Lingering delays in a go/no-go task: mind wandering delays thought probes reliably but not reaction times

ALEXANDER P. L. MARTINDALE, Brighton and Sussex Medical School, UK
ELEANOR M. DEANE, Brighton and Sussex Medical School, UK
CATARINA I. PERAL-FUSTER, Brighton and Sussex Medical School, UK
OMAR ELKELANI, Brighton and Sussex Medical School, UK
ZIQIAO QI, Brighton and Sussex Medical School, UK
SARA I. RIBEIRO-ALI, Brighton and Sussex Medical School, UK
RHIANNON S. HEROLD, Brighton and Sussex Medical School, UK
CARINA E. I. WESTLING, Bournemouth University, UK
HARRY J. WITCHEL*, Brighton and Sussex Medical School, UK

BACKGROUND: In a go/no-go task, changes to the inter-trial interval (ITI) or the press percentage (PP) are known to have decelerating effects on both reaction time and on thought probe response time. The mental causes of these delays remain obscure.
AIMS: To see whether the delaying effects of ITI and PP are additive, and to determine whether these timing effects are linked with mental states detectable by subjective ratings.
METHODS: An 18-minute online experiment with 60 participants who each performed 8 versions of the ToVA with different ITIs and PPs. At the end of each block were mind wandering (MW) thought probes and rating scales for subjective effort and awareness.
RESULTS: The decelerating effects of long ITIs, low PPs, and MW seem to be synergistic, but the effects of individual factors on thought probes seem brittle. A version of the ToVA with zero no-go-stimuli spontaneously and implicitly accelerated mean reaction time significantly. That version also quickened three subsequent response times for rating tasks by hundreds of milliseconds, which suggests that the basis of this effect is a lingering mental state (or substrate). None of the subjective ratings measured were strongly related to the reaction time delay, although MW seems to delay the thought probe response.
CONCLUSION: The strategic effect on both the reaction time and the thought probe response time is presumably a change in the speed-accuracy trade-off in which the participant adopts a mental strategy that speeds up thinking by reducing caution, so caution needs to be subjectively measured.

CCS Concepts: • **Applied computing → Psychology**; • **Human-centered computing → Laboratory experiments**; **User studies**.

Additional Key Words and Phrases: mental strategy, mind wandering, attentional resources, caution, effort, awareness, speed-accuracy tradeoff

ACM Reference Format:
Alexander P. L. Martindale, Eleanor M. Deane, Catarina I. Peral-Fuster, Omar Elkelani, Ziqiao Qi, Sara I. Ribeiro-Ali, Rhiannon S. Herold, Carina E. I. Westling, and Harry J. Witchel. 2023. Lingering delays in a go/no-go task: mind wandering delays thought probes reliably but not reaction times. In . ACM, New York, NY, USA, 10 pages. https://doi.org/XXXXXXX.XXXXXXX

*Corresponding author

1 INTRODUCTION

1.1 Performance Decrement: Mind Wandering during Go/No-Go Tasks

Mind wandering is a family of states similar to daydreaming in which the thoughts stray from the task at hand [11, 14] Mind wandering (MW) is known to lead to performance decrement and accidents in a variety of work and vehicular contexts [17]. A laboratory system for observing performance decrement and failure with computers is Go/No-Go tasks such as the Sustained Attention to Response Task (SART) [9, 10] or to the similar Test of Variables of Attention (ToVA) [8]. SART and ToVA are go/no-go tasks in which the computer user must press a response button as quickly as possible whenever one image appears on the screen, but they must not press (i.e. inhibit) their response if a different image appears. This means that these go/no-go tasks require both attention and arousal to detect the stimulus and executive control to inhibit the no-go stimuli. Therefore, go/no-go tasks are linked with three types of performance decrement: slow responses, commission errors (pressing when a 3 appears), and omission errors (failing to press when another digit appears).

The traditional SART has an inter-trial interval (ITI) of 1150-3000 milliseconds (ms) and a press percentage (PP, the % of go-trials divided by the total number of trials) of 89% [10, 13]. Under these circumstances, healthy participants make many commission errors, which have been proposed to represent risks to innocent victims when law officers must make split second decisions [16]. These commission errors have a well-established link to mind wandering [9]. However, the relationship between mind wandering and reaction time in go/no-go tasks remain controversial. Initially MW was shown to speed up responses to SART [13], presumably due to truncating serial mental processes (see Figure 1A at right). An alternative view is that MW will slow down responses due to perceptual decoupling (see Figure 1A at left); in this view a parallel process is linked to paying attention, and this additional process either helps scanning the environment, or works at an executive level to maintain goal focus. At an experimental level, the direction of change of go/no-go reaction times during MW is not agreed, and may depend on which of the two processes above is dominant in a given individual.

