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Impulsive responding and the sustained attention to response task

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Two studies investigated whether the sustained attention to response task (SART) is a better measure of impulsive responding than of sustained attention. Participants performed target detection tasks with global–local letter stimuli using one of two response formats: standard, responding to targets; and SART, withholding to targets. In the first experiment, performance in the SART changed rapidly over time, whereas performance in the standard format was stable over time. In the second experiment, performance in the SART was susceptible to global–local condensation tasks, a result previously found with highly impulsive individuals. Overall the results indicate that the SART is sensitive to impulsive responding.

Keywords: Attention; Impulsivity; Mindlessness; Vigilance.

Sustained attention or vigilance tasks require participants to monitor visual displays or auditory streams for target stimuli over prolonged periods of time (Davies & Parasuraman, 1982; Warm, 1984). The ability to sustain one's attention or remain vigilant is critical in many daily activities, during both work and recreation. Needless to say, lapses of attention can prove extremely dangerous—for example, when operating a vehicle or other heavy machinery (Howell, 1993; Parasuraman, 1986; Proctor & Van Zandt, 1994; Wickens, Gordon, & Liu, 1998). Given the ubiquitous importance of vigilance in people's daily lives, clinicians have closely examined sustained attention and how different neurological impairments relate to changes in the ability to sustain attention (Ballard, 1996; Berch & Kanter, 1984; Damos & Parker, 1994; Davies & Parasuraman, 1982). An issue for clinicians and neuropsychologists interested in employing sustained attention tasks in either their clinical research or diagnoses is the inconvenience of the long duration of traditional vigilance tasks. Since the pioneering work of Mackworth (1948; 1950/1961), experimentalists studying vigilance have typically employed long-duration signal detection tasks lasting from 30 min to several hours (Warm, 1993). Long test times slow down the rate of data collection, raise ethical and economic concerns regarding participants' time, potentially limit their use in test batteries, and, finally, make the use of these tasks in conjunction with modern imaging technology, such as functional magnetic resonance imaging (fMRI) and positron emission tomography (PET), difficult.

Actual task duration, however, may be a relatively unimportant dimension of sustained attention (Posner, 1978). In line with this perspective, researchers have generated short vigilance tasks demonstrating similar features to those of long-duration vigilance tasks. Three examples of short vigilance tasks are the Continuous Performance Task (CPT; Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956), often used in applied settings with clinical populations, the Abbreviated Vigilance

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Task (AVT; Temple et al., 2000), and the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997).

In the CPT observers typically detect a single letter (usually X) or in a more mentally demanding version a letter sequence (usually X following A). In the original CPT the target signals occur at random positions within a 31-letter series. Target letter appearance probability is usually 20% or higher, and the letter stimuli appear roughly one per second. Participants perform the task for a 10-min period, although this can be lengthened as needed. There have been many subsequent modifications of this task. Many studies using the CPT have, however, ignored essential features of long-duration sustained attention tasks, such as the vigilance decrement—for example, a decline in performance efficiency over the watch (Davies & Parasuraman, 1982).

The AVT is a 12-min signal detection task devised by Temple and colleagues (2000). The AVT was based on the original work by Nuechterlein, Parasuraman, and Jiang (1983) who demonstrated the occurrence of a vigilance decrement in short durations (8 min) when perceptually degraded stimuli are utilized. The AVT consists of the rapid (57.5/min), repetitive presentation of the letters O, D, and a backwards-D, with the letters masked by many small circles to reduce the figure–ground contrast. The target stimulus in this task is the letter O, which occurs randomly 20% of the time. Studies utilizing the AVT have consistently demonstrated declines in performance efficiency over the 12-min period similar to the vigilance decrement found with long-duration tasks (Helton, Dember, Warm, & Matthews, 1999; Helton et al., 2007; Helton et al., 2004; Helton, Warm, Mathews, Corcoran, & Dember, 2002; Matthews, Warm, Dember, Mizoguchi, & Smith, 2001; Rose, Murphy, Byard, & Nikzad, 2002; Temple et al., 2000). While not all findings with the AVT perfectly match those found with long-duration tasks, there are a number of parallel findings such as right cerebral dominance, improvement of performance with caffeine consumption, and high self-reported stress and mental workload (Helton et al., 1999; Helton et al., 2007; Helton et al., 2004; Matthews et al., 2001; Temple et al., 2000).

