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Forgetting Induced Speeding: Can Prospective Memory Failure Account for Drivers Exceeding the Speed Limit?

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It is generally assumed that drivers speed intentionally because of factors such as frustration with the speed limit or general impatience. The current study examined whether speeding following an interruption could be better explained by unintentional prospective memory (PM) failure. In these situations, interrupting drivers may create a PM task, with speeding the result of drivers forgetting their newly encoded intention to travel at a lower speed after interruption. Across 3 simulated driving experiments, corrected or uncorrected speeding in recently reduced speed zones (from 70 km/h to 40 km/h) increased on average from 8% when uninterrupted to 33% when interrupted. Conversely, the probability that participants traveled under their new speed limit in recently increased speed zones (from 40 km/h to 70 km/h) increased from 1% when uninterrupted to 23% when interrupted. Consistent with a PM explanation, this indicates that interruptions lead to a general failure to follow changed speed limits, not just to increased speeding. Further testing a PM explanation, Experiments 2 and 3 manipulated variables expected to influence the probability of PM failures and subsequent speeding after interruptions. Experiment 2 showed that performing a cognitively demanding task during the interruption, when compared with unfilled interruptions, increased the probability of initially speeding from 1% to 11%, but that participants were able to correct (reduce) their speed. In Experiment 3, providing participants with 10s longer to encode the new speed limit before interruption decreased the probability of uncorrected speeding after an unfilled interruption from 30% to 20%. Theoretical implications and implications for road design interventions are discussed.

Keywords: driver safety, interruptions, speeding, prospective memory

Approximately 1.25 million people worldwide die in road traffic accidents each year, with excessive speed identified as a major contributor (World Health Organization, 2015). It is generally assumed that drivers who speed are doing so intentionally as a result of factors such as frustration with the speed limit or general impatience (Fleiter, Lennon, & Watson, 2010; Kanellaidis, Golias, & Zarifopoulos, 1995). As such, existing programs to reduce speeding have focused on enforcement and punitive measures to discourage drivers from choosing to exceed the speed limit (Delaney, Ward, Cameron, & Williams, 2005; Pilkington & Kinra, 2005). Critically however, 20% to 50% of drivers fined for speeding report that they were unaware of their actions until ticketed for the offense (Blincoe, Jones, Sauerzapf, & Haynes, 2006; Corbett, 2001).

If a significant proportion of speeding is unintentional, then it is crucial to understand the causes of this behavior and to identify ways to reduce it. In a recent real-world study, Gregory, Irwin, Faulks, and Chekaluk (2014) examined the speeding behavior of drivers who were interrupted shortly after they encountered a new lower speed limit. They found that 100 m after an interruption (caused by a red traffic light) drivers exceeded the new 40 km/h speed limit in a school zone by an average of 8 km/h. Uninterrupted drivers, on the other hand, exceeded the speed limit by less than 2 km/h. To explain this, Gregory et al. suggested that the speeding resulted from drivers forgetting to travel at the new lower speed limit following interruption—a type of memory error known in the psychological science literature as a prospective memory (PM) failure (Kliegel, McDaniel, & Einstein, 2008).

A PM task requires individuals to remember to perform a deferred task at an appropriate time in the future (Einstein & McDaniel, 1990). PM failures occur when individuals forget to enact their deferred intention at the appropriate time. PM tasks also include a retrospective memory component since individuals need to remember what their PM intention is and when it will be required. However, a defining feature of PM tasks is that, unlike retrospective memory tasks, there are no external agents directing individuals to engage in a memory search at the point that the PM action should be performed, and therefore individuals need to self-initiate the retrieval of their intended action (Einstein, Smith, McDaniel, & Shaw, 1997). A PM intention can be formed when one task is interrupted by another since the interruption makes it necessary to remember to resume the original task after finishing the interrupting task (Dodhia & Dismukes, 2009). The conscious recollection of the PM intention at the appropriate time after the

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interruption constitutes the prospective component of the PM task (Smith & Bayen, 2004). Relating this to the Gregory et al. (2014) study, drivers needed to form a PM intention to remember to travel at the new reduced speed of 40 km/h after the traffic lights turned green.

