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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 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

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(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

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