatial demands to the motor system were high, the impulsivity had a functional, adaptive effect on motor control.

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1. Introduction

Characteristics usually observed in impulsive behavior are the inability to inhibit an activated or precued response (Dannon, Shoenfeld, Rosenberg, Kertzman, & Kotler, 2010) and the rapidity of response (Moeller, Barrat, Dougherty, Schmitz, & Swann, 2001). Impulsive behavior in normal adults may be partially attributable to inhibitory dyscontrol, often referred to as motor impulsivity. High-impulsive subjects demonstrate a difficulty in ignoring irrelevant information and suppressing inappropriate responses compared to their low-impulsive counterparts (Enticott, Ogloff, & Bradshaw, 2006).

Another common impulsive behavior discussed in the literature is the inability to delay gratification, observed as an increased preference for an immediate reward over a more advantageous but delayed reward (Pattij & Vandershuren, 2008). In gambling tasks, for example, impulsives tend to maintain high risk strategies to obtain immediate rewards regardless of the possible negative consequences of this behavior. Bechara, Damasio, and Damasio (2000) argue that the inability to delay gratification is a more complex form of disinhibited behavior. This facet of impulsivity is called impulsive decision making (Pattij & Vandershuren, 2008) or cognitive impulsivity (Bechara et al., 2000).

The impact of impulsivity on human behavior has been much investigated as far as different aspects of cognition and social interaction are concerned, but are less studied in motor domain. Studies have shown that high-impulsive subjects present higher reaction time than low-impulsives in conditions of low compatibility stimulus-response (Expósito & Andrés-Pueyo, 1997) and are less accurate than low-impulsives in tapping at a specified rate (Barrat, 1981) and on pursuit rotor (Barrat, 1967). Furthermore, high-impulsives trace circles faster than the low-impulsives (Bachorowski & Newman, 1985, 1990). In spite of some controversial findings (cf. Dickman, 1993), the general pattern over the course of these studies has indicated that high-impulsive subjects are faster in their responses but less accurate than their less impulsive counterparts.

Recently, two studies used advanced techniques of motion analysis to assess possible differences between low- and high-impulsive subjects in terms of a general measure of impulse control (Lemke, 2005; Lemke et al., 2005). In both studies, kinematic analysis was used to investigate the role of impulsivity in a goal-directed aiming task. Healthy individuals with higher impulsivity scores on BIS-11, a self-report questionnaire, demonstrated shorter relative times required to achieve peak velocity than those who were less impulsive. There were no differences between low- and high-impulsive subjects in movement time, peak velocity or movement trajectory.

Goal-directed manual aiming movements performed with visual feedback include an initial impulse part that roughly approaches the target by open-loop control and a final homing part under closed-loop control, with adjustments visually guided in the last portion of the movement (Woodworth, 1899). A common kinematic marker used to distinguish the two components of the movement is the peak velocity. The time interval preceding peak velocity, the initial impulse, reflects the preprogrammed characteristics of the movement. After peak velocity is achieved, an error correction phase or final homing part occurs (Khan et al., 2006). Results from Lemke (2005) and Lemke et al. (2005) indicate that differences between low- and high-impulsive subjects in aiming tasks occur in the preprogrammed part of the movement. However, because the discontinuities in acceleration after the peak velocity, indicating adjustments, were not analyzed, it is possible that low- and high-impulsive subjects also demonstrate differences in visually guided online corrections.

We designed this study to investigate if there is dissociation between impulsivities (motor and cognitive) and motor performance in an aiming task with different sensory-motor requirements. Cognitive resources are recruited to enable holding information in mind in order to remember the supposed goal, to resist distraction and stay on task, to resist responding too early, and to inhibit a prepotent response. All these functions are related to response selection and monitoring. From the two types of impulsivity, motor impulsivity seems to be more associated with these cognitive functions. This assumption is based on the view that cognitive (decision-making) impulsivity is a more complex form of disinhibited behavior (Bechara et al., 2000) that may not directly influence manual motor control. The inability to delay gratification is not a typical variable of influence in a fast aiming task. Hence, we hypothesized that motor impulsivity is more associated with motor control than cognitive impulsivity.