doi:10.1016/j.concog.2005.11.009

Consciousness and Cognition 15 (2006) 578–592

Absent-mindedness: Lapses of conscious awareness and everyday cognitive failures

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Abstract

A brief self-report scale was developed to assess everyday performance failures arising directly or primarily from brief failures of sustained attention (attention-related cognitive errors—ARCES). The ARCES was found to be associated with a more direct measure of propensity to attention lapses (Mindful Attention Awareness Scale—MAAS) and to errors on an existing behavioral measure of sustained attention (Sustained Attention to Response Task—SART). Although the ARCES and MAAS were highly correlated, structural modelling revealed the ARCES was more directly related to SART errors and the MAAS to SART RTs, which have been hypothesized to directly reflect the lapses of attention that lead to SART errors. Thus, the MAAS and SART RTs appear to directly reflect attention lapses, whereas the ARCES and SART errors reflect the mistakes these lapses are thought to cause. Boredom proneness was also assessed by the BPS, as a separate consequence of a propensity to attention lapses. Although the ARCES was significantly associated with the BPS, this association was entirely accounted for by the MAAS, suggesting that performance errors and boredom are separate consequences of lapses in attention. A tendency to even extraordinarily brief attention lapses on the order of milliseconds may have far-reaching consequences not only for safe and efficient task performance but also for sustaining the motivation to persist in and enjoy these tasks.

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The year was 2081, and everybody was finally equal. They weren't only equal before God and the law. They were equal every which way . . . It was tragic, all right, but George and Hazel couldn't think about it very hard. Hazel had a perfectly average intelligence, which meant she couldn't think about anything except in short bursts. And George, while his intelligence was way above normal, had a little mental handicap radio in his ear. He was required by law to wear it at all times. It was tuned to a government transmitter. Every twenty seconds or so, the transmitter would send out some sharp noise to keep people like George from taking unfair advantage of their brains.

Harrison Bergeron - Kurt Vonnegut, Jr. (1961)

Introduction

At all levels of ability, lapses of attention are clearly a part of everyone's life. Some are merely inconvenient, such as missing a familiar turn-off on the highway, and some are extremely serious, such as failures of attention that cause accidents, injury, and loss of life (Robertson, 2003). Beyond the obvious costs of accidents arising from lapses in attention there is lost time, efficiency, personal productivity, and quality of life in the lapse and recapture of awareness and attention to everyday tasks. As the managers of Vonnegut's fictional society well knew, lapses of attention are also inherently cognitively debilitating. Indeed, individuals for whom intervals between lapses are very short are typically viewed as impaired (Giambra, 1995). Given the prevalence of attentional failures in everyday life and the ubiquitous and sometimes disastrous consequences of such failures, it is rather surprising that relatively little work has been done to directly measure individual differences in everyday errors arising from propensities for failures of attention.

The work that is perhaps most relevant to a discussion of failures of attention in everyday settings has been conducted or inspired by Reason (1977, 1979, 1984, Reason and Mycielska, 1982). In several diary studies, Reason had participants provide descriptions of action slips as they occurred in their daily lives. Based on these reports, Reason created a classification scheme for everyday failures. Most generally, Reason distinguished between errors based on mistakes in planning and those based on lapses in the course of execution. In the first case, errors arise from lack of knowledge, or inadequate or incorrect information (ignorance or misunderstanding), or from the misapplication of rules, or simply failure to implement them (i.e., faulty or absence inferences from available (correct) information). These sorts of errors will most likely occur in unfamiliar domains or problematic situations. Errors of the second type (i.e., those arising during execution), which constitute our present concern, tend to occur during highly practiced routine actions. There is, however, in such cases, an unexpected and apparently arbitrary departure from the normal smooth flow of action when events unfold in a manner inconsistent with plans. Reason labelled these rather succinctly as "actions not as planned." It is worth noting that the actions not as planned that were recorded by Reason were not specific to failures of attention, but rather might have arisen from errors of attention, perception, memory, action execution or some combination of these factors (Reason, 1977, 1979).

Inspired, in part, by Reason's work, Broadbent, Cooper, fitzGerald, and Parkes (1982) designed the Cognitive Failure's Questionnaire (CFQ) to assess individual differences in proneness to errors in routine activity. The CFQ was designed to assess a variety of commonplace errors. Items on this scale include questions about errors of action, attention, and memory. The available evidence suggests that the CFQ has considerable ecological validity. For instance, people who report a high frequency of cognitive failures (i.e., have high CFQ scores) tend to be more likely to cause automobile accidents than are people reporting a low degree of cognitive failures (e.g., Larson & Merritt, 1991; Larson, Alderton, Neideffer, & Underhill, 1997). The CFQ also predicts how people cope with stress in their work environment (Broadbent et al., 1982). Some evidence that the CFQ is correlated, inter alia, with attention-related errors comes from studies showing that the CFQ correlates with overt behavioral measures of attention (e.g., Robertson, Manly, Andrade, Baddeley, & Yiend, 1997; Tipper & Baylis, 1987). Nonetheless, although it is often employed as a measure of sustained attention (e.g., Robertson et al., 1997; Smallwood et al., 2004), it is clear that the CFQ measures proneness to more than just attention-related errors. Indeed, the items assessed by the CFQ were explicitly designed to be non-specific with regard to underlying cognitive processes. Broadbent et al. assumed that different processes leading to lapses would likely be positively associated. More recent studies suggest, however, that the CFQ might consist of a number of different underlying factors. And there seems to be little agreement on how many factors there are and what exactly these factors represent. For instance, Pollina, Greene, Tunick, and Puckett (1992) suggest that the CFQ consists of five underlying factors, which they describe as distractibility, misdirected actions, spatial/kinaesthetic memory, interpersonal intelligence, and memory for names. Seven and nine-factor solutions have been reported by Matthews, Coyle, and Craig (1990) and a two-factor solution has been reported by Larson et al. (1997). The meaning of this bewildering assortment of factors is quite unclear, except that the CFQ would seem to assess a good deal more than attention-related cognitive failures. Adding to the conceptual confusion, some items on the CFQ refer directly to attention lapses (e.g., daydreaming) rather than errors consequent to such lapses. Thus, the CFQ assesses both attention lapses without action errors as well as a variety of action errors and cognitive failures potentially resulting from several underlying cognitive failures, including attention lapses.

