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On Working Memory and a Productivity Illusion in Distracted Driving

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Drivers claim to use cell phones for benefits such as getting work done and to increase productivity (Sanbonmatsu, Strayer, Behrends, Medeiros-Ward, & Watson, in press). However, individuals who use cell phones while driving may be more likely to rely on reconstructive processes in memory due to divided attention, making them more susceptible to errors, yielding an ironic effect of multitasking that, in fact, may diminish productivity rather than increase it. To test this possibility, the present study included three within-subject conditions: single-task driving in a high-fidelity simulator, single-task memory including encoding and retrieval using the Deese–Roediger–McDermott false memory paradigm (Deese, 1959; Roediger & McDermott, 1995), and a dual-task combination of both the driving and memory tasks. The effects of divided attention in working memory were bidirectional, impairing both driving and episodic memory performance, likely due to competition for limited resources needed to successfully maintain task goals related to driving or memory alone. More specifically, under dual-task conditions, participants became increasingly reliant on reconstructive, error-prone processes in memory, with high levels of false recall. Taken together, these results indicate there is a *productivity illusion* associated with distracted driving in that individuals wrongly believe that combining cell phones with driving will make them more productive. Results are discussed in relation to theories of working memory and the domain-free ability to maintain task goals and to avoid distractions, whether this interference occurs in more traditional lab tasks or in more applied settings, highlighting the value of such converging evidence in sharpening theories of attention.

Keywords: Distracted driving, Working memory, Cognitive control

Cognitive control refers to the ability to maintain task goals and guide performance, particularly in challenging, resource-intensive situations with potential for distraction or conflict (Engle, 2002). In the modern world, cognitive control is highly valued, and over 25 years of empirical research conducted in psychological laboratories have shown individual differences in working memory to predict the ability to successfully maintain task goals and to avoid distraction (see Watson, Lambert, Miller, & Strayer, 2011, for a recent review). The overwhelming majority of the research conducted on working memory/cognitive control has focused on exerting limited-capacity attentional resources to strictly regulate automatic behaviors. In doing

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so, cognitive science has relied heavily on oppositional logic, pitting automatic and controlled processes against one another, by measuring response speed and accuracy to stimuli that contain incongruent automatic and controlled responses (e.g., **RED**). With oppositional logic, participants are explicitly instructed to maintain a task goal (e.g., name ink colors) while ignoring other salient aspects of a stimulus that lead to less effortful, more habitual responding (e.g., word reading). Consistent with this reasoning, individuals with lower working memory capacity (WMC) perform more poorly than individuals with higher WMC in situations where successful performance is dependent on minimizing interference, including but not limited to Stroop color naming, associative false memories, Simon task response conflict, retrieval from episodic memory, inattentional blindness, and the saccade task (see Kane & Engle, 2003; Miller, Watson, & Strayer, 2012; Seegmiller, Watson, & Strayer, 2011; Unsworth & Engle, 2007; Unsworth, Schrock, & Engle, 2004; Watson, Bunting, Poole, & Conway, 2005, respectively). Taken together, these findings strongly support the notion that the increased cognitive control afforded by those with greater WMC can be used to minimize interference to task goals in a variety of contexts, but especially standard laboratory paradigms that elicit cognitive conflict.

More recently, there has been considerable interest in determining the extent to which the predictive power of individual differences in WMC can be generalized beyond traditional lab settings to include more naturalistic contexts. Indeed, in their review chapter, Watson et al. (2011) characterized this approach as "applied cognitive neuroscience" and even recommended working memory/cognitive control researchers consider "venturing outside the ivory tower" in their future empirical work. Consistent with this idea, Kingstone and colleagues encouraged cognitive psychologists and neuroscientists to consider whether their laboratory findings generalized to the "real world" and what value, if any, they had placed on cognitive ethology when designing their research programs to build and test cognitive theory on attention (Kingstone, Smilek, Ristic, Friesen, & Eastword, 2003). In this regard, and in keeping with the spirit of this special issue on "Working Memory in the Wild," one avenue of applied research our lab has found to be particularly fruitful is to investigate the effects of distracted driving on cognition (see Strayer & Drews, 2007). Driving is an example of a real-world, complex, divided attention task with multiple embedded task goals such as simultaneously scanning the visual environment, tracking one's lane, and maintaining manual control of a vehicle, and thus highly likely requires the use of limited capacity working memory/cognitive control resources (Kramer & Madden, 2008). Such attention-demanding processes and their reliance on limited-capacity working memory/cognitive control may even explain age-related changes in driving performance (Strayer & Drews, 2004; Watson, Lambert, Cooper, Boyle, & Strayer, 2013).