Robertson and colleagues (Robertson et al., 1997) developed the SART to investigate lapses of sustained attention in individuals with neurological impairments and high self-reported scores on the Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, Fitzgerald, & Parkes, 1982). In the SART, participants typically look for a single number (usually 3) presented at random in a series of single digit numbers. Target number appearance probability is usually 11%, and the number stimuli appear quickly (52.2/min). Participants perform the task for a 4.3-min period, although this can be lengthened. The SART was designed to promote attention lapses by altering the traditional vigilance task response paradigm, in which participants make responses to signify the detection of rare targets to one in which responses acknowledge frequent neutral signals, and response withholding signifies signal detection of the rare targets. The SART and modified versions, such as a dual-task version, have been used in a number of studies investigating sustained attention in clinical populations (Chan, 2001; 2002; Dockree et al., 2006; Dockree et al., 2004).

While the SART has proven to be a useful tool in neuropsychological research, the change of response format may tap processes other than sustained attention. The SART may, for example, be contaminated with impulsivity and response strategy regarding the relative benefits of speed and accuracy. Helton et al. (2005), for example, found with both standard response format (respond to targets and withhold responses to neutral signals) and SART response format (withhold responses to targets and respond to neutral signals) participants utilize subtle temporal patterns of target appearances. A temporal pattern of targets enhanced signal detection performance in the standard response format, but degraded performance in the SART version. Helton et al. (2005) argue that the constant responding to the more common neutral signals may lead to the development of a ballistic feed-forward motor program, which may prove difficult for the supervisory attention system to control, inhibit, or harness, especially when distracted with other activities. As Doyon, Prenhune, and Ungerleider (2003) describe, the repetitive key pressing to the very common neutral or distractor stimuli in the SART is the sort of task that leads to the development of a feed-forward motor routine. The feed-forward motor program induced by the continual pressing in the SART would require regulation by the supervisory attention system (Logan & Cowan, 1984; Matthews, Davies, Westerman, & Stammers, 2000; Norman & Shallice, 1986; Shallice, 1988; Stuss, Shallice, Alexander, & Picton, 1995). When there is a temporal pattern of the target occurrences, the supervisory system is actively keeping track of the pattern, and this interferes with motor inhibition. The observer in a SART paradigm may be completely mindful of the stimuli (e.g., perceptually aware), but may be unable to interrupt or inhibit the ballistic motor program, especially when distracted or without adequate practice in performing the task. This is not the same construct as traditional sustained attention, where performance errors are attributed to a lack of perceptual awareness of the targets due to the depletion of attention resources (Warm, 1993).

In the present two studies, target detection tasks made up of global–local letter stimuli (Navon, 1977), letters composed of smaller letters, were examined using both SART and more standard response formats. Dickman (1984) found that impulsive people have difficulties when performing condensation discriminations requiring the sorting of targets and distractors using a combination of both the global and the local letters. A global letter only discrimination, on the other hand, is generally easier for people to make. Participants in the current experiments performed both a global and a condensation global–local target detection task. Participants in both studies were randomly assigned to either the SART response format, responding to the more common distractors, or the standard response format, responding to the rare targets, to prevent response confusion. Perceptually, however, the tasks were identical.

EXPERIMENT 1

In Experiment 1, participants performed global and global–local detection tasks for three periods of watch, thus enabling the examination of changes in performance over time. SARTs are of very short duration (4–6 min), and performance changes over time have not typically been investigated in SART studies. From Helton et al.'s (2005) perspective, performance on the complex global–local detection task using the SART response format should be particularly affected. Discrimination tasks requiring both global and local letters are difficult for impulsive individuals (Dickman, 1984). If the SART elicits or is susceptible to impulsive responding, then there should be consequences for performance: either more errors or a strategic slowing of response rates. This should not be the case in the standard response format condition. In addition, the SART format, but not the standard response format, should be characterized by changes in performance over time, implicating the observers' attempts to harness or control the feed-forward motor response. These changes should not be seen in the standard format task as neither is the discrimination perceptually difficult nor is the duration of the task long enough to see the emergence of the vigilance decrement.

