Topic: Neuroergonomics

Is Semantic Vigilance impaired by Narrative Memory Demands? Theory and Applications

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Abstract

Objective: Two verbal tasks were utilized in a dual-task paradigm to explore performance theories and prior dual-tasking results.

Background: Both the decline in vigilance performance over time, or vigilance decrement, and limited dual-tasking ability may be explained by limited mental resources. Resource theorists would recommend removing task demands to avoid cognitive overload, while mindlessness theorists may recommend *adding* engaging task demands to prevent boredom. Prior research demonstrated interference between a verbal free recall and semantic vigilance task, but exploring tasks with greater ecological validity is necessary.

Method: A narrative memory task and semantic vigilance task were performed individually and simultaneously. Relative performance impairments were compared to a previous dual-task pairing.

Results: The semantic vigilance task caused performance degradation to the narrative memory task, and vice versa. A vigilance decrement was not observed, and the interference was to a lesser extent than when the semantic vigilance task was paired with a free recall task.

Conclusion: Resource theory was supported, though passive learning effects during a semantic vigilance task with novel stimuli may prevent a vigilance decrement. The interference was less than that of a previous similar dual-task pairing, but even tasks as routine as listening to a conversation or story can impair other task performance.

Application: A better understanding of resource theory and dual-task performance outcomes can help inform feasible task loads and improve efficiency and safety of operators in high risk and other professions.

Keywords: Attentional processes, Dual task, Resource theory, Signal detection theory, Vigilance, Working memory

Précis: Memory and vigilance tasks were performed in a dual-task experiment. Dual-task performance was inferior to single-task performance, but interference was less severe than that observed in prior research. The results support a resource theory perspective and highlight the need for understanding the reasons behind performance outcomes in real world applications.

Is Semantic Vigilance impaired by Narrative Memory Demands? Theory and Applications

Resource theorists suggest that the mental resources required for attention and information processing are limited but renewable (Kahneman, 1973). When tasks require sustained attention, or vigilance, the ability to detect critical stimuli often declines over time (Szalma et al., 2004; Warm, 1984). From the resource theory perspective, this vigilance decrement is due to a decline in cognitive resource availability: vigilance requires hard work and therefore drains mental resource stores (Grier et al., 2003; Head & Helton, 2014; Helton & Warm, 2008; Warm, Parasuraman, & Matthews, 2008).

In addition to the decline in performance with time on task as resource stores are drained, when limited resources are distributed among more than one task, they may be utilized faster than they are replenished, resulting in *further* reduction in performance (i.e. dual-task interference; Helton & Russell, 2015; Helton & Warm, 2008; Parasuraman & Mouloua, 1987; Warm et al., 2008). Many studies have demonstrated worse performance in dual- compared to single-task conditions, regardless of the type of tasks used (Blakely, Kemp, & Helton, 2016; Bourke, 1996; Darling & Helton, 2014; Epling, Blakely, Russell, & Helton, 2017, 2016; Epling, Russell, & Helton, 2016; Green & Helton, 2011; Head, Helton, Russell, & Neumann, 2012; Head, Russell, Dorahy, Neumann, & Helton, 2012).

Other researchers, however, believe task underload and resulting operator mindlessness or mind-wandering is the underlying cause of the vigilance decrement and sustained attention lapses (Head & Helton, 2012; Pattyn, Neyt, Henderickx, & Soetens, 2008; Thomson, Besner, & Smilek, 2015; Thomson, Smilek, & Besner, 2015). Essentially, the lack of external novel stimulation in vigilance tasks causes the operator to withdraw effortful processing from the task (Manly, Robertson, Galloway, & Hawkins 1999; Robertson, Manly, Andrade, Baddeley, &

Yiend, 1997). From this mindlessness theory perspective, vigilance tasks are not mentally taxing; in fact, they are too dull for operators to stay engaged and maintain optimal performance (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997; Warm et al., 2008). Dual-task methodology can be useful for exploring this issue: if cognitive underload (i.e., mindlessness theory) is the underlying cause of the vigilance decrement, giving operators more engaging task demands (up to a point, which may vary with different types of task) could improve performance. If cognitive overload (i.e., resource theory) is the cause of the decrement, additional cognitive demand should impair performance. Due to the necessity of sustained attention and frequent occurrence of multi-tasking in high risk environments, the underlying cause of such performance outcomes needs to be fully understood.

In recent research, Epling, Russell, and Helton (2016) observed a significant vigilance decrement in a semantic vigilance task. They also observed significant interference when participants concurrently performed the semantic vigilance task with a verbal free recall task (i.e., performance on each task in the dual-task condition suffered compared to performance in the individual task conditions). These results provided support for the resource theory and would appear contrary to the mindlessness perspective. The ability to memorize a list of unrelated words (the verbal free recall task used in the experiment mentioned above), however, would rarely be a mission-essential task, so it lacks ecological validity. Moreover, a mindlessness theory advocate could argue that while the words provide increased exogenous or novel stimulation, they may not be subjectively interesting enough to prevent underload, disengagement, and the vigilance decrement.

