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Long-term reliability and stability of behavioral measures among adolescents: The Delay Discounting and Stroop tasks

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ABSTRACT

Delay Discounting (DD) and the Stroop test are two fundamental tasks for the assessment of impulsivity and inhibitory control, core features of several behavioral disorders. Although the study of reliability and temporal stability is important, only studies with adults and small samples have been carried out. The aim of this study is to assess the one-year reliability and temporal stability of both tasks among adolescents. A total of 1375 adolescents ($M = 13.08$ years old, $SD = 0.51$) made up the final sample (53.5% males). The results showed moderate stability and good reliability for both DD ($\alpha = 0.90$) and Stroop ($\alpha = 0.85$). Indices based on the reaction times and not the number of errors are recommended when using the Stroop test. These results support the use of both behavioral tasks in longitudinal research among adolescents.

1. Introduction

Impulsivity is a multidimensional construct, often defined as a predisposition to rapid and unplanned reactions to internal or external stimuli regardless of the long-term negative consequences (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). Although there is no comprehensive model that accounts for all of the features that this construct comprises, two facets (impulsive choice and inhibitory control) have been consistently shown as central variables in various psychiatric and behavioral disorders (Alcorn et al., 2013; Chamberlain & Sahakian, 2007; Perry & Carroll, 2008). In addition, several explanatory models have identified low inhibitory control as an underlying factor of other dimensions of impulsivity (Enticott, Ogloff, & Bradshaw, 2006; Logan, Schachar, & Tannock, 1997), so impulsive choices would be a consequence of inhibitory problems related to certain responses. Furthermore, the role of these variables is even more relevant during adolescence, when the executive functions are only partially developed (Zelazo & Müller, 2002), and most risk behaviors such as substance use (Banich et al., 2007; Chambers, Taylor, & Potenza, 2003), risky driving (Ryb, Dischinger, Kufera, & Read, 2006) or sexual risk (Hayaki, Anderson, & Stein, 2006) behaviors begin to occur.

Two main approaches have been developed to assess impulsivity: self-reported questionnaires and behavioral tasks (Enticott et al., 2006). The use of behavioral tasks, which are based on specific behaviors performed in normative situations,

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helps us to overcome the validity threats of self-reported information, such as social desirability or insufficient insight to rate personality constructs. Moreover, these technologies also allow for in situ evaluations, extending their use from experimental to clinical settings (Stanger et al., 2012; Streeter et al., 2008). Considering that impulsive people do not account for long-term consequences, one of the most used behavioral tasks for assessing impulsivity is the Delay Discounting task (DD, see Bickel, Koffarnus, Moody, & Wilson, 2014 for a review). This task conceives impulsivity as the tendency to choose smaller, immediate rewards over larger but more delayed ones (Johnson & Bickel, 2002), and it has been used in several studies due to its sound validity (Imhoff, Harris, Weiser, & Reynolds, 2014; Manwaring, Green, Myerson, Strube, & Wilfley, 2011; Petry, 2001). Similarly, the Stroop test has been widely used as a measure of inhibitory control in several contexts (Dimoska-Di Marco, McDonald, Kelly, Tate, & Johnstone, 2011; MacLeod, 1991; Sharma, Albery, & Cook, 2001). Inhibitory control is defined as the ability to control or suppress a response that has already been initiated (Bickel, Jarmolowicz, Müller, Gatchalian, & McClure, 2012). The well-known Stroop effect (Stroop, 1935) is produced when the inhibitory control is not effective enough to prevent the interference of automatically activated characteristics of stimuli, precluding the correct task performance.