To more directly test the potential contribution of working memory/attention to driving performance, our lab tested 200 young adults in a high-fidelity driving simulator in both single- and dual-task conditions (see Watson & Strayer, 2010, for additional details). More importantly for the purposes of the present paper, the overwhelming majority of participants, 97.5%, showed significant performance decrements in dual-task conditions compared to single-task conditions for both the driving and working memory tasks (in this case, a complex span measure of working memory, the auditory operation span task, inspired by the laboratory work of Engle and colleagues). One implication of this bidirectional interference was that operating a motor vehicle while performing a working memory measure over the phone placed a competing demand on the limited capacity cognitive control resources needed to successfully maintain task goals related to either driving or memory alone. Given the widespread performance decrements associated with combined cell phone use and driving reported by Watson and Strayer, both in terms of the outcomes – increased brake reaction times and lengthened car following distances for driving, and diminished memory and poorer math performance for the complex span task – and in terms of the percentage of individuals impacted by the cognitive distraction, it is reasonable to wonder why individuals engage in multitasking.

To empirically address the question of who multitasks and why, Sanbonmatsu, Strayer, Medeiros-Ward, and Watson (2013) examined the relationship between personality and individual differences in multitasking ability (also see Ophir, Nass, & Wagner, 2009, for a similar approach). Participants completed measures of multitasking activity, perceived multitasking ability, impulsivity, sensation seeking, and the operation span task (where the latter, a complex span task taken directly from the work of Engle and colleagues, was administered to assess WMC; see Sanbonmatsu et al. for additional details). Somewhat ironically, the results revealed that those individuals who multitasked the most (a) had the least working memory/cognitive control as reflected by their reduced performance on the operation span task (a negative correlation), yet (b) had the greatest perceived multitasking ability, which was inflated (a positive correlation). High levels of impulsivity and sensation seeking also accompanied increases in multitasking activity. Taken together, the results of Sanbonmatsu et al. suggested individuals who regularly engaged in multitasking, including cell phone use while driving, had a profile of increased susceptibility to cognitive distraction. Consistent with this argument, and most importantly for the purposes of the present paper, high levels of multitasking were associated with reduced levels of cognitive control, where as we highlighted earlier, diminished performance on complex span measures like the operation span task have been shown to predict difficulties with resolving interference in standard cognitive conflict paradigms like Stroop color naming (Kane & Engle, 2003) or even failures to notice unusual items in one's environment with increased inattentional blindness (Seegmiller et al., 2011). However, recent evidence suggests inattentional blindness may not be associated with working memory capacity (see Beanland & Chan, 2016; Kreitz, Furley, Memmert, & Simons, 2015, 2016). In this light, although multitasking may reduce working memory and cognitive control, perhaps increasing susceptibility to inattentional blindness to one's own impairments, to understand who multitasks and why, it may be more beneficial to focus on the tendency of many to believe that their performance on cognitive tasks is above the average (i.e., a "Lake Wobegon effect"; see Horswill, Waylen, & Tofield, 2004, for an example related to driving).

Therefore, multitasking in general, and combined cell phone use while driving in particular, may compromise working memory/attention as indexed by reduced performance on an auditory complex span task (see Watson & Strayer, 2010), perhaps making many, if not all, individuals less likely to be aware of their objective impairments in driving, and perhaps even in those tasks that are combined with driving (see Strayer & Drews, 2007, for similar arguments). Further still, in these divided attention situations, individuals may be more likely to rely on egocentric cognitive biases, inflating their subjective estimates of their ability to multitask without impairment. Hence, work in our lab suggests it is little wonder some individuals spontaneously choose to engage in multitasking (Sanbonmatsu et al., 2013), as they may not have the attentional resources to notice their cognitive deficits when self-selecting to multitask in the first place, and these initial deficits in working memory may be further exacerbated by any additional division of attention with multiple task goals. Such restrictions in attention may in turn reduce the ability to accurately monitor one's performance and increase reliance on cognitive biases or other sunny self-assessments.