Such results are perhaps unsurprising as the CFQ items were intended to, and evidently do, sample a wide array of cognitive failures. As such, the CFQ does not provide a specific measure of attention-related errors. To our knowledge, a scale that directly assesses attention-related cognitive errors has not been previously developed. The frequent use of the CFQ as a proxy for attention-related action and cognitive failures suggests a need for such a scale.

We first set out to find everyday cognitive failures for which attention lapses seemed the major, originary, or most likely, cause, that is, failures associated with inadequate monitoring of highly practiced, familiar, repetitive, or tedious tasks for which there are obvious, appropriate, and adequate rules known and available to the actor. We began by selecting items from the CFQ that seem most likely to primarily reflect attentional lapses, adding items from Reason (1977, 1979, 1984), as well as from our own experiences based on personal diaries of attentional lapses. The resulting scale we called the Attention-Related Cognitive Errors Scale (ARCES). We specifically refer to "attention-related" errors as we sought to include items reflecting errors in performance that would result in part or entirely from attentional lapses.

In an effort to assess the assumption that the errors measured by the ARCES are the result of attention lapses, in Study 1 we sought to evaluate the association between the ARCES and a measure that directly indexes everyday attention lapses but not subsequent errors in performance. A scale that appears to do this is the Mindful Attention Awareness Scale (MAAS—Brown & Ryan, 2003). The MAAS purports to be a measure of the ability to sustain conscious awareness of attention in everyday life. Items generally refer, however, to tendencies to perform "automatically," "without being aware," "without much awareness" or "without paying attention," except for two items, which were eliminated for our analyses as they did refer to performance errors. Interestingly, as virtually all items reflecting positive endorsements of mindfulness were eliminated during test construction (Brown & Ryan, 2003, pp. 825–826), all retained items actually reflect a tendency to experience lapses of attention or conscious awareness and hence are reverse scored to provide a positive scale of mindfulness. It would be more accurate, however, to describe the MAAS as directly assessing a propensity to experience such lapses. Thus, under the hypothesis that the ARCES items are a consequence of the sorts of lapses reflected in the MAAS items, a substantial negative (as a consequence of the convention of reverse scoring) association is predicted between the MAAS and the ARCES.

There are grounds to suggest that a related consequence of the inability to engage and sustain attention is boredom. Boredom is often described as an aversive affective or cognitive state (Izard, 1977; Plutchik, 1980; Tompkins, 1962), but is arguably more fundamentally an inability to engage and sustain attention (Berlyne, 1960; Damrad-Frye & Laird, 1989; Hebb, 1966). Boredom has been concisely defined as a state arising when we are: (a) prevented from doing what we want to do or (b) forced to do what we do not want to do" (Fenichel, 1951). These two situational types of boredom may be referred to as *thwarted engagement of attention* and *forced engagement of attention*. A third type of boredom, not explicitly named in the literature on boredom, is characterized not by constraint, but by a condition of apparent freedom in which the individual is nonetheless unable to maintain attention on, or interest in, any object, environmental or mental. That is, we are free to do what we will but nothing engages our attention for any appreciable duration. This latter definition would appear to reflect a dispositional tendency of proneness to boredom. In all three types, attention is the key process implicated in boredom.

Consistent with the last, dispositional definition, there is an extensive literature suggesting substantial individual differences in susceptibility to boredom (Vodanovich, 2003). Attention slips and action failures are frequently attributed to situational boredom (Reason & Lucas, 1984; Robertson et al., 1997) and, consistent with this claim, boredom proneness, assessed by the Boredom Proneness Scale (BPS), has been found to be positively associated with the CFQ (Wallace, Kass, & Stanny, 2002; Wallace, Vodanovich, & Restino, 2003). It is also possible that boredom proneness leads to carelessness, and is directly associated with a tendency to make high rates of cognitive and behavioral errors through lack of motivation or effort. According to the foregoing definitions, however, boredom prone individuals have fundamental deficits in the ability to sustain attention. On the present view, therefore, everyday cognitive errors and boredom proneness are two separate consequences of a tendency to experience attention lapses. This reasoning leads to the hypothesis of a positive association between attention-related errors (measured by the ARCES) and boredom proneness (measured by BPS) as a result of a common association with the propensity to have lapses of attention (measured by the MAAS). This hypothesis was also assessed in Study 1.

Study 1

Method

Participants

Participants were 449 undergraduates enrolled in an Introductory Psychology course. Included with the scales of Study 1 were several samples of the general on-line assessments associated with Introductory Psychology. Students received bonus credit for completing the questionnaires.