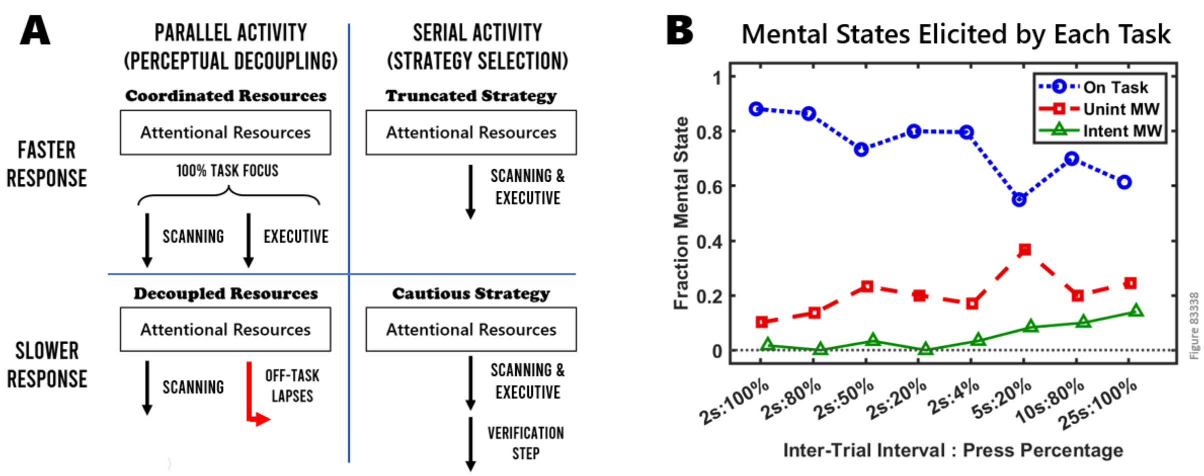

Fig. 1. Panel A: Schematic of parallel vs. serial attentional resources relating to Mind Wandering (MW). Panel B: Responses to thought probe during different versions of the task. Unint = unintentional, Intent = intentional.

A change in mental strategy that can occur in a go/no-go task results from changing the press percentage. When the press percentage in a go/no-go task is increased, there is a change in strategy that speeds up reaction times by up to 100 ms as well as increasing error rates. [16]. In addition to reaction times, we have shown at a previous ECCE conference [1] that when increasing the press percentage during a go/no-go task (from 20% to 80%), participants would unequivocally speed up (by nearly one second) their subsequent thought probe response time (to the question, "In the moment that just passed, were you focused on the task, mind wandering deliberately, or mind wandering spontaneously (without meaning to)?") [15]. The tentative conclusion from this extraordinary result is that MW leads to a lingering state of delay and lapsed attention that has an even greater effect on complicated tasks such as thought probes than it does on simple go/no-go tasks. Note that the compliant activity did not have clear effects on the reaction time element of the go/no-go task. If the *lingering state* hypothesis is true, then this implies that MW has an effect on parallel processing during complex tasks (see Figure 1A, left). The observation that MW leads to far greater delays during a complicated task would mean that supposed short lapses occurring during go/no-go task, like a momentary break for looking away, cannot fully explain the much longer MW-induced delay of the thought probe. A momentary break during a go/no-go task would imply a serial process (see Figure 1A, right), where the delay would be an extra step of reorientation, and in a serial process model, that reorientation would be a constant time, irrespective of the following step. By contrast, in a parallel processing model of reorientation, where the reorientation step requires several attentional resources simultaneously, then a more complex task (such as task switching or introspection) could be much more delayed by the previous deployment of resources to the mind wandering thought than a simple button pressing task would be.

The main critique of the conclusion from this extraordinary result (i.e. MW causes longer delays in complex tasks) is that the thought probe itself may have led to unequal response times, in the absence of a previously lingering stated. The thought probe in [15] gave a choice of three options: on-task, deliberate mind wandering, and spontaneous mind wandering. One can easily imagine a situation where a person who has no thinking delays would answer with the on-task option instantly, but if they had actually been mind wandering, this undelayed person may have spent a moment thinking, "Okay, I was mind wandering, but was I doing it deliberately? And what is deliberate mind wandering, anyway?" To address this criticism, we needed a thought probe where the mind wandering option required no more introspection than the on-task option, such as a binary choice, where you were either mind wandering or not.

Another result from [15] is that increasing compliant activity (without changing stimulus presentation rate) also reduced intentional MW (but this was supplanted by unintentional MW rather than being on-task). This implied that the compliant activity was hijacking parallel resources, possibly executive control, that were used for feeling "in control", such that the MW could no longer be believed to be intentional. This meant that there were three processes fighting for the same resources: the go/no-go task, the executive control that led to having a strategy, and the mind wandering. Because compliant activity reduced subjective ratings of detachment [15], which is much more strongly related to intention MW than unintentional MW, we suspect that the additional compliant activity triggers a change to a more cautious cognitive strategy. The detachment feeling may be an explicit parallel process of performing the task while introspecting ("I am bored but I still see it"). A simple way to test for this is to ask the participant subjective questions about awareness, or even about meta-cognition [2]; if they lack awareness, then it is probably not parallel processing.