Method

Participants

A total of 16 undergraduate students (12 men and 4 women) from introductory psychology classes at Michigan Technological University served as participants for course credit. All of the participants had normal or corrected-to-normal vision and were right-handed as indexed by the Edinburgh Handedness Inventory (Oldfield, 1971). Participants ranged in age between 18 and 25 years ($M = 20.19$ years, $SD = 2.45$).

Procedure

A total of 8 of the 16 participants (6 men and 2 women) were assigned at random to each of the two response formats (SART and standard) to prevent response confusion. Participants were tested individually in small laboratory room. The ambient illumination in the room was 0.22 cd/m^2 provided by overhead lighting positioned to minimize glare on the video display terminal used for stimuli presentation. The display terminal (270 mm × 340 mm) was mounted on a table at eye level approximately 40 cm from the seated participant. The participants were not restrained and could move their upper bodies freely. Participants performed two detection tasks using global–local letters (letters composed of smaller letters). Participants inspected the repetitive presentation of global capital letters composed of solid smaller black capital letters. The letter stimuli consisted of either a capital H or a capital T composed of smaller capital Es or Os. The target stimulus was always an H composed of Os (H_O). In the global task, the assignment was to discriminate between H_O targets and T_O and T_E distractors. In the global–local condensation task, the assignment was to discriminate between H_O targets and H_E and T_O distractors. See Figure 1 for examples of the stimuli. Three different font sizes of the local letters were employed (12 pt, 14 pt, 16 pt) in order to reduce, though not necessarily eliminate, the possibility of the participant using a unique perceptual feature instead of the letter content to discriminate target stimuli (see Robertson et al., 1997). The global letters varied in size between 50 mm × 70 mm and 60 mm × 95 mm. The target and distractor letters were presented in random sequences with the restriction that the target letters occurred with a probability $p = .13$, and the nonsignal letters occurred with a probability of $p = .87$. The stimuli were presented for 50 ms and then were masked for a 1,100-ms intertrial interval during

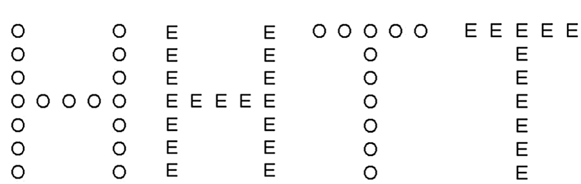

Figure 1. Letter stimuli used in Experiments 1 and 2.

which a response could be recorded; thus, there was a 1,150-ms onset-to-onset interval. There were approximately 52 stimuli presentation events per minute. The mask was a solid black rectangle (85 mm × 110 mm). Participants signified their detection of critical signals by pressing a key labeled "SIG" on an electronic response pad located in front of them. The stimuli were presented for three blocks of 2.2 min. There were no rest periods between blocks. All participants performed both the global and global–local tasks with order of tasks counterbalanced and were provided with 4.4 min of practice with the respective task prior to the start of the main test task.

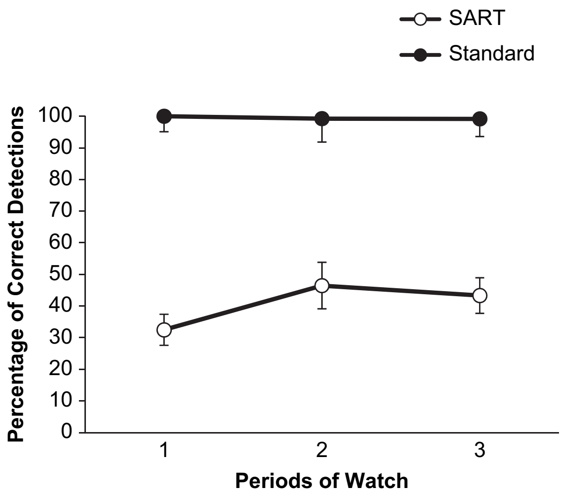

Figure 2. Mean percentages of correct detections over time for the two response formats: sustained attention to response task (SART) and standard (error bars are standard errors).