Unlike the verbal free recall task, processing verbal stimuli from the environment or understanding the gist of a verbal narrative (such as a conversation), could be very important in high-risk, complex missions. Pilots, army scouts, firefighters, search and rescue climbers and divers, and countless others may rely on communications from a remote intelligence source in order to complete their missions. Incorrect understanding of the communications, or failure to correctly remember the gist of a situation, can lead to accidents (Edgar & Edgar, 2007). The present research will therefore build upon previous research with a more ecologically valid verbal memory task meant to represent narrative or gist memory, where the *meaning* of information, rather than verbatim representations, are stored in memory (Abadie, Warquier, & Terrier, 2013). It is of practical importance to understand what happens to vigilance performance when the additional memory demand is not a contrived free recall task, but rather more naturalistic and subjectively interesting (stories are interesting to people; Abbott, 2008). It is also of theoretical importance (i.e., the overload vs. underload debate) to know how the additional processing and memory demand of the auditory narrative affects vigilance performance.

Present Research

In the present semantic vigilance task, participants had to classify briefly displayed and low visually discriminable words as naming either living or nonliving things (Epling, Russell, et al., 2016). Though this task is somewhat simplistic, semantic vigilance can be required in real-world situations such as monitoring chat boxes or radio channels for specific danger words. In the narrative memory task, participants had to listen to a narrated scenario with the knowledge that a true/false memory test on the scenario would follow. Participants also performed these tasks simultaneously in a dual-task condition. One aim of this report is to explore the performance outcomes on the two tasks when they are performed simultaneously versus individually, in light of the ongoing resource versus mindlessness theory debate. Another aim is to compare the dual-task interference in the present study to the interference observed in prior research that utilized a free recall task with the same semantic vigilance task (Epling, Russell, et al., 2016). Differences in the tasks' memory requirements (true/false recognition memory versus free recall) could lead to different working memory load/cognitive resource requirements between the narrative memory and free recall tasks, and thus differential levels of dual-task interference.

Due to previous findings with this semantic vigilance task (Epling, Russell, et al., 2016), we expect to find a decline in vigilance performance over time. Because the narrative memory task requires verbal resources, constant attention, and situation updating (e.g., learning that a fire contained in one room has now spread to other rooms), we expect to find significant interference between tasks in the dual-task condition, based on the resource theory and previous research (Epling, Russell, et al., 2016; Wickens, 2002). However, we expect less interference in the present dual-task pairing than that observed between the prior free recall and semantic vigilance task pairing, due to an assumed lesser demand on working memory when rehearsal/free recall is not involved (Kahneman, 1973). An unexpected result (according to resource theorists) would be dual-task *improvement*. Mindlessness theorists may suggest that adding the narrative memory task to the semantic vigilance task could benefit vigilance performance, as an additional subjectively interesting task demand may help prevent cognitive underload, boredom, and/or mind-wandering.

Method

Participants

Thirty-seven undergraduate psychology students at the University of Canterbury participated as part of requirements for course credit. The data from two participants was omitted from analyses due to an exceptionally poor hit rate (less than 15% correct detections in the single semantic vigilance task), for a total of 35 participants (27 women). All participants had normal or corrected-to-normal vision, normal hearing, and were fluent English speakers based on self-report. Participant age ranged from 15 to 30 years (*M* = 21 years, *SD* = 4.0). The study was approved by the University Human Ethics Committee, and informed consent was gained from each participant.

Materials

Narrative memory task. We employed the Quantitative Analysis of Situation Awareness (QASA) technique in the creation of the new narrative memory task (Catherwood, Edgar, Sallis, Medley, & Brookes, 2012; Edgar et al., 2018). QASA accounts for the notion that false information may be stored alongside true information (Edgar, Edgar, & Curry, 2003). Using QASA, narrative memory can be assessed by providing operators a list of probe statements about a scenario or narrative, some true and some false, and applying Signal Detection Theory (SDT) metrics to extract an operator's memory based on their responses. Correctly identifying a true statement as true would be considered a hit, while identifying a false statement as true would be a false alarm. QASA developers (Catherwood et al., 2012; Edgar et al., 2017, 2003; Edgar & Edgar, 2007) computed A´ as a measure of the ability to distinguish true from false information.