1.2 Aims and Hypothesis

Our aim was to extend our previous data [15] showing that a latent state (a substrate, e.g. caution) could linger from a go/no-go task (where it was elicited purposefully) to a subsequent rating task, where this state would no longer be strategically relevant. Our hypotheses were: (H1) a PP% of 100% would lead to elimination of a cautious state or mental strategy that would be detectable as a faster reaction time, (H2) this mental substrate would still be detectable later as a faster response time on subjective rating scales, (H3) this response would not be related to MW, but would instead be due to a reduction in caution and monitoring, and (H4) any combination of lowering the press percentage, increasing the ITI, and MW would have additive effects on delaying reaction times and thought probe response times.

2 METHODS

2.1 Experimental Participants

Sixty online volunteers were recruited via Prolific and received £2.50 for their time. This study was carried out in accordance with the approval of BSMS's Standard Risk Ethics Protocol. Prolific allows for specifying and pre-selecting participants; we specified: English speaking, UK based, aged 18-70, using a laptop/desktop computer (i.e. not using a mobile phone or a tablet). All participants gave explicit informed consent (by pressing the letter "A", signifying "I agree") in accordance with the Declaration of Helsinki.

2.2 Protocol

Once recruited by advertising on Prolific, participants were sent to Pavlovia; this web platform allowed presentation of the stimuli on the participant's local computer and then uploaded the anonymised results to the platform. The online protocol had the following steps: open text for participant number (provided by Prolific) and simple demographic data, informed consent including description of how to withdraw instantly and button press for "I agree", detailed instructions for both the experimental task (Test of Variables of Attention, ToVA) and for the subjective ratings that they would make, an explicit practice block (4 trials), announcement that the experiment would begin, a rehearsal block (50 seconds) that was never included in the analyses, 8 experimental blocks (50 seconds each) presented in a pseudo-random order, and the thank you screen that sent participants back to Pavlovia for confirmation and payment. The entire experiment would take approximately 18 minutes, although it could be longer if the participant delayed during the subjective responses.

2.3 Stimuli and Subjective Rating Scales

The online go/no-go task (ToVA visual stimulus) was as described [8, 15], in which all responses were gathered by keyboard (i.e. not via mouse). For each trial, one of two easily distinguished images were presented: a go-stimulus (small box uppermost) and a no-go-stimulus (small box lower). The entire trial (including the participant's response) was set to be the inter-trial interval (ITI). The combination of ITI and the ratio of go-stimuli versus no-go-stimuli (Press Percentage, sometimes referred to as "non-target" in the literature) were set differently for each block (see Results). The number of trials in a block was set to be approximately 50 seconds. Each block ended with a series of 3-4 subjective tasks. The first rating task was a forced-choice, binary thought probe, "In the moment just preceding this thought probe were you:" and the choices were "On Task" (spacebar) or "Mind Wandering" (any other letter). If, and only if, the participant answered "Mind Wandering", the next part of the thought probe was presented, "Was your mind wandering:", and the choices were "Intentional" (spacebar) or "Unintentional" (any other letter). The next subjective task was the meta-awareness rating: "How aware were you of whether or not you were paying attention? Press one key 1-6". The final subjective task was the mental effort rating: "How much mental effort were you making to do the task correctly? Press one key 1-6" where 1 had an anchor "minimum effort" and 6 had an anchor of "maximum effort". The instructions described maximum effort as "compared to what is possible in an experiment like this. Mental effort means you are using your willpower to press the button as FAST as you can, whilst being CAREFUL to only do so when the correct square is shown. It is possible to fail at a task when making a lot of effort, particularly if the task is difficult or if you are fatigued. It is also possible to succeed with very little mental effort, particularly if the task seems easy."

2.4 Analysis and Pre-determined Data Exclusion Criteria

Pavlovia files were read into Matlab using a specially designed script, and all statistics were performed in Matlab. Individual trials were dropped if the reaction time > 0.9 seconds. Individual subjective ratings were capped at 15s if the response time (e.g., thought probes and subjective ratings) > 15 seconds. A block was dropped if the block had more than 4 omission or commission errors. The entire participant was dropped if a participant's data included more than 3 dropped blocks. The entire participant was dropped if the participant did not complete the experiment or if the participant's experimental duration was greater than 30 minutes (i.e. they took a break in the middle of the experiment).