Measures

An attention-related cognitive errors scale (ARCES) was developed based on items from the Broadbent CFQ, examples from Reason, and by the current authors' own experiences based on entries from attention failure diaries. We began with 20 items but four items were dropped because of poor item-total correlations and their reference to memory problems. In addition, a preliminary factor analysis revealed four items, referring to lapses while driving, loaded on a separate factor. This, plus the realization that a significant percentage of our subjects were non-drivers (15%), led us to drop these items as well, leaving 12 items reflecting ubiquitous everyday situations likely encountered by individuals with widely varying backgrounds and lifestyles. Items from the final 12 item scale appear in Appendix Table A1. The ARCES employs a Likert scale of 5 possible responses ranging from never (1) to very often (5), with higher scores indicating a greater number of slips.

The 15 item Mindful Attention Awareness Scale was selected as a measure of attention lapses. MAAS items ask about mindlessness in everyday situations, e.g., “I find it difficult to stay focused on what’s happening in the present,” and responses indicating greater frequency signify less mindfulness, therefore requiring the MAAS to be reverse-scored. Two items were eliminated from the analysis, however, because they refer to performance errors. Item two actually refers to attention-related accidents: “I break things because of carelessness, not paying attention or thinking of something else.” Item six refers to a memory failure: “I forget a person’s name as soon as I have been told it for the first time.” The MAAS uses a Likert scale ranging from almost never (1) to almost always (6). The revised MAAS has a minimum score of 13 and a maximum score of 69.

The 28 item Boredom Proneness Scale was incorporated as a measure of the propensity to become bored. The BPS uses a Likert scale ranging from strongly disagree (1) to strongly agree (7), with a neutral midpoint (4) with a minimum score of 28 and a maximum score of 196. BPS items reflect situations in which we are likely to become bored, e.g., “Much of the time I just sit around doing nothing,” and related personal ascriptions, e.g., “I would like more challenging things to do in life.”

Results

The ARCES was found to have good distributional and psychometric properties. There was a good range of scores, with significant but minor deviations from normality in skewness and kurtosis, and very satisfactory internal consistency (Table 1). The items all had good item-total correlations (Table A1). The MAAS also had good distributional and psychometric properties, with a good range of scores, and significant but minor deviations from normality in skewness and kurtosis, and very satisfactory internal consistency. The BPS was characterized by some skewness and kurtosis, a good range of scores, and good internal consistency (Table 1).

Table 1
Means, standard deviations, ranges, skewness and kurtosis (with standard errors), α coefficients, and *N*s for three questionnaires

Scale	Mean	*SD*	Range	Skew	Skew *SE*	Kurtosis	Kurtosis *SE*	α	*N*
Attention-related cognitive errors	33.37	7.82	12–56	.22	.11	.23	.23	.88	465
Mindful awareness of attention	49.95	9.68	23–77	.12	.12	−.13	.23	.87	449
Boredom proneness	100.84	18.04	3–166	−.46	.10	−1.58	.21	.91	557

Table 2
Pearson product-moment correlations among three questionnaires (sample sizes in italics)

	ARCES	MAAS	BPS
Attention-related cognitive errors		−0.54	0.27
		499	*205*
Mindful awareness of attention			−0.42
			198

$p < .01$ for all coefficients.

Table 3
Multiple regression testing for mediation of attention-related cognitive errors and boredom proneness association by mindful awareness

Predicting attention-related cognitive errors	β	t	p
Mindful awareness of attention	−0.49	7.19	.001
Boredom proneness	0.06	0.81	.419
	$R = .51$, $F(2,195) = 34.77$, $p < .001$		

As predicted, the ARCES and the MAAS were highly correlated. Also, as predicted, both attention measures were associated with the BPS. The association of the BPS with the MAAS was greater than that between the BPS and the ARCES (Table 2). When the MAAS and BPS were entered simultaneously as predictors of the ARCES in multiple regression analyses only the independent contribution of the MAAS was significant (Table 3).

Discussion

The ARCES appeared to have good psychometric properties and both convergent and construct validity. The ARCES was associated with a direct measure of the ability to sustain attention (i.e., the MAAS). In addition, both measures of attention were associated with a conceptually related measure of boredom proneness (i.e., the BPS). Finally, consistent with the initial hypothesis, the association of the ARCES and the BPS appears to have been mediated by the MAAS. Importantly, the finding that the association between the ARCES and the BPS is mediated almost entirely by the MAAS suggests that the ARCES and the BPS measure distinct consequences of attention lapses. Specifically, the results are consistent with the hypothesis that the MAAS measures the inability to sustain attention, while the ARCES measures the errors caused by lapses of attention and boredom proneness, as assessed by the BPS, is a consequence of the inability to sustain attention and does not directly affect attention-related errors. Thus, it appears that inability to sustain attention (measured by the MAAS) is the source of both attention-related errors (measured by the ARCES) and proneness to boredom (measured by the BPS).