Two audio scenarios were developed to present a simulation of members of the public involved in a building fire. The scenarios were designed to be audio analogues of visual scenarios that have been successfully employed in previous QASA research (Catherwood et al., 2012). The two scenarios were of the same duration (four minutes, thirty four seconds) and contained enough information for 24 true/false statements to be presented for each (one scenario had 10 true and 14 false probes, and the other scenario had 12 true and 12 false). All statements were unambiguously true or false with respect to the scenario. Probes related, as far as possible, to events evenly spaced throughout the scenario. Examples of probe statements used were: ‘The smoke alarm was broken’ and ‘The people were on the 5^{th} floor when the fire broke out.’ Silence was added to the beginning and end of each audio track so that each track lasted five minutes. A response grid, where participants could give a true or false response to each probe, accompanied each set of probe statements to facilitate true/false scoring. Over the ear headphones were worn throughout the duration of the experiment.

Semantic vigilance task. This task was utilized from prior research (Epling, Russell, et al., 2016) without changes. Two lists, each of 48 “living” words (targets; probability = .2; e.g., “dog”) and 192 “non-living” words (neutrals; probability = .8; e.g., “chair”), were used. Words ranged from three to seven letters and lists were balanced for average word length. A separate practice task word list included 16 target words and 64 neutral words. The two audio scenarios for the narrative memory task (described above) were spliced into small segments which were randomly arranged to create a five minute nonsensical scenario, using Audacity sound editing software. The scrambled scenario provided incomprehensible noise to be played during the semantic vigilance-alone task.

Dual-task. The second target-neutral list created for the semantic vigilance task was paired with the second audio scenario for the narrative memory task. The pairings were counterbalanced across participants.

Procedure

Participants were tested at individual computer workstations within a laboratory room at the University of Canterbury. Participants were run individually or in pairs seated on opposite sides of the room. Participants were unrestrained and seated approximately 50cm from eye-level screens (377 x 303 mm, 60 Hz refresh rate) and wore the provided headphones for the duration of the experiment. Computer loudness was set at 30% of max intensity for all participants, confirmed to be a comfortable loudness after the practice session. Stimulus presentations and recordings of response times and accuracy were executed by PC computers using E-Prime Professional 2.0 (Schneider, Eschman, & Zuccolotto, 2002).

Participants read instructions on how to complete the experiment and were given the opportunity to ask questions. They were then given a 100 second semantic vigilance practice session with audio performance feedback on hits and misses. If they had no further questions after the practice, they proceeded to the experiment. Participants were randomly assigned to one of six groups which counterbalanced the order of the three tasks (narrative memory alone, semantic vigilance alone, dual-task) in a within-subjects design.

Conditions and Task Stimuli

For the narrative memory task, computer screens remained blank and participants were instructed to listen to the scenario and remember as much as possible, for they would be completing a true/false assessment regarding elements of the scenario. At the end of five minutes, participants were given as much time as needed to complete the assessment.

For the semantic vigilance task, participants monitored the computer screen and responded to living words with the spacebar, and withheld responses to non-living words. Neutral and target stimuli were randomly sampled without replacement from the appropriate list such that there were 48 target and 192 neutral words presented in each five minute task (event rate = 48 stimuli per minute). Target and neutral stimuli words were presented in E-prime silver transparent Arial size 20 font. Words were centered on a mask (used to increase difficulty of detecting targets from neutrals) consisting of a grid of black outlined circles, as seen in Figure 1.

The mask appeared 133mm tall by 178mm wide, and the rest of the screen remained white. The mask was visible throughout the entire trial and was overlayed for 250ms every 1250ms by a target or neutral word. During this task, participants heard the scrambled scenario with no memory imperative as an auditory control for the narrative memory scenario.