3 RESULTS

There were a total of eight versions of the go/no-go task that this cohort experienced (ToVA). Of the 474 non-excluded blocks, 122 (25.74%) were reported as mind wandering. Figure 1B shows the breakdown by task. There were subtle increases in mind wandering when more false alarms appeared (when press percentage was lower, as tested among the blocks with 2s inter-trial intervals). There were slightly larger increases in MW when ITIs were longer (compare 2s:80% to 10s:80%), but substantially larger increases in MW appeared when there was a co-occurrence of both slow ITI and many false alarms (5s:20%).

3.1 Mean Reaction Times

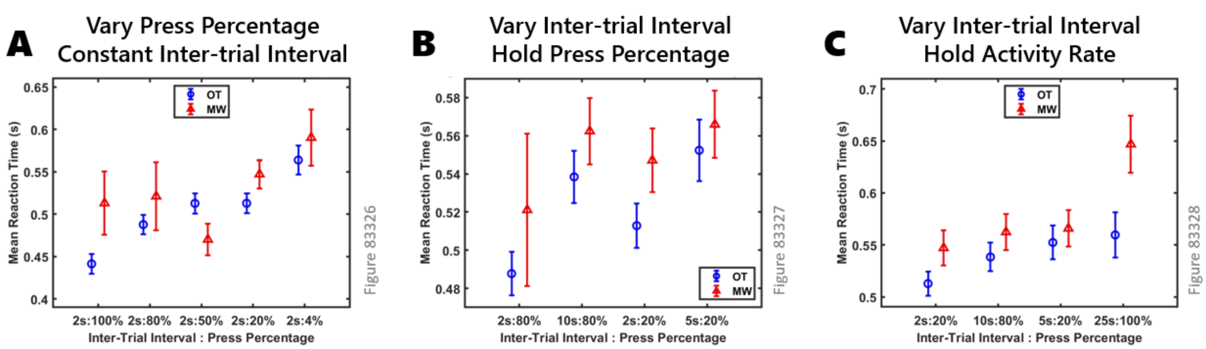

Fig. 2. Reaction times are slowed by longer Inter-Trial Intervals and Lower Press Percentages. Panel A: As press percentage is decreased, reaction times slow down. Panel B: Two pairs of tasks showing that when inter-trial interval is lengthened, reaction times are slowed down. Panel C: Two pairs of tasks with the same activity rate (10 seconds and 25 seconds) despite having altered both press percentages and inter-trial intervals. Error bars are SEMs.

Figure 2 shows how mean reaction times (not including the first trial) varied when both the ITI was made longer and the PP was lower. Panel A shows that mean reaction slowed down when the PP was lower for four versions of the task that all had an ITI = 2s. In an LME model of these tasks, the effect of PP was highly significant ($t = -10.56, P = 2.6\times10^{-22}$) but the effect of mind wandering was not ($P = 0.29$). Panel B shows for two examples that when ITI is lengthened (i.e. the task becomes slower, but not longer), reaction time increases. Again this effect was significant ($t = 4.90, P = 2.13 \times 10^{-6}$)

and the effect of mind wandering was not ($P = 0.18$). Panel C attempts to change the two features oppositely (to determine if one effect dominates) by maintaining a stable expected activity rate (button presses per minute). At left 2s:20% and 10s:80% both expect presses approximately once every 10s. The effect of the task was significant ($t = 2.75, P = 0.007$) while the effect of MW was not ($P = 0.40$). At right 5s:20% and 25s:100% both expect a button press every 25s. The effect of the task was significant ($t = 24.1, P = 6.40 \times 10^{-31}$) and so was the effect of MW ($P = 0.013$). The implication is that ITI has a slightly stronger effect on reaction time than does PP, and that MW has only a weak effect unless it is combined with another factor that slows down reaction times (in this case, an ITI of 25s).

3.2 Subjective Responses

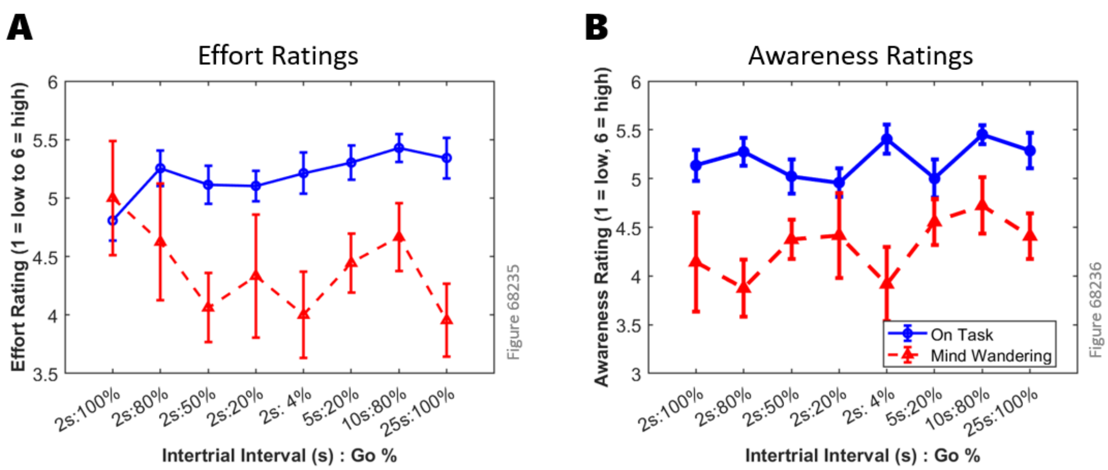

Fig. 3. Mean Effort and Awareness Ratings elicited by each task. Error bars are SEMs