Study 2

Having established that the ARCES is related to, yet distinct from, an existing measure of the inability to sustain attention (i.e., the MAAS), in Study 2 we sought to evaluate whether the ARCES preferentially measures attention-related errors and not other cognitive failures such as memory errors. To do this we sought a questionnaire specifically to assess memory failures. This proved more difficult than expected as many of the memory failures in everyday life really indirectly reflect prior attention lapses. A review of items of existing everyday memory questionnaires revealed that they also cover a broad array of cognitive failures, generating factors such as face recognition, conversational and task monitoring, expressive communication, and route finding (Cornish, 2000; Richardson & Chan, 1995). Not surprisingly, these questionnaires overlap considerably with more general assessments of cognitive failures such as the CFQ (Cornish, 2000). Consequently, we decided to attempt to create a somewhat more specific, in terms of face validity at least, everyday memory failure scale by selecting and modifying items from the Broadbent CFQ and factor 5 of the Everyday Memory Questionnaire (Sunderberg, Harris, & Baddeley, 1983, 1984), examples from Reason, and from the authors' own experiences (Table A2).

The difficulty we had in creating items for the MFS that minimized the contribution of attentional errors suggested to us from the outset that the MAAS, the ARCES and the MFS would be highly associated. Indeed, some of the items in the ARCES can be construed as attention-related memory failures - see items 2, 5, 10, 11, and 12 — caused by earlier lapses of attention affecting encoding and subsequent cognitive errors. Therefore, we sought to demonstrate that each of these scales measured different constructs by showing how they are differentially associated with behavior measures of attention and attention-related errors.

Thus, to further assess the validity of the self-report of attention slips, Study 2 incorporated a behavioral measure of sustained attention, the Sustained Attention to Response Task (SART—Robertson et al., 1997). The SART was designed as a behavioral measure of "the ability to self-sustain mindful, conscious processing of stimuli whose repetitive, non-arousing qualities would otherwise lead to habituation and distraction" (Robertson et al., 1997, p. 747). The task requires continuous responding to a series of digits, except that a response is withheld whenever a specific infrequent digit appears. Thus, the SART is intended to assess transient lapses of attention. Robertson and his colleagues showed that people who report a greater frequency of cognitive failures (via the CFQ) perform more poorly on the SART than do people who report fewer cognitive failures (Robertson et al., 1997).

The SART was specifically designed to assess failures of endogenous (self-sustained) maintenance of attention. The SART therefore minimizes all sources of exogenous support such as novelty and salience and with minimal or no memory load. Moreover, by requiring continuous responding, a prepotent automatic response set is created, which must be actively suppressed on the no-go trials. This arrangement is hypothesized to require a high level of endogenously controlled attention and to be sensitive to transitory lapses of attention. Consistent with these claims, SART performance has been shown to be sensitive to coma severity in TBI subjects, but not to post-traumatic amnesia duration (Robertson et al., 1997).

The SART has excellent face validity in that it simulates the repetitive and tedious tasks that fail to provide the external scaffolding for attention maintenance. For this task, individuals are required to attend to an extended presentation of random digits (from 1 to 9) on a computer screen and respond with a key press whenever the presented digit is not the target digit and to refrain from responding to the infrequent target digit. SART errors are hypothesized to reflect mistakes arising from decreased attention to the task, thought to be directly indexed by the speeding of reaction times (Robertson et al., 1997). Faster SART RTs are hypothesized to directly reflect the attentional lapses that lead to SART errors. Evidence for this is provided in the finding of faster reaction times (RTs) on trials immediately preceding no-go errors than on trials preceding successful withholding of responses (Manly, Robertson, Galloway, & Hawkins, 1999; Robertson et al., 1997). SART errors on no-go trials are therefore hypothesized to reflect action failures consequent to failures to monitor digit values (i.e., attention lapses), which are directly assessed by faster over-all RTs (Robertson et al., 1997). Thus, SART RTs are to SART errors as the MAAS is to the ARCES. The SART therefore provides behavioral measures that should correspond to the self-report dispositional measures of the MAAS and ARCES. The dispositional self-report measures (MAAS and ARCES) are hypothesized to be causally linked to the behavioral measures. Hence, SART errors and RTs are predicted to be positively associated with the ARCES and the MAAS, with the ARCES more directly associated with the SART errors and the MAAS more directly associated with SART RT. SART errors and SART RTs will likely be associated with the MFS, but this will be entirely explained by the mutual association with attention measures. Just as the putative attention-related cognitive errors are hypothesized to be caused by attention lapses, so too will memory failures often be the result of encoding problems introduced by prior cognitive errors, such as attention lapses and subsequent attention-related errors. Thus, we expect a substantial correlation between the MFS and both the ARCES and the MAAS, although the ARCES is predicted to mediate the MAAS–MFS correlation.

A further goal of Study 2 was to evaluate the association between sleepiness and attention related errors. Sleepiness is a common occurrence for most people and is, by definition, a reduction in alertness. Recently, Fronczek, Van der Hiele, Van Dijk, Middelkoop, and Lammers (2004) reported an association between narcolepsy and SART performance. As sleepiness increases and alertness is impaired, attention slips should become an increasingly regular occurrence. Thus, to evaluate the role of sleepiness and sleep disturbance in cognitive errors related to attention lapses, we compared performance on the ARCES and the MAAS with a measure of daytime sleepiness, the Epworth Sleepiness Scale (Johns, 2000). It was hypothesized that sleepier people will behave less mindfully and commit a greater number of attention slips, resulting in the Epworth Sleepiness Scale being negatively associated with the MAAS, and positively associated with the ARCES and SART errors. SART errors will be positively associated with ARCES scores and have similar correlations to the other measures included in the current research, providing support for the conceptual validity of the ARCES as a measure of attention slips. To ensure a good range of sleepiness and to evaluate the impact of sleep disturbances we also selected a sample with a high proportion of sleep difficulties (i.e., insomnia).