As initial evidence in favor of this PM explanation, Gregory et al. were able to reduce speeding by placing a flashing LED sign immediately after the interruption to remind drivers to check their speed. This is consistent with studies showing that PM accuracy can be improved by providing memory aids to assist with appropriate recall (Grundgeiger et al., 2013; Loft, Smith, & Bhaskara, 2011). However, although effective, there are several potential issues with applying this solution more widely. First, drivers are likely to habituate to the signs over time (Loft et al., 2011; Shiffrin & Schneider, 1977; Yanko & Spalek, 2013), thus reducing their effectiveness as an intervention. Second, it is not always practical or safe to introduce additional visual clutter to the driving environment since directing attention away from the road can be dangerously distracting (Bendak & Al-Saleh, 2010; Bowden, Loft, Tatasciore, & Visser, 2017; Chan & Singhal, 2013).

From a theoretical standpoint, the evidence for the PM explanation provided by Gregory et al. (2014) is equivocal. For one, their experimental design confounded frustration and memory failure as possible explanations for speeding. It cannot be ruled out that drivers were frustrated by interruptions and intentionally chose to speed afterward to make up lost time (Shinar, 1998), rather than unintentionally forgetting. The "check-speed" sign used in Gregory et al. may have reduced speeding by raising concern that enforcement might be present nearby (Oei, 1996), rather than by promoting the retrieval of the intention to travel at the new lower speed limit. It is also possible that the presence of the sign had other effects not directly tied to improving PM. For example, the flashing sign may have served as a general alerting signal, improving the ability of drivers to effectively monitor their speed. In sum then, though intuitively persuasive, there is insufficient evidence that the speeding observed by Gregory et al. was due to PM failures. Conducting the current experiments in a controlled simulator environment allowed for the removal of the external pressures that could have contributed to frustration likely experienced by drivers in Gregory et al. study (e.g., real-life time constraints, social pressure from other drivers etc.). Should similar rates of speeding still occur in the current study following interruptions, this would provide stronger evidence for the role of PM failure in speeding after interruption.

Another real-world constraint in Gregory et al. (2014)'s study was that vehicle speed could only be measured at a single point 100 m after the interruption using a speed camera. As a result, any variation in speeding behavior during the postinterruption period was not available for analysis. Capturing this information is important because continuous assessment of driver behavior would enable discrimination between drivers who completely forgot the revised speed limit (i.e., those who sped through the whole postinterruption period), and those who initially forgot but then corrected their speeding. Measuring the extent to which interruptions cause drivers to forget the speed limit completely, or whether drivers are later able to remember to travel at the new speed limit without prompting, will allow us to better understand the role of PM failures by establishing the probability of uncorrected and corrected speeding behaviors arising from PM failures under different driving conditions. This enhanced understanding should further assist with the development of effective road design interventions.

In the current study, we examine speeding after interruptions in a controlled driving simulator environment. This study seeks to (a) provide evidence supporting a PM explanation for speeding in a driving environment where potential frustrating factors are controlled and (b) use PM theory to identify driving conditions which will further influence the probability of PM failures and subsequent speeding after interruptions, thereby further bolstering a PM-based explanation for speeding following interruption. In Experiment 1A, we examine whether speeding occurs after all interruptions or only those in recently reduced speed limit zones. Conversely, Experiment 1B investigates whether participants travel under their new speed limit when interruptions occur in recently increased speed limit zones. That is, we test whether participants are as likely to forget their new speed limit and travel too fast as they are to forget and travel too slow. The remaining two experiments draw on theory to identify two driving conditions that should influence the probability of PM failures after interruption, and thus the probability of speeding. In Experiment 2, we investigate whether the probability of speeding is increased when participants perform a cognitively demanding task during the interruption when compared to unfilled interruptions. In Experiment 3, we investigate whether providing participants with 10 s longer to encode a new speed limit before interruption can significantly decrease the probability of speeding.