Figure 3 shows the combined effects of mind wandering, ITI and PP on the the subjective ratings of effort and awareness. Panel A shows that mind wandering was associated with a fairly clear drop in subjective effort (LME $t = -6.21, P = 1.15 \times 10^{-9}$), and that compared to the reference of 2s:100%, the two tasks with 80% PP elicited significantly more effort (LME $t > 2.75, P = 0.0062$ for both), but the effects of the other tasks were not significant. Panel B shows that mind wandering was associated with a fairly clear drop in subjective awareness (LME $t = -7.15, P = 3.40 \times 10^{-12}$), and that compared to the reference of 2s:100%, 10s:80% PP elicited significantly more awareness (LME $t > 2.28, P = 0.023$), but the effects of the other tasks were not significant. The implication is that participants subjectively described themselves as on-task, highly aware, and making an effort all at the same time. It is common in experiments like these that the various subjective ratings are related to one another, and there is always a question among the limitations as to how able lay participants are to discriminate between various subjective ratings [12, 15].

To test for this subjective coupling, Figure 4A shows the relatedness for the effort and awareness responses, and they are fairly clearly on the diagonal. In an LME for awareness rating as an outcome, with effort rating and task design as predictors, this relationship between effort an awareness was statistically unequivocal (LME $t = 14.8, P = 6.01 \times 10^{-41}$). Panel B of Figure 4 shows the relationship between effort and on-task states. Above effort ratings of two, the relationship is fairly clearly diagonal and statistically significant (LME $t = 6.21, P = 1.15 \times 10^{-9}$). Panel C shows the relationship

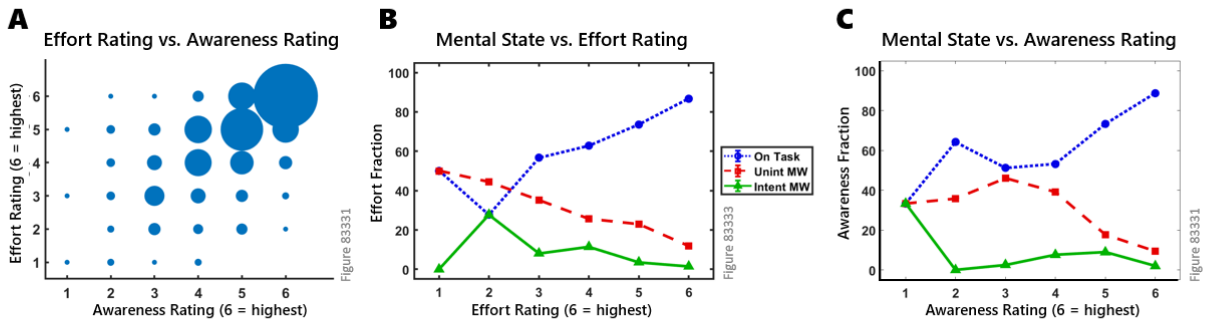

Fig. 4. Relatedness of Effort vs. Awareness vs. On Task. Panel A: Effort vs. Awareness Bubble Plot for all tasks. Panel B: Mental state vs. effort rating (for all tasks combined). Panel C: Mental state vs. awareness rating (for all tasks combined). For Panels B & C On-task = blue circles with dotted line, unintentional MW = red squares with dashed line, and intentional MW = green triangles with continuous line

between subjective awareness and on-task states. Above effort ratings of four, the relationship is fairly clearly diagonal and statistically significant (LME $t = 3.40, P = 1.15 \times 10^{-12}$).

Although these results suggest that all three subjective responses (effort, awareness and on-task states) are locked in a coupled relationship, there are differences when looking at statistics for the type of mind wandering. Intentional MW is strongly related to effort (LME, $t = -4.55, P = 6.74 \times 10^{-6}$), but not significantly related to awareness (LME, P = 0.13). Unintentional MW is strongly related to both awareness (LME, $t = -6.70, P = 6.16 \times 10^{-11}$) and effort (LME, $t = -5.08, P = 5.39 \times 10^{-7}$), and if they are both in a model all the relationship is partitioned to awareness (LME, $t = -4.36, P = 1.58 \times 10^{-5}$), and not effort (P = 0.32).