Method

Participants

Participants in Study 2 were selected from a group of prior respondents to a WWW survey on sleep paralysis, as sleep paralysis is sometimes associated with narcolepsy and a relatively large number of these respondents reported a diagnosis of narcolepsy or experienced insomnia. All participants contacted had previously expressed a willingness to be re-contacted.

Of the WWW survey respondents who expressed a willingness to be re-contacted, 91 reported suffering from narcolepsy, and an additional 2339 reported experiencing insomnia. We contacted all of these respondents for the present research, in addition to a random selection of 1000 respondents who did not report experiencing narcolepsy or insomnia.

All blank or incomplete submissions were removed from analysis and any instances of multiple submissions from the same participant were removed so that only the most recent submission remained in the data set. Similarly, results from participants who failed to attempt or complete all 225 trials of the SART, or responded in opposite manner to that in which they were instructed (i.e., key press provided only when the target appeared), were removed from the data set. A total of 213 participant responses were removed in this manner. The final selection of participants who completed the full study included 349 females, 155 males ($N = 504$). Of these, a relatively small proportion reported experiencing narcolepsy (13 respondents), while a majority reported experiencing insomnia (327 respondents). Participants ranged from adolescence to senescence, with a mean age of 32.23 ($SD = 11.23$). Participants were primarily located in the US (62.9%), the UK (15%), and Canada (11.2%).

Measures

The measures included the 12-item ARCES and the 13-item revised MAAS. A Memory Failures Scale (MFS) was developed consisting of 12 items related to situations involving memory failures, e.g., “Even though I put things in a special place I still forget where they are,” and follows the same 5-point Likert scale as the ARCES, ranging from never to very often (minimum = 12, maximum = 60). Items from this scale appear in the Appendix Table A2.

Participant incidences of narcolepsy and insomnia, as well as demographic data, were previously collected via the Waterloo Unusual Sleep Experiences Questionnaire. As part of this online questionnaire, participants are asked to “. . . indicate, by checking the appropriate boxes, if any of the following conditions apply to you,” which included narcolepsy and insomnia.

The Epworth Sleepiness Scale consists of 8 items using a Likert scale with 4 possible responses ranging from *would never doze* (0) to *high chance of dozing* (3) for situations involving monotonous tasks, e.g., “Sitting and reading,” with a minimum score of 0 and a maximum score of 24. An additional item requesting participants to indicate their tendency to be a 'morning' or 'evening' type was appended to the Epworth Sleepiness Scale but is not discussed in this report.

The SART procedure, as described by Robertson et al. (1997), involves 225 single digits, 25 each from 1 to 9, presented for 250 ms and followed by an encircled X mask for 900 ms, for a total digit-to-digit duration of 1150 ms. Participants are instructed to respond via a key press to each digit, unless that digit is a 3. The digits are randomly distributed, as are the font sizes of all 225 trials, with equal representation of 48, 72, 94, 100, and 120 point size Symbol font in white against a black background. The SART was recreated in Macromedia Flash MX 2004 according to these specifications, to allow online presentation of the SART with the rest of the questionnaires. Actual stimulus displays were dependent on the computer equipment used by each participant and viewing distance was not controlled. On a Compaq Presario R3140CA series notebook, with 15.4 in WXGA (1280 · 800) display, used for scale development, stimulus height varied from 8.74 mm (34 px) to 21.33 mm (83 px) and the circular mask diameter was 21.07 mm (82 px).

Procedure

Participants received an informational e-mail regarding the study, including a link to the study website and a pre-assigned personal identification number. Upon visiting the study website, participants received further instructions regarding the purposes of the study and were given the opportunity to participate by completing, in random and undisclosed order, the ARCES, MFS, MAAS, and Epworth Sleepiness Scale. Participants completed the four measures in a single session, followed by the Sustained Attention to Response Task, at the end of which they were given a feedback page thanking them for their participation and providing further information about the purposes of the study and links to a website with additional information on sleep paralysis.

Causal modeling of theory

A causal model was designed to test the theoretical predictions using structural equation modeling (SEM). First, causal paths were hypothesized from MAAS to ARCES and from SART RT to SART errors to reflect the hypothesized causal role of attention failures on the presumed attention-related cognitive errors. Second, causal paths were constructed from the MAAS to SART RT and from ARCES to SART errors to reflect the causal role of dispositional attentional factors on behavioral performance on the SART. No causal paths were provided from the MAAS to SART errors or from the ARCES to SART RTs as these associations are hypothesized to be explained by the previous causal paths. Similarly, no causal paths were provided for the MFS to either SART RT or SART errors as the theory stipulates that any MFS–SART relation will be mediated by dispositional attentional variables. Finally, causal links were provided from MAAS and ARCES to MFS. It was predicted that the ARCES would at least partially mediate the MAAS–MFS link.

Results

Means and SDs for all variables appear in Table 4. Internal consistency was high for ARCES, MAAS, MFS, SART error, and SART RT (i.e., response time on go trials) and moderate for the Epworth Sleepiness Scale. All variables had good ranges and distributional properties, except SART RT, which had substantial skewness and kurtosis. A principal component analysis of ARCES items generated a single component with an eigenvalue = 5.50, accounting for 45.83% of the common variance. For Component loadings see Table A1. A parallel principal components analysis of the MFS yielded a strong first component with an eigenvalue of 4.74, accounting for 39.46% of common variance. For first component loadings see Table A2. A minor second component yielded an eigenvalue of 1.27 and accounted for 10.54% of the common variance. A factor analysis with a Varimax rotation revealed that the second factor consisted of only two items, 3 and 6, both referring to forgetting names.