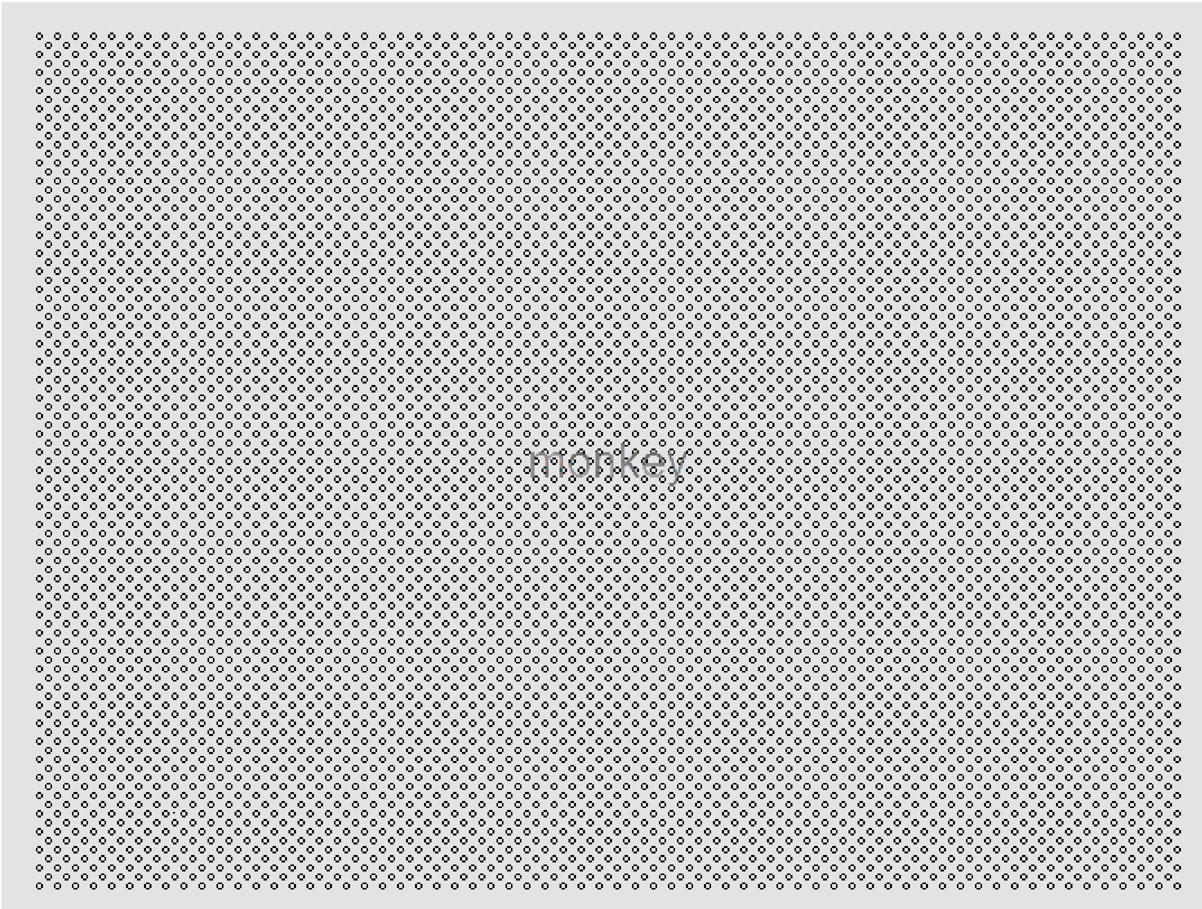

Figure 1. The semantic vigilance task display with a target word.

For the dual-task, both of the above tasks were run simultaneously. Participants heard a new scenario to remember, while also responding to the semantic vigilance task. At the end of five minutes, participants were given the narrative memory true/false assessment.

Results

Semantic Vigilance

For each participant the proportion of correct detections, the proportion of false alarms, and the mean response times were calculated for each of the three 100-second periods (adding up to five minutes in total) for the semantic vigilance-alone task (single) and semantic vigilance with narrative memory task (dual). We then calculated the signal detection theory metric of A´. We analyzed the raw proportions and A´ using two (single-task versus dual-task) by three (period of vigil) repeated measures analyses of variance. The primary focus for the analyses regarding period and period by task interaction was with changes over periods or trend analyses. For these tests, we used orthogonal polynomial contrasts as they are the most powerful tests of the specific hypotheses regarding change over periods and because they are 1-df tests, violation of the sphericity assumption is not a concern.

For correct detections, participants committed a significantly greater proportion of hits in the single- (M = .659, SE = .028) compared to the dual-task (M = .616, SE = .030), $F(1,34)$ = 4.52, p = .041, $M_{\text{difference}}$ = .043 (95% CI [.001,.084]), Cohen's d_z = .352 (95% CI [.107,.597]). Percentage of correct detections over time is displayed in Figure 2. The linear trend for period was nonsignificant, $F(1,34)$ = .203, p = .656, η_p^2 = .006, as was the quadratic trend for period, $F(1,34)$ = .418, p = .522, η_p^2 = .012. The linear trend for period by task interaction, $F(1,34)$ = .543, p = .466, η_p^2 = .016, and quadratic trend for period by task interaction, $F(1,34)$ = 1.170, p = .287, η_p^2 = .033 were also both nonsignificant.

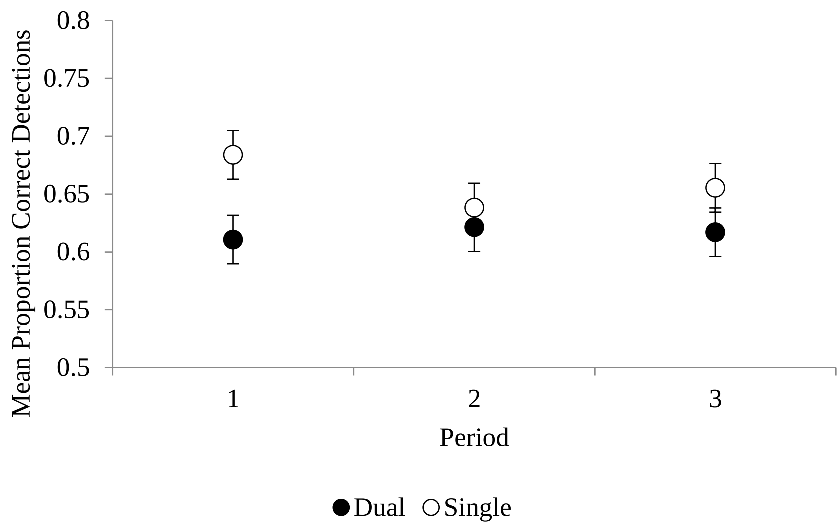

Figure 2. *Proportion of hits in dual- and single-task across periods. Error bars are standard errors of the mean.*