In a recent follow-up study, we examined why drivers use cell phones and why they support legislation to restrict this practice (see Sanbonmatsu, Strayer, Behrends, Medeiros-Ward, & Watson, in press). More specifically, participants completed a survey about their driving attitudes, abilities, and behaviors, and for the purposes of the present study, there were four main findings. First, drivers claimed to use cell phones for benefits such as getting work done and to increase productivity (a point to which we will return below when motivating the Present Study; see Eost & Flyte, 1998, for evidence of similar claims made by drivers). Second, consistent with our arguments on working memory/cognitive control and likely due to the potential divided attention effects associated with multitasking, whether that be increased susceptibility to inattentional blindness to one's impairments or increased reliance on egocentric biases during self-assessment, many drivers believed they could drive safely while using their cell phones. Importantly, there was no relationship between individual differences in WMC and self-reports of perceived safety of using a cell phone while driving. Third, in contrast to self, drivers believed others could not drive safely while using their cell phones, and believed others' use of cell phones while driving was dangerous. Fourth, the threat of others' usage of cell phones while driving was a strong predictor of support for legislation to restrict this practice. Taken together, these results suggest a pattern of hypocrisy. That is, individuals claim to use cell phones while driving to enhance productivity, among other reasons, and believe they can do so safely. However, drivers who use cell phones simultaneously hold the belief others doing so are dangerous, even indicating they would support legislation to restrict it. We now turn to the implications of these findings for motivating the Present Study, an initial empirical test of whether those who use cell phones while driving are indeed more productive, or whether, as we argue, this belief is more likely an illusion generated by divided attention.

Present Study

Bartlett (1932) was the first to distinguish between reconstructive, potentially fallible forms of memory and rote reproduction, where the latter is thought to be more accurate. It is our contention that individuals who use cell phones while driving are more likely to rely on reconstructive processes in memory due to divided attention, thereby making them more susceptible to errors, yielding an ironic effect of multitasking that, in fact, may diminish productivity rather than increase it. It is important to note that we are assuming full attention and an accurate memory may be beneficial to one's productivity, particularly in relation to getting work done or job performance, a point to which we will return in the Caveats and Future Directions section of this paper when discussing limitations of the Present Study. Consistent with this argument, previous research suggests working memory capacity is indeed related to job performance and in tasks that simulate high-stakes work environments (cf., Bosco & Allen, 2011; Hambrick, Oswald, Darowski, Rench, & Brou, 2010). If this is the case, one might argue that drivers' claims of increased productivity could, in part, represent a special case of an illusion of memory, a byproduct of the division of attention and reduced working memory while multitasking, coupled with an increased reliance on egocentric biases and inflated subjective estimates of performance.

In the present study, to test this hypothesis, we used an experimental technique originally introduced by Deese (1959) and subsequently revived by Roediger and McDermott (1995) in which participants are presented with lists of words that are strong associates (e.g., *bed, rest awake*, . . .) to a missing, critical word (e.g., *sleep*). In this Deese–Roediger–McDermott (DRM) paradigm, participants frequently recall the non-presented critical words with about the same probability as items occurring in the middle of a study list, despite being given a warning against guessing (see Gallo, 2006, for a partial review). False memories in the DRM paradigm may result from an automatic spread of activation from studied words to non-presented critical words, coupled with a breakdown in attentional control/working memory or monitoring systems that differentiate the activity of critical words in associative networks from the actual presentation of words at encoding (i.e., an activation-monitoring account of the DRM illusion; see Balota et al., 1999; McDermott & Watson, 2001; Roediger, Balota, & Watson, 2001; Roediger, Watson, McDermott, & Gallo, 2001; Watson, Balota, & Sergent-Marshall, 2001). Turning to the implications of false memory accounts for the design and possible outcomes of the Present Study, we predict combining cell phone use with driving – in our case, using the DRM paradigm as a tool to investigate reconstructive memory processes in conversation – will impair performance versus driving alone, elongating following distance and slowing brake reaction time. Moreover, due to divided attention and the effects of cognitive distraction in working memory, this interference will be bidirectional. That is, operating a motor vehicle while performing the DRM task over the phone as a conversation surrogate will place a competing demand on the limited capacity cognitive control resources needed to successfully maintain task goals related to either driving or memory alone. Consequently, memory performance will suffer, with dissociable effects observed in accurate and false recall, as participants will become increasingly reliant on reconstructive, error-prone processes in memory (with diminished accurate recall, and stable or even increased false recall in the DRM task, particularly if critical words are automatically activated in associative networks). Taken together, this pattern of results would indicate a productivity illusion with driver distraction, as a *reconstructive* memory is not necessarily a more *productive* memory, where divided attention impairs one's monitoring of both the conversation and driving performance, perhaps increasing susceptibility to the belief that one is above average.