Table 4
Means, standard deviations, ranges, skewness and kurtosis (with standard errors), α coefficients, and *N*s for Study 2 variables

	Mean	*SD*	Range	Skew[a]	Kurtosis[b]	α
Attention-related cognitive errors	35.88	7.95	16–60	−.24	−.33	.89
Mindful awareness of attention	47.77	10.89	19–75	−.10	−.53	.88
Memory failures	34.11	8.04	17–60	.31	−.17	.86
SART errors	10.84	5.83	0–25	.30	.67	.86
SART RTs	311.83	73.03	159–651	1.14	1.81	.98
Epworth Sleepiness	8.51	4.65	0–21	.28	−.53	.79

[a] $SE = .11$.
[b] $SE = .22$.

Mean RTs were calculated for the four trials preceding successful no-go trials and for four trials preceding failed no-go trials (Robertson et al., 1997). RTs for the two sets of RTs prior to the first two no-go trials were eliminated because of high variance. A further six no-go trials were eliminated because there were fewer than four go trials intervening between no-go trials. A *t* test of the difference between these two means was highly significant, $t(503) = 18.11$, $p < .001$ (mean RT preceding successful no-go trials = 369.68, SD = 85.82; mean RT preceding failed no-go trials = 321. 28, SD = 66.74).

A path analysis using structural equation modeling (Arbuckle, 2002) was conducting using self report (dispositional) measures (ARCES, MAAS, and MFS) to predict behavioral measures, SART error and SART RT. We predicted significant path coefficients between ARCES and SART error and between the MAAS and SART RT but not between the ARCES and SART RT or between the MAAS and SART error. In an analysis with all possible paths included, significant path coefficients were found, as predicted, between ARCES and SART error and between the MAAS and SART RT (Fig. 1). The path coefficients from ARCES to SART RT and from the MAAS to SART error were not significant, also as predicted. Neither path coefficient from the MFS to SART measures was significant. The a priori model, based on theoretically derived predictions, is presented in Fig. 1. This model, eliminating the ARCES–SART RT and the MAAS–SART error paths and between the MFS and both SART measures, provided very good fit indices, $\chi^2(4) = 2.96$, p = .309, CFI = 1.00, NFI = .99, RMSEA = .00.

Table 5
Pearson product-moment correlations of attention and memory scales with the Epworth Sleepiness Scale and with age

	MAAS	MFS	SART errors	SART RT	Epworth Sleepiness	Age
Attention-related cognitive errors	**−0.71**	**0.71**	**0.32**	−0.11	**0.31**	−.12
Mindful awareness of attention		**−0.61**	**−0.31**	**0.17**	**−0.30**	.11
Memory failures			**0.23**	0.08	**0.32**	.09
SART errors				**−0.64**	0.06	**−.22**
SART Go RT					0.01	**−.28**
Epworth Sleepiness						.12

$p < .001$ for coefficients in bold. $N = 508$.

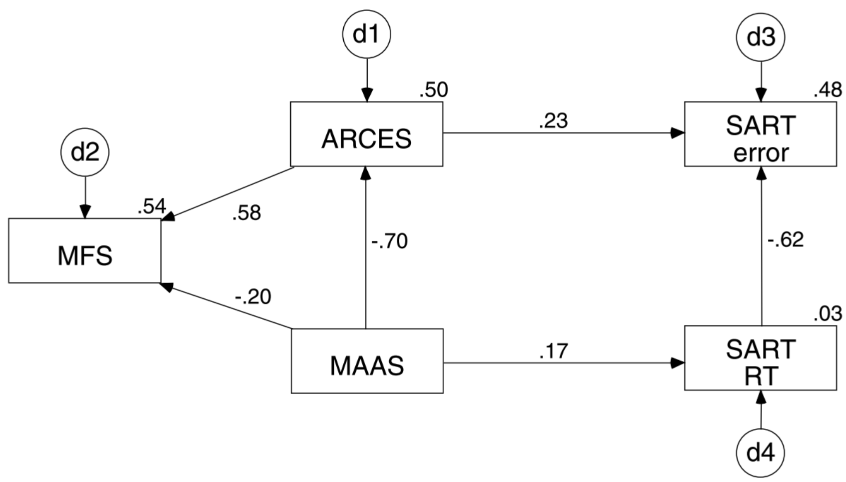

Fig. 1. Final path model with significant path coefficients for self-report attention (ARCES, MAAS) and memory (MFS) measures and behavioral attentional (SART RT, SART error) measures: All significant path coefficients are shown.

Table 6
Multiple regression testing for mediation of SART error–age association by SART response time

Predicting SART errors	β	t	p
SART response time	−.64	17.07	.001
Age	−.04	1.13	.259
	$R = .65$, $F(2, 501) = 18.86$, $p < .001$		

There were small positive correlations of age with both SART RT and SART errors. Older individuals both made fewer errors and responded more slowly on go trials. Given the strong correlation between SART errors and SART RTs, a stepwise regression analysis was conducted to assess the degree to which the correlation between age and SART errors is accounted for by the slower response times of older subjects. When SART RT was entered first as a predictor of SART errors, the effect of age was essentially zero, indicating that the slower response times completely explained the age–SART error correlation (Table 6).