Results

Correct detections

In the standard response format correct detections were defined as key presses to the occurrence of targets stimuli. In the SART response format correct detections were defined as the withholding of key presses to such signals. The percentages of correct detections in all experimental conditions were subjected to a two (response format, SART vs. standard) × 2 (target type, global vs. global–local) × 3 (periods) split-plot analysis of variance (ANOVA). Prior to analysis the correct detection scores were arcsin transformed as recommended (Kirk, 1995; Maxwell & Delaney, 2004). The analysis revealed that the overall correct detection rate for the standard format (M = 99.5%) was significantly higher than that in the SART format (M = 40.8%), $F(1, 14) = 58.88$, $p < .001$, $\eta_p^2 = .81$. There was also a significant main effect for periods of watch, $F(2, 22) = 4.81$, $p = .03$, $\eta_p^2 = .26$, and, moreover, a significant response format by periods interaction, $F(2, 22) = 6.33$, $p = .01$, $\eta_p^2 = .31$. None of the other sources of variance in the analysis were significant, $p > .05$ in each case. The response format by periods of watch interaction is shown in Figure 2 (error bars are standard errors). It is evident that the rate of correct detections in the SART increased over time, whereas the rate of correct detections did not change over time in the standard format. In this and in subsequent analyses, Box's epsilon was used when appropriate to compute degrees of freedom for the repeated measures factors to correct for violations of the sphericity assumption (Maxwell & Delaney, 2004).

False alarms

In the standard response format false alarms were defined as key presses to the occurrence of neutral letter stimuli (distractors). In the SART response format false alarms were defined as the withholding of key presses to such events. The percentages of false alarms in all experimental conditions were subjected to a two (response format, SART vs. standard) × 2 (target type, global vs. global–local) × 3 (periods) split-plot ANOVA. Prior to analysis the false alarm scores were arcsin transformed as recommended (Kirk, 1995; Maxwell & Delaney, 2004). The analysis revealed that the overall false-alarm rate for the SART format (M = 5.8%) was significantly higher than that in the standard format (M = 0.1%), $F(1, 14) = 7.67$, $p = .02$, $\eta_p^2 = .35$. There was also a significant main effect for periods of watch, $F(1, 19) = 4.80$, $p = .03$, $\eta_p^2 = .26$, and, moreover, a significant response format by periods interaction, $F(1, 19) = 4.80$, $p = .03$, $\eta_p^2 = .26$. None of the other sources of variance in the analysis were significant, $p > .05$, in each case. The response format by periods of watch interaction is shown in Figure 3 (error bars are standard errors). It is evident

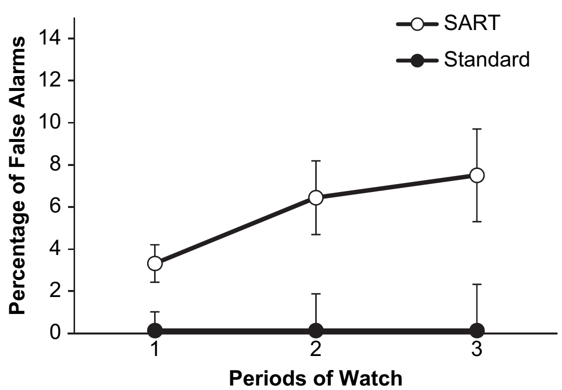

Figure 3. Mean percentages of false alarms over time for the two response formats: sustained attention to response task (SART) and standard (error bars are standard errors).

that while the false-alarm rate in the standard format did not change over time, the false-alarm rate increased over time in the SART format.

Reaction times

For each task the mean reaction times of responses were calculated for each participant for each period of watch in ms. These reaction time scores were subjected to a two (response format, SART vs. standard) × 2 (target type, global vs. global–local) × 3 (periods) split-plot ANOVA. The analysis revealed that the overall reaction times were slower for the global–local task (M = 383.7 ms) than for the global task (M = 352.3 ms), $F(1, 14) = 11.10$, $p < .01$, $\eta_p^2 = .44$, and significantly slower for the standard format (M = 414.8 ms) than for the SART format (M = 322.2 ms), $F(1, 14) = 7.77$, $p = .02$, $\eta_p^2 = .36$. There was also a significant main effect for periods of watch, $F(2, 23) = 8.65$, $p < .01$, $\eta_p^2 = .38$. None of the other sources of variance in the analysis were significant, $p > .05$, although there was a trend of a response format by periods interaction, $F(2, 23) = 3.32$, $p = .06$, $\eta_p^2 = .19$; this is presented in Figure 4 (error bars are standard errors).