3.3 Lingering Mental Effects on Thought Probe Response Time

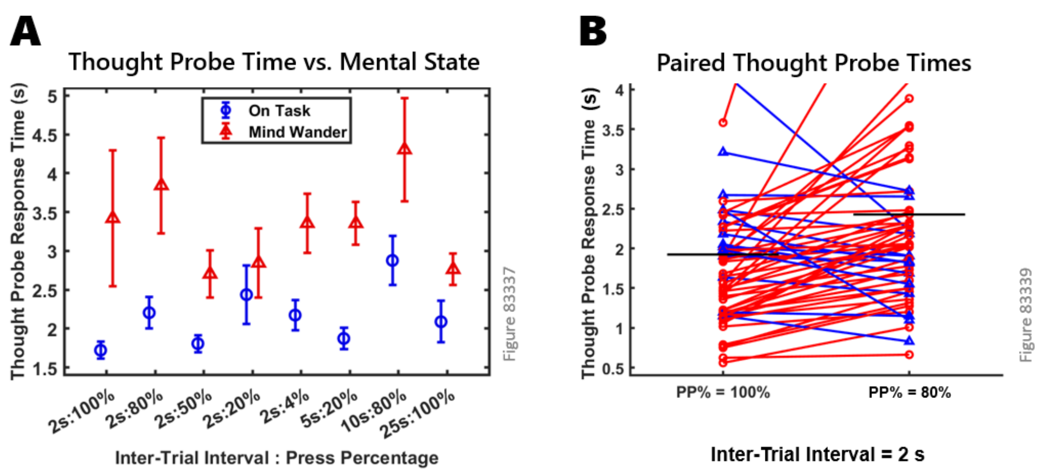

Fig. 5. Slowed response lingers into thought probe response time. Panel A: Comparing on-task (blue circles) to mind wandering (red triangles) for each task version. Panel B: Paired comparison of 100% press percentage to 80% when inter-trial interval = 2s. Black horizontal lines = means. Each participant is one coloured line. Red circles = 80% is slower, blue triangles = 80% is faster.

We previously detected a difference in the thought probe response time between blocks that were on-task versus those that were mind wandering [15], so looked to see that this result was repeated here. Figure 5A shows that there is a fairly clear delay in thought probe response time elicited by MW for virtually every version of the task (LME, $t = 6.13, P = 1.84 \times 10^{-9}$, except 2s:20%, which did not reach significance). The estimate for the additional time needed to respond to the thought probe is 890.5 ms. So MW delays the response to the thought probe by nearly one second, whereas it only delays the mean reaction time (see Figure 2) by 23.5 ms (LME for all blocks together, with predictors task type and MW). Figure 5B shows that 2s:100% speeds up thought probes compared to 2s:80% (see Table 1 for statistics).

3.4 Comparing Two Blocks With and Without False Alarms

To look more deeply at the strategic response to different tasks, we compared one block with no false alarms (ITI = 2s, PP%=100%) to another, more effortful block that had occasional false alarms (ITI = 2s, PP%=80%). The results for the 58 participants who had matching data for ITI = 2s, PP%=100% vs. ITI = 2s, PP%=80% were compared using paired t tests (see Table 1). These two versions of the go/no-go task had nearly identical amounts of button pressing activity, and there was no difference in their instructions (to press as fast as possible when the go-image was shown and to refrain from pressing when the no-go-image was shown). However, over the 50 seconds of the 2s/100% task, participants may have habituated to the total lack of no-go-stimuli by a mental strategy that sped up their responses. Row 1 of Table 1 shows that these participants reacted (simple reaction time = "RT0") to the go/no-go stimuli at 100% by pressing on average 45 milliseconds faster. The effect size for this difference is medium size (Cohen's $d = 0.546$ [3]).

Table 1. Paired Comparisons: Press Percentage PP% = 100% versus PP% = 80%, both at ITI = 2 s

Row	Calculation	100%: mean ± *SEM*	80%: mean ± *SEM*	Cohen's *d*	*P*
1	mean RT0	0.445 ± 0.011 s	0.491 ± 0.011 s	0.546	4.6×10^{-8}
2	RT1 (OTvMW)	1.913 ± 0.157 s	2.454 ± 0.208 s	0.380	0.0051
3	RT3 (aware)	2.664 ± 0.200 s	3.512 ± 0.225 s	0.529	0.0013
4	RT4 (effort)	1.909 ± 0.182 s	2.371 ± 0.171 s	0.344	0.0238
5	Awareness (1-6)	5.017 ± 0.160	5.069 ± 0.147	0.044	0.684
6	Effort (1-6)	4.845 ± 0.161	5.155 ± 0.149	0.263	0.023
7	Omission Errors	0.086	0.086	0	1.00
8	Mind Wandering	12.1%	13.8%	–	1.00