A series of t tests comparing participants reporting insomnia problems with those not reporting such problems revealed significant differences in three variables: ARCES, $t(502) = 2.74$, $p < .006$ (Insomnia group mean = 36.50, SD = 7.79; No-insomnia group mean = 34.38, SD = 7.93); MAAS, $t(502) = 2.79$, $p < .006$ (Insomnia group mean = 46.79, SD = 10.75; No-insomnia group mean = 50.18, SD = 10.89); MFS, $t(502) = 2.79$, $p < .006$ (Insomnia group mean = 34.70, SD = 8.14; No-insomnia group mean = 32.68, SD = 7.62). Insomnia was unrelated to SART measures. There were only 13 participants reporting a diagnosis of narcolepsy. A series of t tests failed to reveal any significant differences related to narcolepsy in any of the attentional or memory measures.

Discussion

As predicted, SART errors and RTs were moderately associated with the MAAS and the ARCES and less with the MFS. Moreover, path analyses corroborated the prediction that the MAAS would account for the associations between SART RT and the ARCES and MFS. The ARCES, but not the MFS, was, however, not only directly associated with SART error independently of the MAAS but also accounted for the associations between SART errors and the MAAS and MFS. These findings are consistent with the hypothesis that the MAAS and SART RT are direct measures of attention lapses and that attention lapses are in turn related to the performance and cognitive errors assessed by the ARCES and SART error.

Replicating earlier results (Manly et al., 2002; Robertson et al., 1997), we also found that RTs were shorter on trials preceding SART errors than on those preceding successful withholding of responses. This pattern of results is consistent with the hypothesis that speeding of responses reflects waning of attention, which then produces SART errors (Robertson et al., 1997). The difference in RTs was approximately 50 ms, a value intermediate between those reported by Robertson et al. and those reported by Manly et al. This consistency with previous results, and the associations with self-report measures of attention lapses and attention-related errors, suggests that the SART translated well to web use, providing a flexible procedure readily transported beyond the laboratory, and appears to be a valid indicator of self-reported lapses of attention and their subsequent errors.

The MFS was strongly correlated with both the ARCES and MAAS. Indeed, the association between the two measures of everyday cognitive failures, ARCES and MFS was as strong as the association between the two attention-related measures. The strong correlation between the MFS and the ARCES is, however, consistent with the assumption that everyday cognitive errors are multiply determined (cf. Broadbent et al., 1982), even when primarily attentional in origin. This finding is also consistent with the hypothesis that at least some memory problems may be the consequence of attention lapses at the time of encoding. Nonetheless, in spite of the large correlation between the MFS and the two attention measures, the correlation between the MFS and SART measures was completely accounted for by their common association with the attention measures. Thus, even given the substantial overlap of variance between the MFS and the attention measures, it was the self-reported attention measures that were most strongly associated with the behavioral attention measures.

The MAAS proved to be a robust predictor not only of self-reported attention-related errors but also of a behavioral measure of attention lapses. These associations, as well as the obvious and frequent reference of MAAS items to acting “automatically,” “without awareness,” and “without paying attention,” does suggest that this scale may be mislabeled and would be better characterized as a direct measure of a tendency to experience attention lapses.

SART error was also strongly predicted by SART RT and age. Reaction time was also associated with age and this latter association explained the correlation between age and the SART error score. Thus, the reduction in SART errors with age is completely accounted for by the slower response times on the go trials. Thus, the improvement of SART error performance with age, as a function of response speed, is an interesting and rare example of better performance with age and is consistent with a finding that daydreaming becomes less frequent, less vivid and less absorbing with increasing age (Giambra, 1999). The pattern of results suggests that a mindful mindset (Brown & Ryan, 2003) might modulate attention-related performance decrements usually associated with age.

There was no evidence that the effects of sleepiness or insomnia were specific to attention lapses or attention-related errors. Self-reported insomnia and Epworth Sleepiness were both related to the self-reported attention and memory measures, but not to the behavioral attention measures. The effects for the self-report measures are consistent with reports that people with insomnia tend to overestimate the impact of sleep loss on cognitive deficits (Chambers & Keller, 1993; Harvey, 2002) and the lack of effects for the behavioral measures are consistent with frequent findings of no differences in neuropsychological functioning between people with insomnia and good-sleepers (Semler & Harvey, 2005). The lack of association of insomnia and Epworth Sleepiness scores with behavioral measures may have also arisen because subjects were able to select the time of participating and may have selected periods of self-assessed optimal functioning. Difficulties sleeping and remaining awake appear to leave people feeling less efficient and effective, and more likely to report various cognitive errors, but there was no evidence that the effects were specific to self perceived attentional lapses. Self-reported narcolepsy was unrelated to any of the measures.

Summary and conclusions

Notwithstanding the challenge of isolating specific processes underlying everyday cognitive failures, our attempt to create a measure of attention-related cognitive failures (i.e., the ARCES) was met with some success. The findings are consistent with the hypothesis that the ARCES measures attention-related errors that are related to, yet distinct from, lapses in conscious attention. First, we found that the ARCES is strongly related to the MAAS, a self report scale of proneness to attentional lapses, and with the SART errors, a behavioral measure of attentional lapses. Though clearly related to the MAAS and the SART RT, the ARCES measures a consequence of attention lapses; namely, the propensity to performance errors. The distinction between the ARCES and the MAAS was also revealed by the fact that boredom proneness (measured by the BPS) was independently related to the MAAS but not to the ARCES when MAAS was controlled for.