Discussion

The prediction that SART response format performance would be especially influenced by global–local condensation discriminations over easier global-only discriminations was not supported by the results of this study. As the correct detection levels were very low in the SART format task, perhaps the task needs to be made easier to detect this effect. The results of this study do, however, provide partial support for Helton et al.'s (2005) perspective that the SART task taps something other than sustained attention. First, the SART response format is much more challenging than the standard response format: mean correct detection difference of 40.8 % versus 99.5% respectively, despite the two tasks being perceptually identical. Indeed, performance in the standard format was nearly flawless, suggestive of a ceiling effect. The vast difference seen in performance levels between the two response formats, despite being perceptually identical to an observer, suggests that the difference is due primarily to failures of response control not stimuli discrimination and/or detection. Second, the SART response format has a very different profile over time than does the standard format. Performance in the standard task is fairly stable over the three periods of watch; performance in the SART, however, changes rapidly. Examining correct detections, SART performance improves over periods of watch; however, when considering the change in false alarms, which also increase over time, the most parsimonious explanation is an overall reduction in responding. Both correct detections and false alarms in the SART format are due to response *withholding*. The SART response format seems to drive a rapid change towards conservativeness—for example, less pressing. This profile with regard to the SART is suggestive of attempts by the participants to harness or gain control over their responses, not failures of signal detection. The participants may be attempting to prevent inappropriate responses by increasingly withholding all responses, both appropriate and inappropriate. While there was a statistically significant increase in reaction time over periods of watch, there was a trend for an interaction of periods of watch by response format ($p = .06$), with greater increases of reaction time over periods in the SART format (see Figure 4). This trend is also suggestive of attempts by the participants to harness the motor response in the SART response format. Observers in the SART format appear, with increasing experience performing the task, to change their response strategy in order to cope with the difficulties of the task. Dickman's (1984) findings that global–local discriminations are more challenging than global-only discriminations were also supported by the findings of this study; reaction times were significantly slower in the global–local condensation task than in the global-only task.

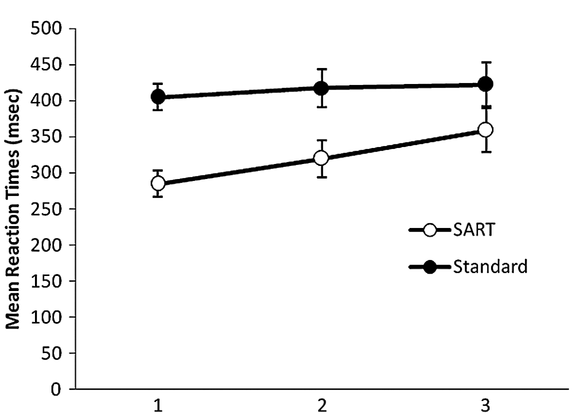

Figure 4. Mean reaction times over time for the two response formats: sustained attention to response task (SART) and standard (error bars are standard errors).

EXPERIMENT 2

As in Experiment 1, participants performed global and global–local condensation detection tasks using both standard and SART response formats.

In this study, however, the tasks consisted of only two periods of watch, and the event rate, the rate at which the letter stimuli are presented, of the tasks was reduced. In Experiment 1 the prediction that SART response format performance would be influenced by complex global–local discriminations over easier global-only discriminations was not supported; perhaps the task needed to be made easier to elicit this effect. Therefore in Experiment 2 the event rate was reduced; high-event-rate tasks are generally more challenging than low-event-rate tasks (Matthews et al., 2000).

Method

Participants

A total of 24 undergraduate students (14 men and 10 women) from introductory psychology classes at Michigan Technological University served as participants for course credit. All of the participants had normal or corrected-to-normal vision and were right-handed as indexed by the Edinburgh Handedness Inventory (Oldfield, 1971). Participants ranged in age between 18 and 23 years (M = 19.54 years, SD = 1.22).

Procedure

A total of 12 of the 24 participants (7 men and 5 women) were assigned at random to each of the two response formats (SART and standard) to prevent response confusion. The testing circumstances in this study duplicated those of the first experiment. The task was similar except that the letter stimuli were presented for 100 ms and then were masked for a 1,340-ms intertrial interval during which a response could be recorded; thus, there was a 1,440-ms onset-to-onset interval. There were approximately 42 stimuli presentation events per minute. The stimuli were presented for two blocks of 2.76 min. All participants performed both the global and global–local tasks with order of tasks counterbalanced and were provided with 5.54 min of practice with the respective task prior to the start of the main test task.