Method

Participants

Thirty-eight participants (19 females) from the University of Utah were recruited via the Psychology Department's online participant pool to receive partial course credit. Fifteen participants were removed from subsequent analyses due to prior knowledge of the DRM paradigm ($N=6$), motion sickness ($N=2$), problems with the simulator or sound recording ($N=4$), lack of driving experience/invalid driver's license ($N=1$), failure to understand task instructions ($N=1$), and an outlier in the driving data ($N=1$). These removals were reasonable given potential difficulties with using driving simulators such as motion sickness, and the need to provide an unbiased test of the magnitude of false memories in the DRM paradigm (Brooks et al., 2010; Watson, Balota, & Roediger, 2003). The remaining 23 participants (10 females) ranged in age from 18 to 40 ($M=23.26$) and were native English speakers with normal or corrected-to-normal vision. In addition, they all held a valid driver's license with at least two-years driving experience and reported no prior knowledge of the DRM paradigm.

Materials

We used a PatrolSim high-fidelity driving simulator, designed by L3 Communications/I-SIM, to simulate a typical driving scenario along a 17.5-mile multilane highway. To present the DRM word lists, we recorded a member of the research team reading the words at a rate of approximately one word every 1.5 s. The recordings were then uploaded to an Apple iPhone 5, which was used to play the word lists to participants via a hands-free Bluetooth earpiece (Model: Era Jawbone). Using a Dell laptop with Audacity software, we then recorded each participant's recall using a lapel microphone.

Word lists were based on the Deese–Roediger–McDermott (DRM) false memory paradigm (1995). The words were grouped into 15-item lists of words that were all semantically related; for example *bed*, *rest*, *awake*, *pillow*. The words in each 15-item list were semantically related to a lure word (e.g., *sleep*) that was not actually presented in the list, but had a high probability of being elicited by the other words. We took four different 15-item lists of semantically related words, each with their own critical lure word, and combined them to form a larger, single set of 60 words. Thus, each set of 60 words had four critical lures (i.e. false memory items) that were not actually presented to participants but were likely to be false recalled according to previous research with the same materials (Roediger, Watson, et al., 2001; Stadler, Roediger, & McDermott, 1999). For counterbalance purposes, we created six 60-item word sets, three of which were presented during the single-task memory condition, and three that were presented during the dual-task driving and memory condition. There were also two different driving scenarios with similar driving conditions. Thus, twelve combinations of experimental stimuli were created, such that the DRM word sets, driving scenarios, and the order of conditions (i.e., single- vs. dual-task) were fully counterbalanced across subjects.

Procedure

Upon arrival, participants read and signed a consent form approved by the University of Utah Institutional Review Board. After consenting to participate, each participant completed a live form questionnaire to confirm age and gender, as well as address other variables such as motion sickness while traveling in cars, medications that may cause drowsiness, visual acuity, and driving experience. After the questionnaire, participants were asked to insert the Bluetooth earpiece and attach the lapel microphone where it would be able to detect his/her voice. Participants were seated in the simulator and adjusted the driver's seat to a comfortable position. Participants drove a short freeway scenario lasting approximately 5 min to allow them to acclimate to the simulator. Prior to beginning the scenario, participants were informed that they would be driving down a highway, following a lead vehicle that would brake periodically. They were instructed to apply their brakes when the lead vehicle braked and then quickly regain their following distance, thereby maintaining a 2-s distance behind the lead vehicle. After the driving simulator warmup, participants completed a DRM memory practice session with two separate 15-item lists to ensure they understood the task, as well as allow experimenters to test the recording device. They were informed that several of the words were semantically related to one another, and instructed that they would have 1 min after each list to recall as many words as possible. Subjects were also instructed to not guess during the free recall period.