A significant difference in false alarms was not observed between the dual-task (*M* = .040, *SE* = .009) and the single-task (*M* = .037, *SE* = .005), $F(1,34) = .342$, $p = .562$, $M_{\text{difference}} = .003$ (95% CI [-.008,.015]). There was, however, a significant linear trend for period, $F(1,34) = 13.27$, $p = .001$, $\eta_p^2 = .281$. The linear trend for the two tasks is displayed in Figure 3. The quadratic trend was nonsignificant, $F(1,34) = 3.92$, $p = .056$, $\eta_p^2 = .103$. There was also neither a significant linear trend for period by task interaction, $F(1,34) = .289$, $p = .595$, $\eta_p^2 = .008$, nor quadratic trend for period by task interaction, $F(1,34) = .211$, $p = .649$, $\eta_p^2 = .006$.

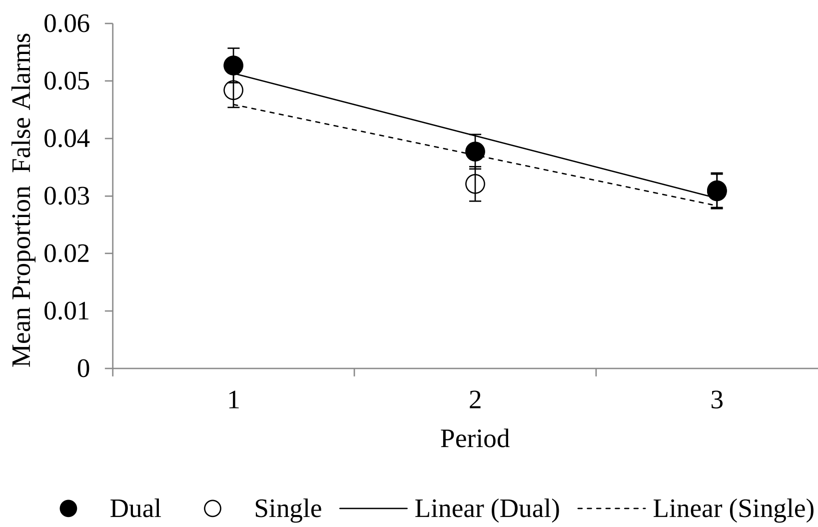

Figure 3. *Proportion of false alarms in dual- and single-task across periods. Error bars are standard errors of the mean.*

No significant difference in mean response time between the single-task (*M* = 706.99ms, *SE* = 9.56) and the dual-task (*M* = 710.00ms, *SE* = 11.92) was observed, *F*(34) = .090, *p* = .766, $M_{\text{difference}}$ = 3.01 (95% CI [-17.40,23.42]). The linear trend for period was nonsignificant, as shown in Figure 4, *F*(1,34) = 3.546, *p* =.068, η_p^2 = .094, as was the quadratic trend for period, *F*(1,34) = .677, *p* = .416, η_p^2 = .020. In addition, the linear trend for a period by task interaction was nonsignificant, *F*(1,34) = .149, *p* = .702, η_p^2 = .004, as was the quadratic trend for a period by task interaction, *F*(1,34) = .866, *p* =.359, η_p^2 = .025.

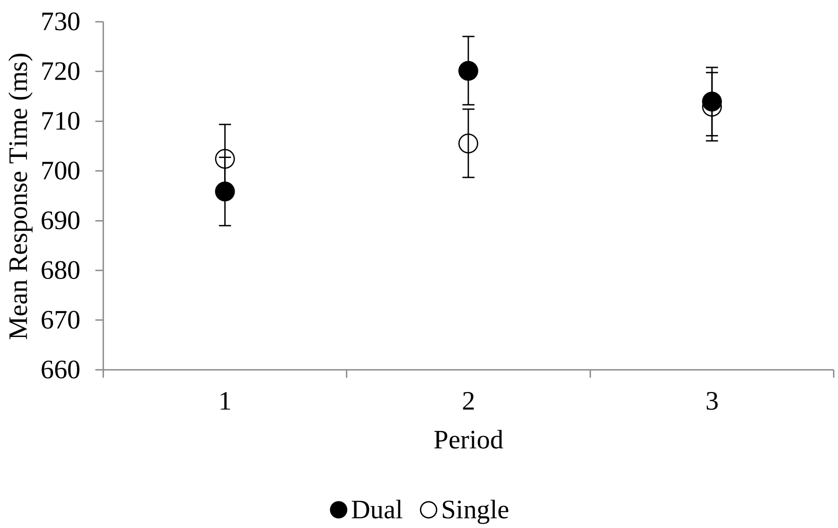

Figure 4. *Mean response time in dual- and single-task across periods. Error bars are standard errors of the mean.*