Experiment 1A: Driving Too Fast After an Interruption

The aim of Experiment 1A was to determine whether participants speed after all interruptions or only after those where the speed limit has recently been reduced. In Experiment 1A, the probability of speeding after interruption was examined within recently reduced speed zones (from 70 km/h limit to 40 km/h limit) and in unchanged speed zones (70 km/h limit). Interruptions occurred 5 s after a change to the reduced speed or at the equivalent time in the driving scenario for unchanged speed zones.

All experiments reported here investigated speeding in a simulator environment where the real-world factors contributing to frustration (e.g., time pressure, social pressure) were largely removed. If PM failures contribute significantly to speeding following interruption, we would expect to replicate the findings of Gregory et al. (2014) with regards to maximum speeds reached after an interruption. However as discussed earlier, we argue that it is more informative from a theoretical perspective to examine the probability of uncorrected and corrected speeding following interruption, and in this way we extend the analysis of Gregory et al. We predicted that the probability of postinterruption speeding should increase when the interruption occurs shortly after a speed limit reduction but not when drivers are interrupted in unchanged speed zones in which no new speed limit intention has to be remembered.

Method

Participants. Sixteen undergraduate student participants (M_{age} = 19.8 years; 10 males) from the University of Western Australia participated in exchange for course credit. Participants were required to have at least a probationary driver's license. On average they had been licensed for 30.4 months. A sample of younger, more inexperienced drivers was used because they are disproportionately represented in accidents where speeding is involved (Palamara, Kaura, & Fraser, 2013). The effect size of the difference in speed between interrupted and uninterrupted 40 km/hr zones reported in Gregory et al. (2014; $d = 1.08$) informed the target sample size. A power analysis based on this effect size suggested that $N = 16$ would yield 0.98 power at a .05 alpha level. No participants were replaced for failing to understand the task instructions.

Stimuli. The driving simulator used Oktal's SCANeR Studio software (France, Paris), housed in a cockpit rig supporting a 135° wide-field video driving display. Data was recorded at 1,000 Hz and down-sampled to 100 Hz for analysis. The display comprised three parallel monitors, with the central monitor representing the front windscreen view and a digital speedometer (see Figure 1). The display also simulated two side mirrors and a central rear-vision mirror. Participants were seated approximately 85 cm from the central monitor and controlled their simulated automatic transmission vehicle using a modified Logitech computer steering wheel and pedal set (China, Beijing). The simulated vehicle and environment were configured for left-hand drive vehicle and road conditions. All participants drove on a continuous 15 km road and were instructed not to turn off the road. Participants kept to the far left lane of the four-lane road, and while no other vehicles appeared in the participants' lane, there was light density traffic (~5 vehicles per min) across the other three lanes.

Participants drove at 70 km/h (70-zone) but encountered 10 zones where the speed limit was reduced to 40 km/h (40-zone) for 300 m. The distance between 40-zones varied between 800 m and 1,400 m. Thus, participants spent approximately 70% of their time traveling in the 70-zones. When the speed limit changed, signs indicating the new limit appeared in the middle of the central display and remained on screen for a maximum of 10 s, or until a response was made. Participants were instructed to respond by pressing a button on the steering wheel to acknowledge the sign.

Participants were interrupted by a red traffic light in five of the 40-zones and in five of the 70-zones. Traffic lights were presented on the left side on the central monitor. Red traffic lights in 40-zones appeared 5 s after the start of the 40-zone. Red traffic lights in 70-zones appeared 400 m before the start of the next 40-zone, when participants had been traveling at 70 km/h for 20 s to 50 s. A red light was preceded by an amber light that lasted for 3 s and signaled that the participant should begin slowing. The red light then appeared and remained on screen for 42 s until being replaced by a green traffic light. Together, the yellow and red light created a 45 s interruption. The green traffic light disappeared once participants began accelerating.

Figure 1. Central monitor view of the driving environment. Digital speedometer displayed at the bottom. See the online article for the color version of this figure.