After completing both practice DRM lists, participants began the experiment. The experiment consisted of three within-subject conditions: single-task driving, single-task memory including encoding and retrieval of the DRM lists, and a dual-task combination of both the driving and memory tasks. For the single-task driving condition, participants completed a simulated driving scenario that consisted of following a pace car for approximately 17.5 miles on a multi-lane freeway loop with moderate-density traffic. Subjects stayed in the middle lane when the roadway had three lanes, and in the right lane when there were only two lanes. The pace car braked periodically throughout the scenario, requiring the participant to brake in response. Participants were not allowed to pass the lead pace car and were instructed to maintain a 2-s following distance. Other vehicles were programmed to drive in the left lane between 5% and 10% faster than the pace car, providing the impression of a steady flow of traffic. Of particular interest were the subjects' speed to press their brake pedal in response to the lead vehicle's brake lights (brake reaction time, measured in milliseconds; ms) and their adherence to the prescribed following distance (measured in meters; m). For the single-task memory condition, participants completed the DRM memory task while sitting in the simulator. Specifically, participants were given three 60-item sets of words to memorize. Each prerecorded word set was presented via the Bluetooth at a rate of approximately one word every 1.5 s. After each set was presented, the experimenter said "recall" and sat quietly as participants recalled words until the 4 min recall period ended, after which the experimenter said "stop" and instructed the participant that the next list was about to begin. Of particular interest were the subjects' probability of retrieval of presented items (accurate recall) and non-presented critical lures (false recall). Finally, in the dual-task condition, participants completed the DRM memory and driving tasks simultaneously, with a different set of DRM lists and driving scenarios than those used in the single-task conditions. The same single-task driving and single-task memory procedures and instructions were used for the dual-task condition, with the added instruction that participants were to do both tasks at the same time. After completing the experiment, participants were given a debriefing form and released from the study.

Results

Single- and dual-task performance patterns for both the driving and the memory dependent measures are shown in Figure 1. With respect to data analysis, in all statistical tests reported below, single- and dual-task means were compared using an Analysis-of-Variance (ANOVA). Consistent with the distracted driving literature, as shown in the bottom left panel of Figure 1, participants were slower to press their brake pedal in response to a lead vehicle's brake lights in the dual-task (1130 ms) than in the single-task condition (1020 ms), $F(1,22) = 9.4$, $MSE = 14{,}453$, $p = .006$, partial $\eta^2 = .30$. As shown in the bottom right panel of Figure 1, participants had a slightly elongated follow distance in the dual-task (27.5 m) than in the single-task condition (26.35 m); however, although in the expected direction given the distracted driving literature, this outcome was not significant, $F(1,22) = 1.8$, $MSE = 8.96$, $p = .19$. Turning to retrieval performance, consistent with the DRM false memory literature, there was a dissociation observed between the probability of accurate and false recall. More specifically, as shown in the top left panel of Figure 1, participants remembered fewer studied items in the dual-task (.30) than in the single-task condition (.36), $F(1,22) = 12.23$, $MSE = .003$, $p = .002$, partial $\eta^2 = .36$. However, in contrast to accurate recall, as shown in the top right panel of Figure 1, false recall was not significantly influenced by the single- versus dual-task manipulation, $F(1,22) = 1.1$, $MSE = .018$, $p = .31$ (although it is noteworthy that false recall increased numerically from .47 to .51 with divided attention).

Taken together, these effects of cognitive load on driving and memory performance are perhaps best illustrated by the results shown in Figure 2, where the probability of false recall has been divided by the probability of accurate recall for both the single- and dual-task conditions to generate a *reconstructive memory quotient*. Importantly, higher values for this quotient