For A´, participants had greater perceptual sensitivity in the single- (*M* = .893, *SE* = .010) compared to the dual-task (*M* = .878, *SE* = .013), but this difference failed to reach the .05 level of significance (*F*(1,34) = 3.88, *p* = .057), $M_{\text{difference}}$ = .015 (95% CI [.000, .030]), Cohen's d_z = .333 (95% CI [.113,.553]). A´ over time is displayed in Figure 5. The linear trend for period was nonsignificant, *F*(1,34) = .984, *p* = .328, η_p^2 = .028, as was the quadratic trend for period, *F*(1,34) = .050, *p* = .825, η_p^2 = .001. There was neither a significant linear trend for period by task interaction, $F(1,34) = .999$, $p = .325$, $\eta_p^2 = .029$, nor quadratic trend for period by task interaction, $F(1,34) = .480$, $p = .493$, $\eta_p^2 = .014$.

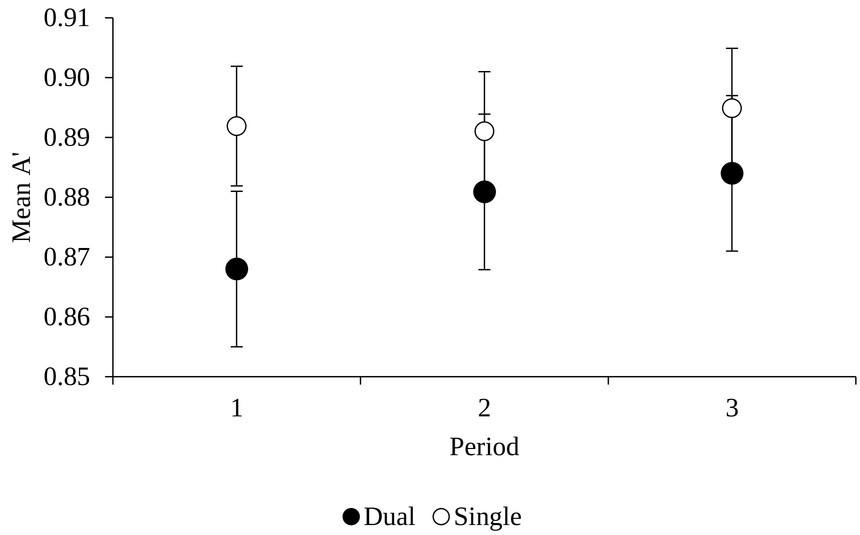

Figure 5. *Mean A´ in dual- and single-task across periods. Error bars are standard errors of the mean.*

Narrative Memory

For each participant the number of correct probe responses (correct detections) was scored, and the proportion of hits and false alarms was calculated. The SDT metric of A´ (sensitivity) was calculated from these proportions using the process described by Edgar and colleagues (2003).

Participants responded correctly to significantly more probes in the single- ($M = 17.3$, $SD = 2.10$) compared to dual-task ($M = 15.3$, $SD = 2.59$) condition, $t(34)= 4.71$, $p < .001$, $M_{\text{difference}} = 2.0$ (95% CI [1.15,2.90]). Participants committed a significantly greater proportion of hits in the single- ($M = .773$, $SD = .126$) compared to the dual-task condition ($M = .708$, $SD = .109$), $t(34) = 2.79$, $p = .009$, $M_{\text{difference}} = .065$ (95% CI [.017,.112]). Participants also committed a significantly lower proportion of false alarms in the single- ($M = .320$, $SD = .139$) compared to the dual-task condition ($M = .424$, $SD = .183$), $t(34) = 3.77$, $p = .001$, $M_{\text{difference}} = .104$ (95% CI [.048,.160]).

For A´, participants had significantly higher sensitivity to true probes in the single-task (*M* = .809, *SD* = .086) than the dual-task (*M* = .708, *SD* = .139), $t(34) = 4.36$, $p < .001$, $M_{difference} = .101$ (95% CI [.054,.148]), $d_z = .737$ (95% CI [.317,1.157]).

Comparison with Prior Research

In order to compare the present study with the previous free recall study (Epling et al., 2016), standardized effect sizes (Cohen's d_z) for dual-task performance decline in both tasks of both experiments were calculated, and can be seen in Figure 6. Note that a larger effect size indicates *more* interference, i.e., worse performance in the dual- compared to single-task condition.