Procedure. Participants first completed a 10 min training scenario where they were instructed to drive safely and obey any traffic signals. Participants were told that although the speed limit would usually be 70 km/h, they would also encounter short sections of road where it would be reduced to 40 km/h. After training was complete, participants were then informed that they would start the experiment with a $3.85 bonus that would be reduced if they drove either too slowly or too quickly. The aim of the bonus was to incentivize participants to travel close to the speed limit, as they would in real-world driving. The order of conditions was counterbalanced across participants and the experiment took approximately 35 min to complete. After the experiment, participants completed a short demographics questionnaire. In this questionnaire they were also asked what speed they should have returned to after an interruption. Participants who answered this question incorrectly were considered not to have understood the task instructions and were excluded and replaced.

Results

We report both the maximum speed reached in the postinterruption period and the proportion of trials that involved speeding. The postinterruption period in a 40-zone began at the end of the interruption (offset of red traffic light) and covered the next 130 m traveled, whereas the postinterruption period in a 70-zone covered the next 250 m traveled. Note that the longer postinterruption period in 70-zones ensured that participants had sufficient time to reach, and potentially exceed, the speed limit upon resumption of driving.

Two kinds of speeding were assessed: *uncorrected speeding* (speed limit exceeded by at least 5 km/h with no attempt to return below the limit) and *corrected speeding* (speed limit initially exceeded by at least 5 km/h, but speed was then reduced by at least 10 km/h). Exceeding the limit by at least 5 km/h is equivalent to the threshold where our current participants indicated on a post-experiment questionnaire that they believed they would be fined for speeding in the real-world ($M = 5.06$ km/h). A reduction of 10 km/h was considered sufficient evidence of a participant attempting to return to the appropriate speed limit given the distance available in the postinterruption period.

We present point (effect size) and interval (within-subjects, 95% confidence) estimates, where within-subjects confidence intervals were determined by the method recommended by Morey (2008). Because we have made clear a priori hypotheses concerning the relationship between interruption and speed limit changes, in all cases we followed up the within-subjects analyses of variance (ANOVAs) with planned contrasts that directly evaluated our specific hypotheses (Rosenthal & Rosnow, 1985). In Experiment 1A, this involved comparing speeding in the interrupted 40-zone to the uninterrupted 40-zone and in the interrupted 70-zone to the uninterrupted 70-zone.

Maximum speed. A 2 (zone: 40, 70) × 2 (interruption: interrupted, uninterrupted) within-subjects ANOVA yielded main effects of zone, $F(1, 15) = 707.9$, $p < .001$, $\eta_p^2 = .98$, and interruption, $F(1, 15) = 7.45$, $p = .016$, $\eta_p^2 = .33$, and an interaction between zone and interruption, $F(1, 15) = 10.96$, $p = .005$, $\eta_p^2 = .42$. The maximum postinterruption speed reached during the interrupted 40-zones (M = 47.8 km/h, 95% CI [45.7, 49.9]) was significantly higher than in the uninterrupted 40-zones (M = 42.6 km/h, [40.5, 44.7]), $t(15) = 3.19$, $p = .006$, $d = .96$. This postinterruption speed increase of 5.2 km/h in the simulator is very similar to Gregory et al.'s (2014) 6.5 km/h increase for real-world driving. There was no difference in the maximum speed reached between the interrupted 70-zones (M = 71.4 km/h, [70.6, 72.1]) and the uninterrupted 70-zones (M = 71.8 km/h, [71.1, 72.6]; $t < 1$). This indicates that participants' maximum speed was only increased following interruptions in the recently reduced 40-zones.

Uncorrected speeding proportions. A 2 (zone: 40, 70) × 2 (interruption: interrupted, uninterrupted) within-subjects ANOVA revealed no effect of zone, $F(1, 15) = 3.30$, $p = .089$, $\eta_p^2 = .18$, a main effect of interruption, $F(1, 15) = 11.81$, $p = .004$, $\eta_p^2 = .44$, and an interaction between zone and interruption, $F(1, 15) = 6.51$, $p = .022$, $\eta_p^2 = .30$. The proportion of 40-zones where uncorrected speeding occurred was significantly higher for interrupted zones (M = .26, 95% CI [.20, .32]) compared with uninterrupted 40-zones (M = .09, [.03, .15]), $t(15) = 3.96$, $p = .001$, $d = .71$. Participants were therefore nearly three times more likely to speed throughout the entire 40-zone after an interruption (see Figure 2). When speeding occurred in an interrupted 40-zone the average maximum speed reached was 59.7 km/h (95% CI [55.3, 64.1]), which suggests that participants were attempting to return to the previous but no longer relevant speed limit of 70 km/h. Conversely when speeding occurred in uninterrupted 40-zones, the average maximum speed reached was only 46.8 km/h (95% CI [45.8, 47.8]). There was no difference in uncorrected speeding between the interrupted (M = .08, 95% CI [.03, .12]) and uninterrupted 70-zones (M = .04, [–.01, .09]; t = 1).

