Consciousness and Cognition 22 (2013) 913–919

Contents lists available at SciVerse ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Perceptual decoupling or motor decoupling?

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ARTICLE INFO

Article history:
Received 10 October 2012
Available online 7 July 2013

Keywords:
Motor control
Motor decoupling
Perceptual decoupling
Response inhibition
SART
Sustained attention

ABSTRACT

The current investigation was conducted to elucidate whether errors of commission in the Sustained Attention to Response Task (SART) are indicators of perceptual or motor decoupling. Twenty-eight participants completed SARTs with motor and perceptual aspects of the task manipulated. The participants completed four different SART blocks whereby stimuli location uncertainty and stimuli acquisition were manipulated. In previous studies of more traditional sustained attention tasks stimuli location uncertainty reduces sustained attention performance. In the case of the SART the motor manipulation (stimuli acquisition), but not the perceptual manipulation (stimuli location uncertainty) significantly reduced commission errors. The results suggest that the majority of SART commission errors are likely to be indicators of motor decoupling not necessarily perceptual decoupling.

1. Introduction

The Sustained Attention to Response Task (SART) was first conceived as a tool to measure lapses of sustained attention (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). The task itself is generally short in duration (4–6 min) relative to traditional formatted sustained attention or vigilance tasks (Helton & Russell, 2011b; Helton & Warm, 2008; Warm, 1993; Warm, Parasuraman, & Matthews, 2008). In addition to the shorter task duration, the SART differs in response criteria to targets and neutral stimuli. Participants in traditional vigilance tasks are required to respond to infrequent targets while withholding responses to frequently occurring neutral stimuli. These tasks are Go No-Go tasks with high No-Go rates and low Go rates. Conversely within the SART, participants are instructed to respond to frequent neutral stimuli and withhold responses to infrequent targets. The SART is a Go No-Go task with a high Go rate and low No-Go rate. Another difference between the SART and traditional sustained attention tasks are the primary markers of failures of sustained attention. In the SART the primary marker are errors of commission (false alarms), whereas in traditional sustained attention tasks the primary marker are errors of omission (misses).

The original SART involves participants responding to simple numerical digits (although see Head & Helton, 2012; Head, Russell, Dorahy, Neumann, & Helton 2011; Smallwood & Schooler, 2006, for use of word and pictorial stimuli used in the SART) using a stationary button response. For example, in the original Robertson et al. (1997) task, participants were randomly presented with a single numerical digit ranging from 1 to 9. Each number was presented for 250 ms followed by a 900 ms mask. Participants were instructed to make a button response to every number but to withhold responses to the target 3. Unlike traditional vigilance tasks whereby errors of omission (not responding to targets) and slower response to targets over time are of interest, the SART generally results in progressively faster response times to neutral distracters with increases in errors of commission (failing to withhold response to target) over time. In other words, performance on the traditional vigilance task is generally measured by failures to respond to critical targets (misses). Participants also exhibit progressively slower response times to targets with time-on-task. Conversely, SART performance is characterized by

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http://dx.doi.org/10.1016/j.concog.2013.06.003

participants failing to withhold overt responses to critical targets (error of commission). Additionally, participants in the SART generally have progressively faster response times to neutral distractors with time-on-task (Head & Helton, 2012; Head et al., 2011; Stevenson, Russell, & Helton, 2011). The performance metrics used in traditional vigilance tasks and the SART are different.

Despite obvious differences between traditional sustained attention tasks and the SART, the SART is widely used as a brief measure of sustained attention (Chan 2001, 2002; Docktree et al., 2004, 2006; Manly, Robertson, Galloway, & Hawkins, 1999; Manly et al., 2004; Smallwood et al., 2004). The SART has been used, for example, in studies examining sustained attention deficits due to affective disorders (O'Connell, et al., 2006; Smallwood, O'Connor, Sudbery, & Obosawin, 2007), attention-deficit/hyperactivity disorder (Docktree et al., 2004; Greene, Bellgrove, Gill, & Robertson, 2009), depression (Farrin, Hull, Unwin, Wykes, & David, 2003), schizophrenia (Chan et al., 2009), traumatic brain injury (Chan, 2001; Chan, 2005; O'Keeffe, Dockree, Moloney, Carton, & Robertons, 2007), and mind wandering (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009). Nevertheless, 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 (Head et al., 2011; Helton 2009; Helton, Head, & Russell, 2011; Helton, Kern, & Walker, 2009; Helton, Weil, Middlemiss, & Sawers, 2010; Peebles & Bothell, 2004; Robertson et al., 1997). Some consider the SART errors of commission as indicators of perceptual decoupling and failures to attend to the external stimuli (Smallwood, McSpadden, & Schooler, 2007), whereas others see them as failures of motor control or response inhibition (Helton, 2009).