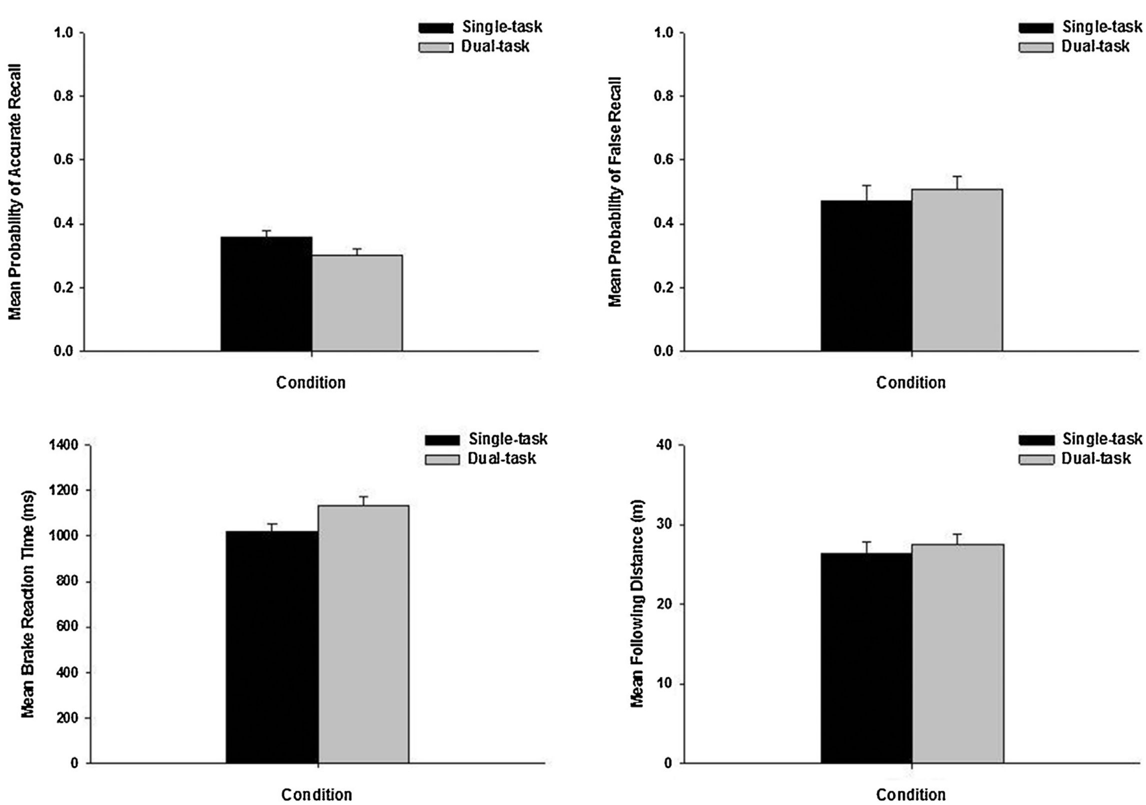

Figure 1. Group average performance for single- and dual-task conditions for memory (top left, accurate recall; top right, false recall) and driving (bottom left, brake reaction time measured in milliseconds; bottom right, following distance measured in meters). Error bars indicate the standard error of the mean.

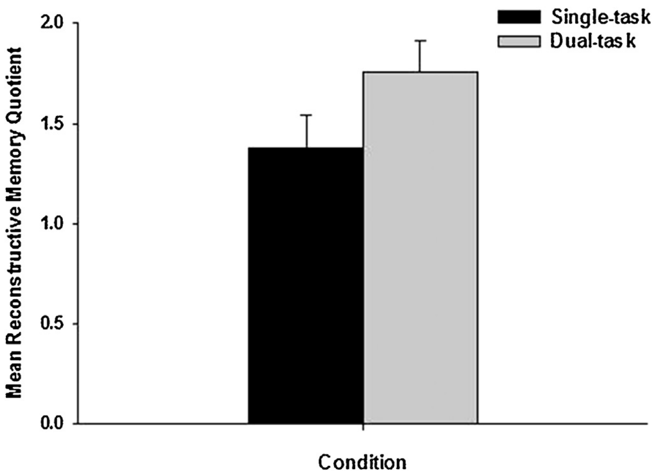

Figure 2. Group average reconstructive memory quotients (false recall/accurate recall) for single- and dual-task conditions. Error bars indicate the standard error of the mean. Importantly, when placed under cognitive load and with divided attention in dual-task conditions, participants become increasingly reliant on error-prone, reconstructive forms of memory, yielding a productivity illusion, where we suggest a reconstructive memory is not necessarily a more productive memory.