Corrected speeding proportions. A 2 (zone: 40, 70) × 2 (interruption: interrupted, uninterrupted) within-subjects ANOVA revealed no main effects of zone, $F(1, 15) = 1.31$, $p = .27$, or interruption ($F < 1$), and no interaction between zone and interruption, $F(1, 15) = 3.46$, $p = .083$, $\eta_p^2 = .19$ (see Figure 2). There was no increase in corrected speeding after interruptions in 40-zones, with no difference between the interrupted (M = .04, 95% CI [.02, .06]) and uninterrupted 40-zones (M = .01, 95% CI [–.01, .03]), $t(15) = 1.46$, $p = .164$. There was also no difference in corrected speeding between the interrupted (M = .00, 95% CI [–.02, .02]) and uninterrupted 70-zones (M = .01, 95% CI [.00, .03]; t = 1).

In summary, interruptions increased the probability of speeding under conditions in which the speed limit had recently been reduced from 70 km/h to 40 km/h. Furthermore, this speeding was uncorrected and therefore persisted throughout the postinterruption period with no evidence of self-correction. In contrast, interruptions had no effect on speeding probability if they occurred during unchanged 70 km/h speed zones. Overall, the findings indicate that interruptions increased the probability of speeding only after a recent change in the speed limit, where drivers were required to form a PM intention to reduce their speed.

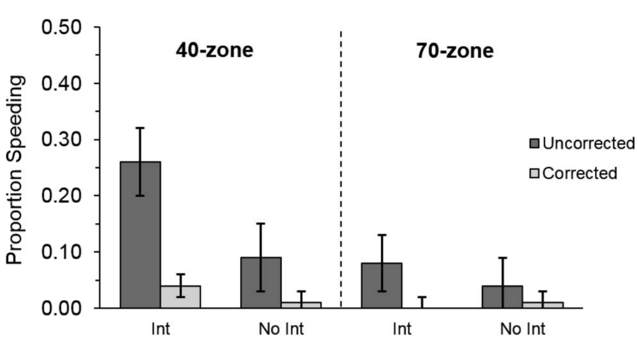

Figure 2. Proportion of interrupted (Int) and uninterrupted (No Int) 40-zones (left panel) and 70-zones (right panel) where speeding occurred in Experiment 1A. Uncorrected speeding (>5 km/h over limit, no attempt to return below the limit) and corrected speeding (>5 km/h over limit, then reduced by at least 10 km/h) is shown. 95% within-subjects CIs determined by the method recommended by Morey (2008).

Experiment 1B: Driving Too Slowly After an Interruption

If speeding after an interruption can be due to PM failure, then drivers should not only forget and drive too fast following a recent reduction in the speed limit, but should also forget and drive too slowly following a recent increase in the speed limit. To test this in Experiment 1B, the speed zones used in Experiment 1A were reversed such that participants traveled at 40 km/h and encountered 10 zones where the speed limit was increased to 70 km/h. If speeding following an interruption is the result of PM failure then participants should attempt to return to their no longer relevant, preinterruption speed (in this case 40 km/h). That is, a significantly higher proportion of interrupted drivers compared with uninterrupted drivers should travel more slowly than the new 70 km/h speed limit. An attempt to return to 40 km/h would indicate that interruptions can lead to a general failure to follow a recently changed speed limit, rather than only leading to increased speeding.

Method

Participants. Sixteen new participants (M_{age} = 20.9 years; 10 males) were recruited for Experiment 2. On average they had been licensed for 36.6 months. Two participants were replaced for failing to understand the task instructions. The sample size was the same as for Experiment 1A.