Results

Correct detections

As in Experiment 1, in the standard response format correct detections were defined as key presses to the occurrence of targets stimuli, and in the SART response format correct detections were defined as the withholding of key presses to such signals. The percentages of correct detections in all experimental conditions were subjected to a 2 (response format, SART vs. standard) × 2 (target type, global vs. global–local) × 2 (periods) split-plot ANOVA. As in Experiment 1, prior to analysis the detection scores were arcsin transformed as recommended (Kirk, 1995; Maxwell & Delaney, 2004). The analysis revealed that the overall correct detection rate for the standard format (M = 99.4%) was significantly higher than that in the SART format (M = 50.1%), $F(1, 22) = 94.65$, $p < .001$, $\eta_p^2 = .81$. None of the remaining sources of variance in the analysis were significant, $p > .05$. As in Experiment 1 in this and in subsequent analyses, Box's epsilon was used when appropriate to compute degrees of freedom for the repeated measures factors to correct for violations of the sphericity assumption (Maxwell & Delaney, 2004).

False alarms

As in Experiment 1, in the standard response format false alarms were defined as key presses to the occurrence of neutral letter stimuli (distractors), and in the SART response format false alarms were defined as the withholding of key presses to such events. The percentages of false alarms in all experimental conditions were subjected to a 2 (response format, SART vs. standard) × 2 (target type, global vs. global–local) × 2 (periods) split-plot ANOVA. As is Experiment 1, prior to analysis the false alarm scores were arcsin transformed as recommended (Kirk, 1995; Maxwell & Delaney, 2004). The analysis revealed no significant effects, $p > .05$.

Reaction times

As in Experiment 1, for each task the mean reaction times of responses were calculated for each participant by period of watch in ms. These reaction time scores were subjected to a 2 (response format, SART vs. standard) × 2 (target type, global vs. global–local) × 2 (periods) split-plot ANOVA. The analysis revealed that the overall reaction times were slower for the global–local task (M = 392.4 ms) than for the global task (M = 359.8 ms), $F(1, 22) = 12.06$, $p < .01$, $\eta_p^2 = .35$, and significantly slower for the standard format (M = 436.8 ms) than for the SART format (M = 315.4 ms), $F(1, 22) = 58.16$, $p < .01$, $\eta_p^2 = .73$. There was also a significant main effect for periods of watch, $F(1, 22) = 6.84$, $p = .02$, $\eta_p^2 = .24$, and, moreover, a significant task by response format interaction, $F(1, 22) = 8.79$, $p < .01$, $\eta_p^2 = .29$. None of the other sources of variance in the analysis were significant, $p > .05$. The task by

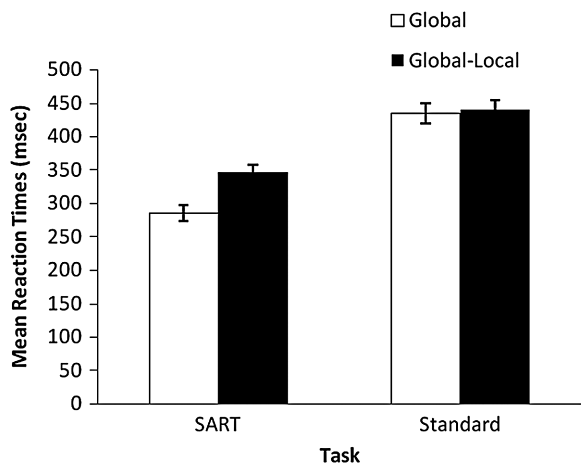

Figure 5. Mean reaction times for the two response formats—sustained attention to response task (SART) and standard—and two discrimination tasks (error bars are standard errors).

response format interaction is presented in Figure 5 (error bars are standard errors).