Row 2 shows that the differences in response times (RT1) for the thought probe ("In the moment just preceding this thought probe were you on task or mind wandering?") between these two versions of the task was slowed down by the 80% condition by 541 ms. Row 3 shows that the differences in response times (RT3) for the subjective question "How aware were you?" between these two versions of the task was slowed down by the 80% condition by 848 ms. This is an enormous deceleration (20-fold the slowing of the mean RT0 and 30% of the entire time it takes to score the rating at 2s/100%). It makes sense that the rating tasks would be slower than reaction time tasks (because rating tasks include at least one *interpretive step*). However, it is not intuitively obvious why the two identical rating tasks following different versions of the go/no-go task would be different: the mechanics and the answer for the rating task after the 2s/100% task are no different from after the rating task for 2s/80%. The actual ratings provided for the two tasks (see row 5) are almost identical (mean difference = 0.05 of a unit on a 1-6 scale, $P = 0.684$). The implication is that some mental element (either a state or a strategy) is lingering from the reaction time task all the way to this rating task, despite the fact that there was a thought probe (lasting about 2 seconds) that occurred between these two tasks. The most obvious lingering state to test would be mind wandering, which was subjectively tested with a binary thought probe and statistically tested using a Fisher's exact test (row 8), but we found no difference in MW for these two versions of the task (odds ratio = 1.166, 95% confidence interval 0.3932 to 3.4560).

One possible strategic difference is that participants spent less effort on the 100% task (row 6). There was a small, statistically significant decrease in subjective effort (0.310 units on a 1-6 scale, Cohen's $d = 0.263$ [3]). Again, the response time for this effort rating (RT4, row 4), which was presented after the awareness rating task, was significantly faster (462 milliseconds) following the 100% version of the go/no-go task than after the 80% version. Although this is nearly half of one second, it is a small effect (Cohen's $d = 0.344$ [3]) because rating times are so variable. The final state that might be different is that the participants might be clumsier or more sloppy during the 100% version. To test for this, we compared the number of errors of omission (when a go-image appeared and the participant failed to press the button in within 2 seconds) per block (row 7), and there was absolutely no difference. Of course, there were errors of commission (when a no-go-stimulus appeared and the participant made a mistake and pressed the button) in the 80% task, and this was not possible in the 100% version of the task because there were not any no-go-stimuli.

4 DISCUSSION

4.1 Overview of the Effects of a Cautious Strategy

It is well-established that immediately after mistakes on a go/no-go task, participants slow down [4, 7] due to caution, which is often described as a strategic choice. The caution is a substrate (latent state) and the error is a trigger, and when the substrate and trigger co-occur together, they trigger a cautious delay. Our team has previously found evidence that a three-way thought probe (between on-task, intentional MW and unintentional MW) manifested slower thought probe responses when mind wandering than when on-task [15]. However, this delay could have been due to the nature of the thought probe. Furthermore, even if the delay was due to an ongoing mental state elicited during the go/no-go task (such as after errors), there was no evidence in the literature that this change would linger through additional go/no-go trials and then through three subsequent rating tasks. In this experiment we re-designed the thought probe into a simpler two-way choice to minimise the chance that thought probe delay is due to the thought probe itself. We also used many more versions of the go/no-go task to determine if the delay might be ascribed to a rational, cautious state, as well as adding two rating scales for effort and awareness. Our results were: (H1) A version of the go/no-go task with zero no-go-stimuli spontaneously and implicitly led to a highly significant acceleration in mean reaction time (RT0), as implied by [16]. (H2) The same version of 100% go-stimuli quickened three subsequent response times for rating tasks by over 500 ms, 400 ms and 800 ms, which suggests that the basis of this effect is a lingering state (or substrate). (H3) This is a change in the speed-accuracy trade-off in which the participant adopts a mental strategy that speeds up thinking by reducing caution [6, 10]; the evidence is that there is a modest decrease in subjective ratings of mental effort, although there is no significant change in MW or in awareness ratings. (H4) The causes of go/no-go delays are synergistic, and may work in parallel. The main limitations in this experiment are the reliability of thought probes in representing conscious states [15].

4.2 Conclusions and Future Research

The observations at 100% go-stimuli are particularly interesting because this strategy of reduced effort lingers from the go/no-go task (where the strategy has a task-related benefit to performance) to a subsequent series of rating tasks, where this strategy has no task benefit. It is possible that the reduced effort is due to less caution, so future experiments should have a subjective caution measure. The other interesting aspect of this data is that we have seemingly eliminated the possibility that this change is due to a state change in awareness (i.e. increased distraction). Thus, although we found, as expected, that low effort does cause reductions in awareness and an increase in MW, the (subtle) reduction in subjective effort we observed reduced the use of mental resources for caution, but not the situational awareness of the participant during the task. This short-term cognitive change may reflect the habitual "yes set" of reduced caution described in Ericksonian hypnosis [5]; instead of a gross change in awareness slowing all attentional resources, in this case we saw a truncation in mental strategy that led to decreased monitoring and the quickening of attentional resources. That is, as the participants realised that the go/no-go task was easier, they rationally decided to improve their performance by truncating their serial strategy for using mental resources in a way that is objectively detectable, and this reassignment of resources lingered into a subsequent parallel process in a way that was not rational [6].