Stimuli and procedure. Participants drove at 40 km/h (40-zone), and they encountered 10 zones where the speed limit was increased to 70 km/h for 525m (70-zone). The distance between subsequent 40-zones varied between 500 m and 800 m. Note that the distances used in Experiment 1B have been scaled from Experiment 1A to ensure participants spent the same amount of time (approximately 70%) traveling at 40 km/h as participants in Experiment 1A spent at 70 km/h, and vice versa. Participants were interrupted by a red traffic light in five of the 70-zones and in five of the 40-zones. Red traffic lights in 70-zones appeared 5 s after the start of the 70-zone. Red traffic lights in 40-zones appeared 229 m before the start of the next 70-zone. All other details were the same as Experiment 1A.

Results

Maximum speed. A 2 (zone: 40, 70) × 2 (interruption: interrupted, uninterrupted) within-subjects ANOVA yielded main effects of zone, $F(1, 15) = 1020.6$, $p < .001$, $\eta_p^2 = .99$, and interruption, $F(1, 15) = 12.24$, $p = .003$, $\eta_p^2 = .45$, and an interaction between zone and interruption, $F(1, 15) = 28.68$, $p < .001$, $\eta_p^2 = .66$. The maximum speed reached during the interrupted 70-zones (M = 66.3 km/h, 95% CI [65.0, 67.7]) was significantly lower than in the uninterrupted 70-zones (M = 71.2 km/h, 95% CI [69.8, 72.6]), $t(15) = 4.60$, $p < .001$, $d = 1.18$, indicating that interruptions in recently increased speed zones caused participants to travel under their new speed limit. The maximum speed reached during the interrupted 40-zones (M = 42.5 km/h, 95% CI [42.1, 42.9]) was significantly higher than in the uninterrupted 40-zones (M = 41.7 km/h, 95% CI [41.3, 42.1]) $t(15) = 2.33$, $p = .034$, $d = .39$, although this difference (0.8 km/h) was much smaller than seen in Experiment 1A (5.2 km/h). While this small difference in Experiment 1B could indicate that drivers increased their speeding after interruptions in the unchanged 40-zone, we suggest that it is more likely a result of participants initially exceeding the intended speed of 40 km/h slightly when accelerating following an interruption.

Uncorrected speeding proportions. To demonstrate that forgetting leads to participants traveling substantially under the speed limit, the proportion of 70-zones where participants reached a maximum speed that was less than 65 km/h in the postinterruption period was determined (referred to here as *underspeeding*). Underspeeding in 40-zones was not evident, as no participants traveled less than 35 km/h. Also, corrected underspeeding could not be determined due to the absence of a turning point in the data (e.g., from increasing speed to decreasing speed), therefore proportions reported below reflect overall speeding (combination of uncorrected and corrected speeding).

The proportion of 70-zones where underspeeding occurred (see Figure 3) was significantly higher for interrupted zones (M = .23, 95% CI [.14, .31]) compared with uninterrupted 70-zones (M = .01, 95% CI [–.07, .09]), $t(15) = 3.44$, $p = .004$, $d = 1.09$. When underspeeding occurred after an interruption, the average maximum speed reached in the 70-zone was 51.0 km/h (95% CI [46.1, 56.0]). The fact that participants were traveling nearly 20 km/h under the limit strongly suggests that they had forgotten to travel at the new 70 km/h speed limit and had reverted to traveling closer to the previous limit of 40 km/h.

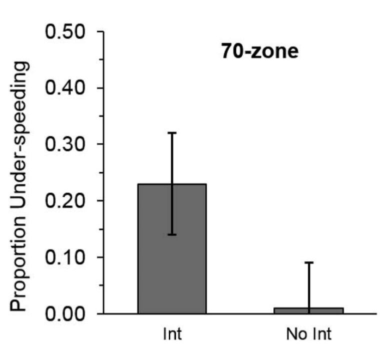

Figure 3. Proportion of 70-zones where underspeeding (maximum speed <65 km/h) occurred in Experiment 1B. 95% within-subjects confidence intervals determined by the method recommended by Morey (2008).