indicate greater reliance on reconstructive memory, and within the DRM literature, may reflect an increased susceptibility to memory errors and/or failures to monitor the source of retrieved information (see Balota et al., 1999; Watson et al., 2001, for additional discussion). Therefore, when placed under the increased cognitive load associated with dual-task conditions, in addition to the expected impairments in driving performance that have been associated with restricted attention to task goals (cf., Figure 1), as shown in Figure 2, participants also became increasingly reliant on reconstructive forms of memory, $F(1,22) = 7.51$, $MSE = .21$, $p = .01$, partial $\eta^2 = .25$. Consequently, for the purposes of the present paper and our core hypothesis, the implication is that individuals who talk on their cell phones while driving will not necessarily be more productive. Rather, as discussed in greater detail below, the compromised working memory and restricted attention to task goals in dual-task conditions may diminish the overall quality of their memories, simultaneously reducing their memory for the episodic details that support accurate memory while also enhancing their memory for some events that may never have happened.

Discussion

The present study revealed four main findings. First, as predicted, relative to single-task performance, the inclusion of our conversation surrogate, the DRM paradigm, in a dual-task context impaired driving, slowing brake reaction time (see Figure 1). This finding is consistent with a large body of research demonstrating the attentional costs associated with multitasking and distracted driving (see Strayer, Watson, & Drews, 2011, for a recent review). Second, as predicted, relative to single-task performance, the inclusion of driving in a dual-task context impaired accurate recall in the DRM paradigm, whereas, false recall remained high with divided attention (see Figure 1). This finding is consistent with a large body of research demonstrating dissociable effects of variables such as divided attention, presentation duration, or study-test trials (practice) on accurate and false recall in the DRM paradigm (cf., Dewhurst, Barry, Swannell, Holmes, & Bathurst, 2007; McDermott & Watson, 2001; Watson, McDermott, & Balota, 2004, respectively). Third, as predicted, the effects of divided attention in working memory were bidirectional, impairing both driving and episodic memory performance, likely due to competition for limited resources needed to successfully maintain task goals related to driving or the DRM memory task alone (see Watson & Strayer, 2010, for similar results with driving and a complex span measure of working memory). Fourth, taken together, and most importantly for the purposes of the present paper, individuals who talk on their cell phones while driving may not notice the aforementioned impairments in either their driving or their phone conversation. As such, as shown in Figure 2, these individuals may be more reliant on reconstructive memory processes, and by extension be more susceptible to false memories, perhaps even inflating subjective estimates of their own ability to multitask without dual-task costs in performance. Therefore, although individuals claim they are more productive if they combine cell phones with driving (Sanbonmatsu et al., in press), we argue that reconstructive memory is error-prone due to divided attention and, hence, not necessarily a more productive memory. We will now briefly consider some Caveats (and possible Future Directions for additional research) for this interpretation of the data, followed by an outgoing section on Conclusions.

Caveats and Future Directions

Elsewhere, it has been suggested that errors in memory, and reconstructive processes in particular, may be considered adaptive features of cognition in that they permit us to retain the gist of learned information at the expense of the details (see Schacter, 2001). Consistent with this argument and with this tradeoff, it is noteworthy that both healthy aging and Alzheimer's disease appear to differentially break down the details of memory that are most dependent on attentional control/working memory or monitoring processes; whereas, reconstructive aspects of memory remain relatively intact. Indeed, akin to the recall results shown in Figure 1, Watson et al. (2001) and Balota et al. (1999) reported a similar profile of increased reliance on reconstructive memory with healthy aging and dementia (where accurate recall was diminished, and false recall was preserved or even increased across these groups). While these developmental trajectories with DRM data certainly highlight an alternative, more favorable interpretation of reconstructive memory processes, within the bounds of the current study, we placed an emphasis on accuracy and minimizing guessing in retrieval. Consequently, as shown in Figure 2, the effects of divided attention associated with distracted driving may increase one's reliance on reconstructive memory and may make one more susceptible to errors. In this light, the data suggest a potential ironic effect of combining cell phones with driving, as it may elicit inattentional blindness to objective performance deficits, impairing driving and likely diminishing one's productivity by increasing memory errors. Moreover, this occurs despite drivers' claims of being safe on the road and more productive in their work while multitasking (Sanbonmatsu et al., in press), where in the absence of objective performance feedback or with reduced ability to effectively monitor one's performance in divided attention situations, subjective assessments may also be increasingly reliant on egocentric biases and the erroneous belief that one is above average in the domain of multitasking ability (i.e., a Lake Wobegon effect). As such, the results of the present study are more consistent with a growing literature on the potential deleterious effects of multitasking and the negative effects of cognitive interruptions in the workplace (cf., Blumberg et al., 2015; Foroughi, Werner, Nelson, & Boehm-Davis, 2014; Lee & Duffy, 2015). The damaging impact of these conditions in everyday life is made very clear by estimations that cognitive interruptions consume 28% of a worker's day (Spira & Feintuch, 2005), and multitaskers experience a drop in productivity, taking 50% longer and making up to 50% more errors than workers who focus on a single task at a time (Medina, 2009, 2014).

