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The Attention-Lapse and Motor Decoupling accounts of SART performance are not mutually exclusive ☆

Paul Seli *

Department of Psychology, Harvard University, Cambridge, MA, USA

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ABSTRACT

There is an ongoing debate about the mechanisms purported to underlie performance in the Sustained-Attention-to-Response Task (SART). Whereas the Attention-Lapse account posits that SART errors result from attentional disengagement, the Motor Decoupling account proposes that SART errors result from failures to inhibit a fast, prepotent motor response, despite adequate attention to the task. That SART performance might be fully accounted for by motor decoupling is problematic for a Attention-Lapse account, and for the use of the SART as an index of attention lapses. To test whether SART performance is in fact fully accounted for by motor decoupling, I examined the relation between SART performance and attention lapses while controlling for motor decoupling. The results were clear: The SART was associated with attention lapses independently of motor decoupling. Thus, the present study suggests that both accounts are correct and that the SART is a valid measure of attention lapses.

1. Introduction

The Sustained Attention to Response Task (SART: Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) is a popular GO/NOGO task that requires repeated responding (key presses) to a series of single "GO" digits ('1–2' and '4–9') and withholding responding when a rare "NOGO" digit ('3') is presented. Participants are instructed to respond as quickly as possible to GO digits while maintaining high accuracy on NOGO trials. Over the past decade, the SART has been widely used to assess lapsing attention/mind wandering in numerous populations, including those suffering from attention-deficit/hyperactivity disorder (ADHD; e.g., Bellgrove, Hawi, Gill, & Robertson, 2006; Dockree et al., 2004), schizophrenia (Chan et al., 2009), depression (Farrin, Hull, Unwin, Wykes, & David, 2003), traumatic brain injury (TBI; e.g., Manly, Hawkins, Evans, Woldt, & Robertson, 2002; Manly et al., 2003), cortical lesions (Molenberghs et al., 2009), affective disorders (Smallwood, McSpadden, & Schooler, 2007), and stress-related burnout (van der Linden, Keijsers, Eling, & Van Schaijk, 2005), to name a few.

A commonly held assumption in studies employing the SART is that its measures assess attention lapses/mind wandering (e.g., Christoff, Gordon, Smallwood, Smith, & Schooler, 2009; Manly et al., 2003; Robertson et al., 1997; Smallwood & Schooler, 2006; Smallwood et al., 2007). In particular, it has been claimed that the SART's fast pace and high frequency of "GO trials" result in an automatic "prepotent" response, and that in order to effectively counter this prepotent response (in cases where NOGO digits are presented), participants must attentively monitor their motor responses. Thus, when participants experience a lapse of attention during the SART, their prepotent response will be engaged, but they will fail to inhibit their response (resulting in a "NOGO error"). According to this view, then, individuals who have poorer

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* Address: Department of Psychology, Harvard University, William James Hall, 33 Kirkland Street, Cambridge, MA 02138, USA.
E-mail address: paulseli@fas.harvard.edu

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sustained-attention abilities should (1) more frequently fail to monitor their "automatic" responses, and (2) this should in turn lead them to produce a greater proportion of NOGO errors.

The Attention-Lapse account of the SART (e.g., Robertson et al., 1997) has received support from numerous investigations. Indeed, many studies have reported associations between SART performance measures and self- and other-reported cognitive- and attention-related failures experienced in everyday life (for a review see, Smilek, Carriere, & Cheyne, 2010). Moreover, research has demonstrated that, during periods of the SART in which participants report the experience of mind wandering (i.e., task-unrelated thought), they produce significantly more NOGO errors relative to periods during which they report being focused on the task (e.g., Christoff et al., 2009). Taken together, these studies provide evidence to support the Attention-Lapse account of SART performance.