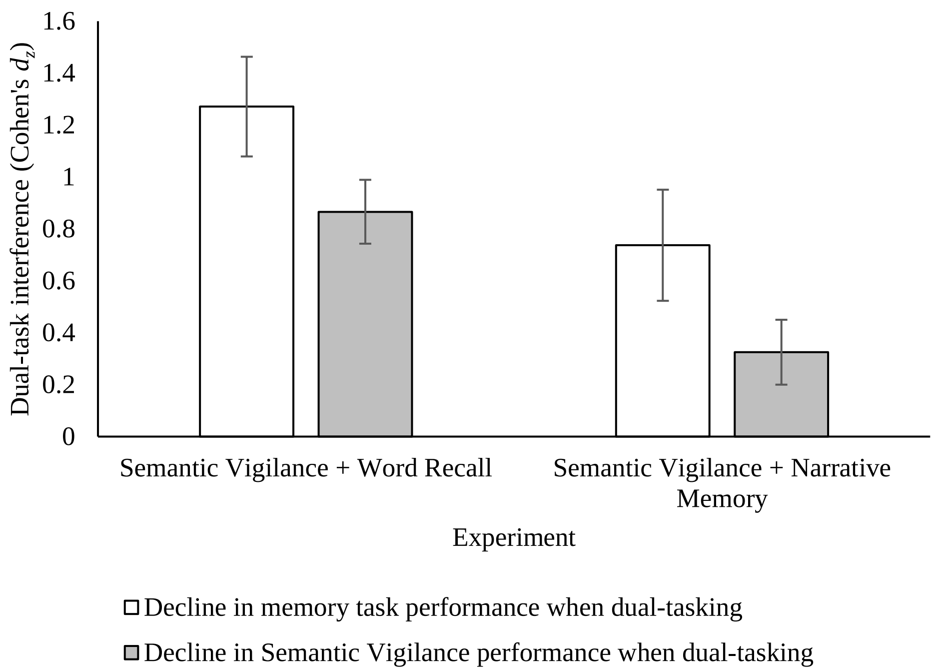

Figure 6. *Dual-tasking performance effects in two experiments. Error bars are standard errors of the mean.*

Two independent samples t-tests were used to compare the dual-task interference effects across the two experiments. First, the average percent word recall decline from single- to dual-task (100*(1 - # words remembered dual-task/# words remembered single-task)) (*M* = 35.32, *SD* = 29.06) was compared to the average percent decline in narrative memory task A´ (100*(1 - A´

dual-task/ A´ single-task)) (M = 13.36, SD = 21.19), t = 3.842, p < .001, $M_{difference}$ = 21.95 (95% CI [10.60,33.31]). Then, the percent decline in hit rate (percent of critical signals detected) in the semantic vigilance task when paired with the word recall task (M = 13.28, SD = 20.91) was compared to the percent decline in hit rate in the semantic vigilance task when paired with the narrative memory task (M = 5.75, SD = 19.81), t = 1.687, p = .095, $M_{difference}$ = 7.53 (95% CI [-1.34,16.39]).

Discussion

In line with expectations, performance on the semantic vigilance task was worse in the dual- compared to the single-task. However, a clear vigilance decrement in the proportion of hits (i.e., reduced critical signal detection over time) was *not* observed in either the single- or dual-semantic vigilance task. Participants did tend to respond more slowly with time on task, an alternative indicator of a vigilance decrement, but this effect was also nonsignificant. A significant linear trend was observed for false alarms: in both single- and dual- tasks, participants became less likely to commit a false alarm with time on task. This is a common finding in vigilance tasks (Epling, Russell, et al., 2016), as participants become increasingly aware of how rare targets are. A', as seen in Figure 5, was relatively stable across the three periods of the single-task, while the dual-task A' increased somewhat. Though the A' trends were not statistically significant, it is still important to note, as it is contrary to the decrement traditionally observed in vigilance tasks and observed with this specific task previously (Epling, Russell, et al., 2016).

Similar to semantic vigilance task outcomes, a dual-task performance impairment was also observed in the narrative memory task: participants were more accurate at detecting true and false statements in the single- compared to dual-task.

Theoretical Implications

Dual-tasking did not prove beneficial to performance on either task: the additional load resulted in reduced performance compared to that achieved in the single-task conditions. This provides at least partial support for the resource theory (overload) perspective, rather than the mindlessness (underload) perspective. The results support the idea that cognitive processing resources are limited, because trying to do two tasks at once impaired performance compared to single-task levels. A mindlessness theorist may have expected that the addition of the subjectively interesting narrative memory task would reduce the dual-task impairment to the semantic vigilance task, but this was not the case. The lack of vigilance decrement in either the single- or dual-task condition, however, was a surprising result and will be addressed later on.