Discussion

The prediction that the SART response format performance would be especially influenced by global–local condensation discriminations over easier global-only discriminations was supported by the results of this study. There was a statistically significant response format by target type interaction for reaction times. Reaction times were significantly slower for the global–local task (M = 345.6 ms) than for the global task (M = 285.1 ms) for participants performing with the SART response format. In the standard response format, reaction times were nearly the same for the two tasks (M = 434.4 ms global and 439.2 ms global–local). Participants appear to have strategically slowed their responses in the more challenging global–local SART than in the global SART, as the number of correct detections (appropriate response withholdings) were not statistically different between the two tasks. Dickman (1984) argues that global–local condensation discriminations are sensitive to impulsive strategies—for example, choosing to respond quickly over accurately. Apparently this is the case for the SART in this study, as participants reduced response rates to cope with the challenging global–local task. This finding, although not conclusive, supports Helton et al.'s (2005) position that SARTs are not measures of sustained attention per se, but are heavily influenced by impulsive errors and the attempt to control a developing feed-forward motor routine. While SARTs have a sustained attention component, SARTs are better measures of response control and strategy than the maintenance of perceptual awareness characteristic of vigilance tasks.

OVERALL DISCUSSION

Abbreviated tasks homologous to long-duration tasks are beneficial to clinicians and researchers interested in sustained attention. Robertson and colleagues developed the SART to be a very brief (4–6-min) task capable of eliciting differences in sustained attention between clinical groups. Critics of the SART being a measure of sustained attention (Helton et al., 2005) have, however, suggested the SART may instead be a measure of impulsive responding and speed–accuracy response strategy. The two studies presented here support a critical stance regarding the SART's status as a measure of sustained attention. In Experiment 1 performance for participants in the SART response format group changed rapidly over time; this was not characteristic of the standard response format group's performance. The SART participants' performance indicated an overall reduction in responding—for example, an increase in response withholding. Perhaps participants in the SART group were attempting to prevent inappropriate responses, and in order to accomplish this they quickly (within 4.4 min) became more cautious. In Experiment 2 there was a statistically significant interaction between task (global–local versus global-only discrimination) and response format (standard and SART), for participants' reaction time measurements. As seen in Figure 5, in the SART response format group reaction times in the global–local task (M = 345.6 ms) were slower than those in the global-only task (M = 285.1 ms), whereas in the standard response format reaction times to the two tasks were essentially the same (M = 434.4 ms global and 439.2 ms global–local). Dickman (1984) previously found that performance on global–local tasks is particularly susceptible to impulsive errors. Participants in the SART global–local condensation task in Experiment 2 may have strategically reduced their rate of responding in order to prevent excessive errors, as this task may be particularly susceptible to impulsive errors (see Dickman, 1984). This did not appear to be the case in the standard response format; perhaps the standard response format is not very susceptible or conducive to impulsive errors.

Robertson's own empirical work is supportive of an impulsivity perspective with regard to the SART; as the relative probability of the target signal is decreased or the overall event rate is increased the probability of an error of commission (pressing inappropriately) increases (Manly, Robertson, Galloway, & Hawkins, 1999). Undoubtedly pressing quickly and frequently increases the likelihood of a feed-forward motor routine developing (Doyon et al., 2003). Feed-forward motor programs and attention rely on distinct neural systems (Gazzaniga, Ivry, & Mangun, 2002; Harrington & Haaland, 1991; Hellige, 1993; Tucker & Williamson, 1984). In the SART, where a strong habitual response, key pressing, needs to be halted appropriately when targets appear, this feed-forward motor routine requires control by the supervisory attention system (Logan & Cowan, 1984; Matthews et al., 2000; Norman & Shallice, 1986; Shallice, 1988; Stuss et al., 1995). The SART adds a new dimension to the traditional sustained attention task. Accordingly, prior to any effort to adopt the SART as a means of reducing the temporal demands of traditional vigilance tasks and incorporating it in test batteries or in brain-imaging experiments, researchers need to be aware of the SART's susceptibility to impulsive errors. Researchers looking for a measure of sustained attention, not impulsive responding, may be better served by using the CPT or the AVT. This does not, of course, preclude the use of SARTs in clinical or experimental settings, as SARTs may effectively measure the ability of an individual to regulate or inhibit impulsive responses. SARTs are not, however, the same as traditional abbreviated and long-duration vigilance tasks. The alteration of the response format adds a new dimension to a sustained attention task: the development of a ballistic, feed-forward motor program and the need to control it. On a positive note, this study does indicate that SARTs are very challenging and may be useful for exploring motor impulsivity and control. Longer duration SARTs may even provide an interesting combination of motor regulation and sustained attention useful in some clinical and research settings.

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