Notwithstanding the foregoing evidence for the Attention-Lapse account, research has suggested that, rather than exclusively indexing lapsing attention, SART performance also appears to reflect individual differences in responding along a speed-accuracy trade-off (SATO) curve (e.g., Helton & Head, 2013, 2014; Peebles & Bothell, 2004; Seli, Cheyne, Barton, & Smilek, 2012; Seli, Cheyne, & Smilek, 2012; Seli, Jonker, Cheyne, & Smilek, 2013; Seli, Jonker, Solman, Cheyne, & Smilek, 2013; but see Manly, Davison, Heutink, Galloway, & Robertson, 2000). As a consequence of this work, some researchers have recently argued against the Attention-Lapse account of the SART, and have instead put forth the "Motor Decoupling" account (e.g., Head & Helton, 2013, 2014), which suggests that speeded responses to the frequent GO trials lead participants to fail to inhibit their responses on NOGO trials, *despite adequate attention to the task*, because the motor program for the response is initiated prior to identification of the critical stimulus (see also Helton, 2009). According to the Motor Decoupling account, then, NOGO errors are viewed strictly as the consequence of response speeding, and not lapsing attention. This has, in turn, led to the suggestion that SART errors are contaminated by an instruction-induced artifact, which renders the SART's assessment of attention lapses as problematic (e.g., Head & Helton, 2013, 2014). In support of the Motor Decoupling account, research has shown that (1) NOGO errors are consistently (and rather strongly) negatively associated with GO-trial RTs (e.g., Peebles & Bothell, 2004; Seli, Cheyne, et al., 2012; Seli, Jonker, Solman, et al., 2013; Wilson, Russell, & Helton, 2015), and (2) various manipulations that delay participants' responses result in significantly fewer NOGO errors (Head & Helton, 2013, 2014; Seli, Cheyne, Smilek, 2012; Seli, Cheyne, et al., 2012; Seli, Jonker, Solman, et al., 2013).

While there appears to be empirical support for *both* the Attention-Lapse and the Motor Decoupling accounts of SART performance, some researchers (Head & Helton, 2013, 2014) have nevertheless treated these two accounts as mutually exclusive, pitting them against each other in their investigations:

> "...there is still active debate regarding whether the SART actually measures lapses in externally directed attention *or is instead* an index of response strategy and motor impulsivity [i.e., motor decoupling] (Head, Russell, Dorahy, Neumann, & Helton, 2011; Helton, 2009; Helton, Head, & Russell, 2011; Helton, Kern, & Walker, 2009; Helton, Weil, Middlemiss, & Sawers, 2010; Peebles & Bothell, 2004; Robertson et al., 1997)" (Head & Helton, 2013, p. 914, italics added; see also Head & Helton, 2014, for similar claims).

The basic premise of the latter research appears to have been that any demonstration of SATOs in the SART would serve to disprove the Attention-Lapse account, and moreover, that such evidence would indicate that the SART exclusively indexes motor decoupling that occurs despite adequate attention to the task. Indeed, upon finding evidence of SATOs in a modified version of the SART, Head and Helton (2013) concluded that, "An alternative account [to the Attention-Lapse account] we suggest, is that SART commission errors are not actually indexes of sustained attention (perceptual awareness), but instead motor decoupling" (p. 918). Roughly one year later, the same authors went on to again provide evidence of SATOs in their modified version of the SART, but this time, they further reported that retrospective reports of mind-wandering frequency during the modified SART were not significantly associated with SART NOGO errors (a finding that is touched upon below). As such, the authors again drew the conclusion that their results lent strong support for the Motor Decoupling account, *and against* an Attention-Lapse account of the SART (Head & Helton, 2014).

In considering Head and Helton's (2013, 2014) work, there are a few important issues to consider. First, it should be clarified that the SART was initially intended to provide a measure of *motor decoupling* specifically resulting from inattention to the required response or lack thereof (Robertson et al., 1997). Indeed, recall that the developers of the SART posited that inattention to one's motor responses (i.e., motor decoupling) should result in increases in NOGO errors (hence the name, "Sustained Attention to Response Task"; Robertson et al., 1997). Thus, referring to an "alternative account" as the "Motor Decoupling account" is potentially misleading because it implies, incorrectly, that the Attention-Lapse account of the SART does not interpret SART performance in terms of motor decoupling.

Second, given that the SART was initially intended to index motor decoupling *resulting from task inattention*, it appears to be unwarranted to claim that a demonstration of SATOs in the SART, on its own, implies that all NOGO errors are the consequence of speeded responding *despite adequate attention to the task* (as in Head & Helton, 2013; Helton, 2009). Indeed, one source of SART errors could be fast responses that occur while participants maintain adequate task attention (as per the Motor Decoupling account), whereas another source of SART errors could be inattention to one's responses (as per the Attention-Lapse account).[1]

[1] Of course, at the trial level, these two types of errors are necessarily mutually exclusive: one type of error is associated with task inattention (as per the Attention-Lapse account), whereas the other is not (as per the Motor Decoupling account). At the task level, however, both of these errors could be occurring, which indicates that it is unwarranted to assume that any demonstration of one type of error precludes the possibility the other (as in Head & Helton, 2013, 2014; Helton, 2009).