Although the results of the present study are promising, providing support for the notion that distracted driving divides attention, diminishes working memory, impairs objective performance, and gives rise to a productivity illusion, we have identified three interrelated avenues for future research. First, in the spirit of our prior work on multitasking and working memory (see Sanbonmatsu et al., 2013, in press; Watson & Strayer, 2010), it may be beneficial to increase our sample size and to consider individual differences in cognitive control in our future work on the productivity illusion. Second, moreover, although the use of the DRM paradigm as a conversation surrogate was a useful first step in assessing the effects of distracted driving on measures of productivity, to improve external validity, future work may benefit by expanding dependent measures to include those that are deemed most relevant to the occupations and/or worker productivity of the individuals under consideration. In general, to the extent some aspects of one's job are relatively automatized and by definition, not (or less) dependent on working memory/cognitive control, there may be instances where objective measures of productivity may be less impacted by divided attention manipulations. More comprehensive, objective assessments of job performance and worker productivity could be useful in this regard (cf., Hambrick et al., 2010). Third, finally, rather than relying on cross-experiment comparisons of objective assessments of driving and productivity (see Present Study; Watson & Strayer, 2010) and subjective assessments of performance (see Sanbonmatsu et al., in press), future work may benefit from integrating both objective and subjective measures of multitasking performance into a single study (see Sanbonmatsu et al., 2013). One clear advantage of an integrated approach is the ability to highlight the dissociation between objective and subjective measures within the same set of individuals, where although one may claim to be better than average in a given cognitive task, objective performance may reveal otherwise. As a related point, future work integrating dual objective and subjective measures of driving with dual measures of productivity may enable researchers to better disentangle what aspects of the productivity illusion may be due to failures to notice objective deficits in performance versus those that may be due to increased reliance on egocentric biases. Ultimately, future work may reveal that both inattentional blindness and egocentric bias processes play a role during distracted driving, contributing to the productivity illusion demonstrated empirically here.

Conclusions

The results of the present study indicate that individuals who use cell phones while driving are very likely to experience negative consequences of divided attention, being susceptible to impairments in both driving and memory performance, and demonstrating bidirectional interference in dual- versus single-task conditions. This interference is likely due to the competing demands placed on the limited capacity working memory/cognitive control systems required to successfully maintain task goals. Therefore, despite their claims to the contrary (Sanbonmatsu et al., in press), those who use cell phones while driving are actually *less* productive (where an error-prone, reconstructive memory devoid of attention to detail is not necessarily a more productive memory). Consequently, our results indicate there is a *productivity illusion* associated with technology-enriched driving, or a myth of multitasking in that individuals wrongly believe that combining cell phones with driving makes them more productive. More generally, the results of the present study provide converging evidence for the domain-free contribution of working memory to the maintenance of task goals and the avoidance of cognitive distraction (Engle, 2002), whether in more traditional laboratory tasks like Stroop color naming (Kane & Engle, 2003) or in applied settings with driving (Medeiros-Ward, Cooper, & Strayer, 2014). In conclusion, future research may benefit from taking an applied cognitive neuroscience approach (Watson et al., 2011) to the study of cognitive control, combining both laboratory research on working memory with empirical investigations of "Working Memory in the Wild," where a synergistic program of research may prove most beneficial in sharpening our theoretical understanding of how attention operates in a variety of different tasks, participants, measures, and settings.

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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