In summary, Experiment 1B shows that underspeeding after an interruption increased to a similar extent as speeding increased in Experiment 1A. We have therefore demonstrated across Experiments 1A and 1B that interruptions lead to a general failure to follow changed speed limits, rather than only leading to increased speeding. These findings are clearly consistent with a PM explanation.

Experiment 2: Adding Cognitive Distraction to the Interruption

A prominent concept in cognitive psychology is that memory items vary along a continuum of activation and that item accessibility varies as a function of activation. Thus, the more frequently an item is rehearsed or otherwise strengthened, the greater its activation level and probability of retrieval (e.g., Altmann & Trafton, 2002; Anderson & Lebiere, 2014; Nowinski & Dismukes, 2005). It follows that more cognitively demanding interruptions should be more disruptive to PM because they would prevent rehearsal by introducing dual task interference, thus reducing item activation. In line with this, previous research indicates that introducing a cognitively demanding secondary task during the interval between PM encoding and retrieval can increase PM failures (Marsh & Hicks, 1998; Stone, Dismukes, & Remington, 2001).

In Experiment 2, a similar experimental manipulation was used to provide further evidence for the role of PM failure in speeding following interruption. This manipulation involved introducing a cognitively demanding task for drivers to complete during the red traffic light interruption. If failures of PM contribute significantly to the probability of speeding following interruption, then we would expect a higher probability of speeding following a cognitively demanding interruption than following an unfilled interruption. In addition to being theoretically informative, this manipulation is practically relevant because drivers seldom focus exclusively on the driving environment when waiting at traffic lights. Rather they often engage in other tasks such as conversing with passengers or using in-vehicle entertainment/communication systems (Huth, Sanchez, & Brusque, 2015; Strayer, Drews, & Johnston, 2003). As such, the levels of speeding seen here may more faithfully reflect the magnitude of speeding encountered in real-life driving situations.

Method

Participants. Thirty-two new participants (M_{age} = 19.8 years; 17 males) were recruited. On average they had been licensed for 26.0 months. Two participants were replaced for failing to understand the task instructions. The sample size was twice that of Experiments 1A and 1B to maintain statistical power, because the addition of the cognitively demanding secondary task reduced the number of observations per condition from five to three.

Stimuli and procedure. In Experiment 2, we returned to the design used in Experiment 1A where participants drove at 70 km/h, except in 12 zones where the speed limit was reduced to 40 km/h. The number of 40-zones was increased from 10 in Experiment 1A to 12 in Experiment 2 to ensure participants experienced the same number of each interruption type. Participants drove at 70 km/h (70-zone), and they encountered 12 zones where the speed limit was reduced to 40 km/h (40-zone) for 300 m. Participants spent approximately 70% of their time traveling in the 70-zones. The distance between 40-zones varied between 800 m and 1,400 m. Participants were interrupted by a red traffic light in six of the 40-zones and in six of the 70-zones. Half of these interruptions (three 40-zones, three 70-zones) included a cognitively demanding secondary task, and half included no task. The secondary task was an auditory N-back task in which single letters were presented serially over headphones and participants were required to indicate verbally whether each letter came before, after, or was identical to the immediately preceding item (Monk, Trafton, & Boehm-Davis, 2008). For example, if the letter sequence was *F* followed by *R* then the correct response was to say "after." Letters were presented at a rate of one letter every 1.6 s. Training was amended to include N-back task instructions, but all other details were the same as in Experiment 1A.

Results

The experimental design did not allow us to perform a fully factorial 2 (zone: 40, 70) × 2 (interruption: interrupted, uninterrupted) × 2 (task: N-back, No-task) within-subjects ANOVA. This is because the N-back task manipulation only occurred during interruptions (i.e., task type was not manipulated under uninterrupted conditions). Instead, we first conducted 2 (zone: 40, 70) × 2 (interruption: interrupted, uninterrupted) within-subjects ANOVAs to assess the impact of interruption presence and followed these up with planned contrasts that directly evaluated our specific hypotheses by comparing the interrupted 40-zone to the uninterrupted 40-zone and the interrupted 70-zone to the uninterrupted 70-zone (thereby replicating Experiment 1A). We then conducted 2 (zone: 40, 70) × 2 (task: N-back, No-task) within-subjects ANOVAs to assess the impact of interruption type, and followed these up with planned contrasts comparing interrupted 40-zones with No-task to interrupted 40-zones with the N-back task and comparing interrupted 70-zones with No-task to interrupted 70-zones with the N-back task.