ACKNOWLEDGMENTS

We gratefully acknowledge funding from BSMS's Independent Research Project programme. We also acknowledge John Kander and Fred Ebb for inspiration on how abandoning caution can feel effortless.

REFERENCES

[1] Oluwademilade Amos-Oluwole, Benjamin Subhani, Harry Claxton, Daisy Holmes, Carina Westling, and Harry Witchel. 2019. Compliant activity inhibits deliberate mind wandering and accelerates thought probe responsiveness compared to compliant inactivity. In *Proceedings of the 31st European Conference on Cognitive Ergonomics*. 65–68.

[2] Thomas Anderson, Rotem Petranker, Hause Lin, and Norman AS Farb. 2021. The metronome response task for measuring mind wandering: Replication attempt and extension of three studies by Seli et al. *Attention, Perception, & Psychophysics* 83 (2021), 315–330.

[3] Jacob Cohen. 2013. *Statistical power analysis for the behavioral sciences*. Routledge.

[4] Gilles Dutilh, Joachim Vandekerckhove, Birte U Forstmann, Emmanuel Keuleers, Marc Brysbaert, and Eric-Jan Wagenmakers. 2012. Testing theories of post-error slowing. *Attention, Perception, & Psychophysics* 74, 2 (2012), 454–465.

[5] Milton H Erickson and Ernest L Rossi. 1981. *Experiencing Hypnosis*. Irvington Publishers, New York: NY.

[6] Mehdi Keramati, Amir Dezfouli, and Payam Piray. 2011. Speed/accuracy trade-off between the habitual and the goal-directed processes. *PLoS Computational Biology* 7, 5 (2011), e1002055.

[7] Donald Laming. 1979. Autocorrelation of choice-reaction times. *Acta Psychologica* 43, 5 (1979), 381–412.

[8] Robert A Leark, Lawrence M Greenberg, CL Kindschi, TR Dupuy, and Steve J Hughes. 2008. *TOVA professional manual*. TOVA Company, Los Alamitos, CA.

[9] Jennifer C McVay and Michael J Kane. 2012. Drifting from slow to "d'oh!": Working memory capacity and mind wandering predict extreme reaction times and executive control errors. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 38, 3 (2012), 525.

[10] Paul Seli, James Allan Cheyne, and Daniel Smilek. 2012. Attention failures versus misplaced diligence: Separating attention lapses from speed–accuracy trade-offs. *Consciousness and Cognition* 21, 1 (2012), 277–291.

[11] Paul Seli, Michael J Kane, Jonathan Smallwood, Daniel L Schacter, David Maillet, Jonathan W Schooler, and Daniel Smilek. 2018. Mind-wandering as a natural kind: A family-resemblances view. *Trends in Cognitive Sciences* 22, 6 (2018), 479–490.

[12] Paul Seli, Evan F Risko, and Daniel Smilek. 2016. On the necessity of distinguishing between unintentional and intentional mind wandering. *Psychological Science* 27, 5 (2016), 685–691.

[13] Jonathan Smallwood, John B Davies, Derek Heim, Frances Finnigan, Megan Sudberry, Rory O'Connor, and Marc Obonsawin. 2004. Subjective experience and the attentional lapse: Task engagement and disengagement during sustained attention. *Consciousness and Cognition* 13, 4 (2004), 657–690.

[14] Jonathan Smallwood and Jonathan W Schooler. 2006. The restless mind. *Psychological Bulletin* 132, 6 (2006), 946–958.

[15] Benjamin R Subhani, Oluwademilade I Amos-Oluwole, Harry L Claxton, Daisy C Holmes, Carina EI Westling, and Harry J Witchel. 2019. Compliant activity rather than difficulty accelerates thought probe responsiveness and inhibits deliberate mind wandering. *Behaviour & Information Technology* 38, 10 (2019), 1048–1059.

[16] Kyle M Wilson, Kristin M Finkbeiner, Neil R De Joux, Paul N Russell, and William S Helton. 2016. Go-stimuli proportion influences response strategy in a sustained attention to response task. *Experimental Brain Research* 234, 10 (2016), 2989–2998.

[17] Matthew R Yanko and Thomas M Spalek. 2013. Route familiarity breeds inattention: A driving simulator study. *Accident Analysis & Prevention* 57 (2013), 80–86.