As expected, the overarching dual-task interference was somewhat different than that observed in a prior semantic vigilance/free recall experiment. As seen in Figure 6, the effect size of the narrative memory performance decline was less than the effect size of the free recall decline when dual-tasking with the semantic vigilance task. The mean performance decline on the free recall task was significantly greater than the decline on the narrative memory task. In addition, semantic vigilance performance declined comparatively less when dual-tasking with the narrative memory task than with the free recall task. This difference failed to reach statistical significance at $p = .095$, but is still worth noting. These mean differences are consistent with the resource theory perspective: tasks requiring rehearsal and time pressure (i.e., the word recall task) require greater cognitive processing than those merely requiring routine perceptual analysis (i.e., the narrative memory task) (Kahneman, 1973). Though interference still occurs with the narrative memory task, people are better able to handle the demands of this more realistic type of task when paired with another verbal task (semantic vigilance), than with a rote memory task (free recall) – even though the rote memory task may be considered more simple (i.e., an understanding of the meaning of words is not required).

An alternate explanation for the differential interference may be that though the scenario is presented verbally, perhaps the narrative memory task does not rely as heavily on verbal resources as the recall task. Listeners must absorb the scenario by listening to spoken words, but perhaps they can process it spatially by visualizing the scenario. Resource theory suggests cognitive processing is limited by overall capacity/resource availability, but there may also be separate limits for different types of cognitive processes/resources (Baddeley, 2000; Cowan, 1988; Wickens, 2002). Because the narrative memory task can potentially be split between visual-spatial and verbal memory systems, this may be another reason why narrative memory performance tends to decline less when dual-tasking than does free recall of words.

Limitations and Future Directions

The lack of a decrement in the semantic vigilance task was an unexpected result. However, Deaton and Parasuraman (1993) noted that detecting a vigilance decrement with semantic stimuli tends to be difficult. Some cognitive vigilance tasks may even lead to a vigilance improvement (Loeb, Noonan, Ash, & Holding, 1987; Warm, Howe, Fishbein, Dember, & Sprague, 1984). In addition, previous researchers have suggested that vigilance tasks employing novel stimuli not only utilize sustained attention, but can also result in passive learning (Head & Helton, 2015). In the present semantic vigilance task, every target and neutral stimulus was unique. Tasks with novel stimuli are more susceptible to practice effects (learning), which means that participants' performance may reflect passive learning (improvements) and this may mask the effects of the decrement (Head & Helton, 2015). Intriguingly, the learning effect may be more noticeable in the dual-task condition. While nonsignificant, and therefore perhaps noise, semantic vigilance performance (A´) appeared to slightly improve in the dual-task condition. This might explain why mindlessness theorists believe extraneous load may actually improve vigilance, because the additional load initially disrupts sustained attention so much that the passive learning mechanism is more notable. At this point, this is merely speculation, but an interesting possibility warranting further research.

It is worth noting that this semantic vigilance task was only five minutes in duration, while many vigilance tasks, particularly those that induce a reliable decrement, can last for 30 minutes or more (Funke, Warm, Matthews, Funke, Chiu, Shaw, & Greenlee, 2017; Hitchcock et al. 2003; Parasuraman & Mouloua, 1987). It is possible that a performance decrement would have been observed with a prolonged vigil. In addition, increasing the mental demand, or difficulty of the task (e.g., shorter dwell time, lower signal salience, increased event rate, spatial uncertainty, etc.) may also result in a more reliable decrement.

Conclusions and Applications

In general, the results of the present experiment are consistent with past dual-task research, and provide general support for the resource theory over mindlessness theory. Semantic vigilance was shown to be cognitively demanding, demonstrated by a decline in narrative memory when performed in a dual-task condition (and vice versa). However, the lack of a clear vigilance decrement (in either the single- or dual-task condition) warrants further research.

Though it was found that the narrative memory task caused *less* interference than the prior free recall task, as expected, it is important to emphasize that the narrative task *did* still cause interference: even a task as simple and well-practiced as listening to a story or conversation may cause dual-task performance interference. This may not be expected by professionals that consider themselves adept at multitasking. If a firefighter is visually scanning a room for signs of trapped people, he may not expect his ability to find said people to be impaired by monitoring incoming audio communications from a team member.

In the future, inserting different types of tasks, different difficulty levels of tasks, more applied/operationally relevant tasks, and different prioritization instructions for tasks, into this dual-task paradigm will help achieve a better understanding of the resource theory (e.g., whether resources are singular or multiple). This can help inform feasible task loads, determine where assistance or augmentation (e.g., memory aids such as a playback function on radio communications) is necessary, and improve efficiency and safety of operators in high risk and other professions.

Key Points

- Performance on two verbal tasks done simultaneously was impaired compared to performance on the tasks individually, consistent with resource theory.
- A secondary task may make a passive learning mechanism more noticeable.
- A better understanding of possible dual-task performance outcomes is important for advising feasible task loads for efficient and safe military, firefighting, and search and rescue operations.

Biographies

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