Notwithstanding the wide use and acceptance of these tasks among adults, the evaluation of impulsivity during a period of intense change, such as adolescence, has its challenges (Crews & Boettiger, 2009). Adolescent behaviors are highly influenced by maturational changes in the frontal cortex and subcortical monoaminergic systems, critically involved in decision making (Chambers et al., 2003). These neurodevelopmental changes have been shown to influence adolescents' behavior through the differential activation of both cortical control and deep brain rewarding regions (Casey et al., 2011; Steinberg et al., 2008). However, changes in impulsivity measures are less conclusive, with different studies suggesting decreases (Harden & Tucker-Drob, 2011), quadratic patterns (Collado, Felton, MacPherson, & Lejuez, 2014) and mean-level stability (Pedersen, Molina, Belendiuk, & Donovan, 2012) across adolescence. Also, whether behavioral indices are stable traits or changing state-dependent measures is still a matter of debate (Audrain-McGovern et al., 2009; King, Patock-Peckham, Dager, Thimm, & Gates, 2014; De Wit, 2009). For these reasons, it is important to shed light on the possible significant effects of impulsivity changes on the test-retest reliability of these measures. If behavioral measures in adolescents are not as stable as in adults, this prevents the direct generalization of the psychometric properties obtained in this latter population. Moreover, if behavioral measures between different time periods are randomly related, they will not be deemed more suitable than self-reports for longitudinal research.

Although previous studies have shown DD as a moderate stable measure in both clinical (Black & Rosen, 2011; Takahashi, Furukawa, Miyakawa, Maesato, & Higuchi, 2007) and non-clinical adult populations (Baker, Johnson, & Bickel, 2003; Beck & Triplett, 2009; Kirby, 2009; Ohmura, Takahashi, Kitamura, & Wehr, 2006; Simpson & Vuchinich, 2000; Smits, Stein, Johnson, Odum, & Madden, 2013; Weafer, Baggott, & deWit, 2013), to our knowledge there is only one study that addresses this issue among adolescents. This study, conducted with a relatively small sample of adolescents, assessed the one-year test-retest reliability of DD (Anokhin, Golosheykin, & Mulligan, 2015). The results showed moderately high correlation magnitudes among late adolescents ($r = 0.65$ - 0.77). Although it is during early adolescence when impulsivity levels peak (Steinberg et al., 2008), no study has evaluated the stability of DD in this early stage of adolescence.

As stated before, maturational changes also influence performance in inhibitory control tasks such as the Stroop test. Despite the moderate to high test-retest reliability yielded among adults (Eide, Kemp, Silberstein, Nathan, & Stough, 2002; Kindt, Bierman, & Brosschot, 1996; Ludwig, Borella, Tettamanti, & de Ribaupierre, 2010; Siegrist, 1997; Strauss, Allen, Jorgensen, & Cramer, 2005; Wöstmann et al., 2013), no previous studies have examined its temporal stability in early adolescents.

The goal of this study is to analyze the internal consistency and one-year stability of the Delay Discounting and Stroop test in a large sample of early adolescents from the general population. This would help us to understand the stability of impulsivity measures during this important period of life. As the study is being carried out in the general population, and despite the reported neurocognitive changes, we expect behavioral measures of impulsivity to be moderately stable, as is the case with late adolescents.

2. Method

2.1. Participants

The participants at T1 were 1621 adolescents aged 12–14 years, recruited from 22 high schools following a random stratified and incidental procedure. One year later (T2) 1529 participants (94.32%) were reassessed. The inclusion criteria were that participants had to: 1) be younger than 15 years old at the first wave and 2) have no sensory impairment. After removing participants not meeting the first ($n = 85$) and the second ($n = 1$) criteria, there were 1375 participants that fulfilled all of the inclusion criteria, and were reassessed at T2 (because administrative reasons not related to the study 68 participants were lost at follow-up). The participants' mean age at the first wave was 13.08 ($SD = 0.51$), with 53.5% being males. The average test-retest interval was 388.54 days ($SD = 33.95$). The mean age at the second wave was 14.14 ($SD = 0.6$) and the attrition rate was 5.68%.

Participation in the study was voluntary and approved by the centers, parents, and education authorities. Letters were mailed in order to obtain the parents' written consent and no parents refused to allow participation. The participants were given guarantees of confidentiality and anonymity. Because of requirements of the educational authorities, the participants who were lost at follow up were due to excused absence not related with the study outcomes (e.g. illness).