Those that argue that the SART is a measure of impulsivity or response strategy claim that speeded response times and increased error rates are a result of the participants developing a self-organizing feed-forward ballistic motor program (Head et al., 2011; Helton et al. 2005). Because of the nature of the SART (fast repetitive button responses) participants develop a pre-potent ballistic motor response (Helton et al., 2011; Robertson et al., 1997). The pre-potent ballistic motor program requires active motor control, in order to appropriately inhibit the motor response to the rare No-Go signals. Indeed there is a growing body of evidence supporting a motor, not perceptual interpretation of commission errors in the SART.

First, participants in our laboratory often report (anecdotally) that they are fully aware when they make errors of commission on the SART; however, they are unable to physically stop their hand from responding. Thus, participants may perceptually be fully aware of target stimuli; however, they are unable to physically withhold their responses due to the prepotent motor routine. Second, it has been noted that participants' performance is modifiable by altering task instructions. Task instructions for the SART generally instruct participants to place equal emphases on responding fast and being accurate (Head et al., 2011; Helton & Russell, 2011a; Manly et al., 1999; Mrazek et al., 2011; Robertson et al., 1997). To test whether participants incorporate a response strategy, Seli, Cheyne, and Smilek (2012), instructed participants to slow their responses down in the task instructions. As a result, reaction time increased and errors of commission significantly decreased. By simply instructing participants to adopt a slower pace of responding, the participants made less errors of commission. Third, introducing a response delay and encouraging the participants to respond slowly by design significantly reduces errors of commission. For example, Seli, Jonker, Solman, Cheyne, and Smilek (2012), introduced an audible metronome response delay, whereby participants were instructed to respond in synch with an audible cue. Delaying participants' responses to the stimuli decreased their errors of commission. Fourth, having participants respond to an auditory version of the SART slows down the response rate and reduces errors of commission (Seli, Cheyne, Barton, & Smilek 2012). Fifth, multiple studies have demonstrated a between-subjects speed-accuracy trade-off (see Helton, 2009). Individuals who respond more quickly make more errors of commission. Sixth, new studies have demonstrated that even simple reaction time experiments (very high Go-signal rates, with a few No-Go catch trials) require proactive response inhibition which was previously overlooked (Boulinguez, Ballanger, Granjon, & Benraiss, 2009; Boulinguez, Jaffard, Granjon, & Benraiss, 2008; Wardack, Ramanoel, Guipponi, Boulinguez, & Hamed, 2012). High-Go tasks activate a feed-forward motor response and this motor response needs to be proactively inhibited. Thus in the SART you would expect pre-potent motor activation to the No-Go stimuli requiring proactive motor inhibition (Boulinguez et al., 2008; Robertson et al., 1997; Wardak et al., 2012).

To the authors knowledge, participants responses in the SART have only been captured using simple button press responses (e.g., Head & Helton, 2012; Head et al., 2011; Helton et al., 2011; Manly et al., 1999; Robertson et al., 1997). Along the lines of Seli, Cheyne, et al. (2012), Seli, Cheyne, and Smilek (2012), and Seli, Jonker, et al. (2012), another approach of slowing responses experimentally, besides inclusion of an auditory metronome signal, is to change the motor movement required to make a response. By making the SART response a motor action taking longer to execute (something beyond a short distance button press), we introduced an experimental delay without substantially modifying the perceptual features of the task itself. The present paper presents the results of an experiment in which the movement requirement of the SART was modified and investigated.

We devised a novel experimental paradigm whereby we manipulated stimuli location uncertainty and the motor task required to make a response. Previous investigations have shown that sustained attention is susceptible to performance decrements due to stimuli spatial location uncertainty (i.e., target location predictability). Indeed, stimuli occurring in unpredictable locations results in poor sustained attention performance (missed targets) vs. stimuli appearing in predictable locations (Adams & Boulter, 1964; Hong & Beck, 2010; Warm, Dember, & Hancock, 1996; Warm et al., 2008). Thus, in the current investigation we manipulated spatial location uncertainty by presenting single number target stimuli in one of four designated locations at random or in a completely predictive pattern (clockwise; see Fig. 1). If the SART errors of commission are a measure of failures of sustained attention (perceptual decoupling), then participants should have improved performance