The correlations between self-report and behavioral attention and attention-related measures were small to moderate in size. It is of some interest, nonetheless, that minor, and likely unnoticed, fluctuations of sustained attention of the order of a few tens of milliseconds are associated with subjective reports of automatic behaviors and absent-mindedness. This is especially striking given that the Flash browser plug-in controlling the task does not ensure millisecond timing accuracy and actual presentation times for the target and mask were often up to 10 ms longer than intended. It seems that one might say, with apologies to Jonathan Swift, that little lapses lead to bigger lapses, which feed on them. These larger lapses, in turn, may lead to extended daydreaming, or subjective impressions of boredom. Thus, even the briefest of micro-lapses of attention may have far-reaching consequences not only for safe, efficient task performance and intellectual functioning, but also for motivation. A fragmentary attention span may make the world and even our own thoughts seem unengaging via the misinterpretation of endogenously produced inattention as indicative of an empty and unengaging world and life.

An issue that our data do not address is the nature of cognitions, if any, during lapses. Future studies on individual differences in proneness to attention lapses and subsequent cognitive errors will profit from an examination of the qualitative and quantitative features of the phenomenology of the lapses using awareness probes (e.g., Smallwood, Baracaia, Lowe, & Obonsawin, 2003, 2004). For example, do individuals with higher rates differ from those with lower rates in task-unrelated or task-relevant thoughts (cf. Smallwood et al., 2004)? As the items in all our questionnaires sample routine activities a variety of settings and contexts, receiving a high score implies a rather general trait, which might be taken to suggest a high rate of task-unrelated thought rather than ruminations about the specifics of task performance. It is also possible that such individual differences depend upon endogenous time-linked attention control operators (e.g., Giambra, 1995) and the phenomenological content of the lapses may vary according to context. These sorts of issues could be further explored with awareness probes.

The ARCES, though highly correlated with our memory measure, the MFS, does appear to measure attention errors that can be distinguished from everyday memory errors. Though the ARCES and the MFS were strongly related, the MFS was not independently associated with SART errors or RTs. This is consistent with the hypothesis that memory failures are, in part, a consequence of original attention failures and cognitive errors arising from attention failures. The idea that attention failures lead to memory failures is consistent with numerous studies showing that dividing attention decreases memory performance and allows retrieval to be dominated by automatic processes (e.g., familiarity) rather than conscious recollection (see Jennings & Jacoby, 1993; Smallwood et al., 2003).

Though the MAAS purports to measure the rather complex concept of mindfulness it is clear, from direct examination of item content, that it is a simple and direct measure of reports of lapses of awareness of one’s current state and situation. The pattern of associations reported here is consistent with such an interpretation.

Our results suggest that momentary lapses of conscious awareness of our actions have pervasive effects on the efficient, effective conduct of every day activity as well as on our affective well-being. The robust association of the MAAS and BPS is particularly revealing of the impact of brief losses of attention on the maintenance of interest and engagement with our world. Difficult though it may be to find a function for consciousness, it seems that there is little we do without it, and its absence appears detrimental to the functioning of the most well-rehearsed and routine of activities.

Appendix A

Table A1
Internal consistency of attention-related cognitive errors scale—Version 2

Item	Corrected item-total correlation	Principal component loading
1. I have absent-mindedly placed things in unintended locations (e.g., putting milk in the pantry or sugar in the fridge).	0.59	.67
2. When reading I find that I have read several paragraphs without being able to recall what I read.	0.50	.58
3. I have misplaced frequently used objects, such as keys, pens, glasses, etc.	0.56	.63
4. I have found myself wearing mismatched socks or other apparel.	0.39	.46
5. I have gone into a room to get something, got distracted, and left without what I went there for.	0.64	.72
6. I fail to see what I am looking for even though I am looking right at it.	0.54	.72
7. I begin one task and get distracted into doing something else.	0.61	.69
8. I have absent-mindedly mixed up targets of my action (e.g., pouring or putting something into the wrong container).	0.88	.73
9. I make mistakes because I am doing one thing and thinking about another.	0.62	.70
10. I have gone to the fridge to get one thing (e.g., milk) and taken something else (e.g., juice).	0.73	.80
11. I have to go back to check whether I have done something or not (e.g., turning out lights, locking doors).	0.56	.63
12. I go into a room to do one thing (e.g., brush my teeth) and end up doing something else (e.g., brush my hair).	0.67	.75

Table A2
Internal consistency of everyday memory failures scale

Item	Corrected item-total correlation	First principal component loadings
1. I leave important letters/emails unanswered for days.	0.37	.61
2. I forget appointments.	0.42	.65
3. I forget people's names immediately after they have introduced themselves.	0.40	.57
4. I forget people's names, even though I rehearsed them.	0.51	.69
5. I find I cannot quite remember something though it is on the tip of my tongue.	0.43	.68
6. I forget what I went to the supermarket to buy.	0.49	.70
7. I forget important dates like birthdays and anniversaries.	0.42	.63
8. I double-book myself when scheduling appointments.	0.33	.61
9. I forget passwords.	0.44	.59
10. I remember facts but not where I learned them.	0.34	.52
11. Even though I put things in a special place I still forget where they are.	0.55	.65
12. When I go to introduce my friends I forget their names.	0.40	.62

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