The impact of interruption.

Maximum speed. A 2 (zone: 40, 70) × 2 (interruption: interrupted, uninterrupted) within-subjects ANOVA yielded main effects of zone, $F(1, 31) = 1501.3$, $p < .001$, $\eta_p^2 = .98$, and interruption, $F(1, 31) = 25.93$, $p < .001$, $\eta_p^2 = .46$, and an interaction between zone and interruption, $F(1, 31) = 54.55$, $p < .001$, $\eta_p^2 = .64$. Replicating Experiment 1A results, the maximum speed reached during the interrupted 40-zones ($M = 50.3$ km/h, 95% CI [48.9, 51.7]) was significantly higher than during the uninterrupted 40-zones ($M = 42.2$ km/h, 95% CI [40.8, 43.6]), $t(31) = 6.52$, $p < .001$, $d = 1.54$. However unlike Experiment 1A, the maximum speed reached during the interrupted 70-zones ($M = 70.3$ km/h, 95% CI [69.8, 70.7]) was significantly lower than in the uninterrupted 70-zones ($M = 71.5$ km/h, 95% CI [71.1, 72.0]), $t(31) = 3.05$, $p = .005$, $d = .68$. Practically this is a small effect (only a 1.2 km/h decrease), but at the same time this was not an expected finding. It is however consistent with Gregory et al. (2014) who found that maximum speeds reached in 60 km/h or 70 km/h unchanged speed zones were slower following interruption. As suggested by Gregory et al., these slightly decreased speeds may reflect the speed at which drivers feel generally comfortable traveling following interruption.

Uncorrected speeding. A 2 (zone: 40, 70) × 2 (interruption: interrupted, uninterrupted) within-subjects ANOVA yielded main effects of zone, $F(1, 31) = 38.93$, $p < .001$, $\eta_p^2 = .56$, and interruption, $F(1, 31) = 30.40$, $p < .001$, $\eta_p^2 = .50$, and an interaction between zone and interruption, $F(1, 31) = 27.50$, $p < .001$, $\eta_p^2 = .47$ (see Figure 4). The proportion of 40-zones where uncorrected speeding occurred was significantly higher for interrupted zones ($M = .33$, 95% CI [.28, .39]) compared with uninterrupted 40-zones ($M = .05$, [.00, .11]), $t(31) = 5.61$, $p < .001$, $d = 1.26$. There was no difference in uncorrected speeding between the interrupted ($M = .02$, 95% CI [.00, .03]) and uninterrupted 70-zones ($M = .03$, 95% CI [.01, .05]; $t < 1$). These findings replicate Experiment 1A.

Corrected speeding. A 2 (zone: 40, 70) × 2 (interruption: interrupted, uninterrupted) within-subjects ANOVA yielded main effects of zone, $F(1, 31) = 4.73$, $p = .037$, $\eta_p^2 = .13$, and interruption, $F(1, 31) = 7.15$, $p = .012$, $\eta_p^2 = .19$, and an interaction between zone and interruption, $F(1, 31) = 4.73$, $p = .037$, $\eta_p^2 = .13$ (see Figure 4). The proportion of 40-zones where corrected speeding occurred was significantly higher for interrupted zones ($M = .06$, 95% CI [.04, .09]) compared with uninterrupted 40-zones ($M = .01$, 95% CI [–.02, .03]), $t(31) = 2.78$, $p = .009$, $d = .71$. Similar to Experiment 1A, there was no difference in corrected speeding between the interrupted ($M = .01$, 95% CI [.00, .02]) and uninterrupted 70-zones ($M = .01$, 95% CI [–.01, .02]; $t < 1$).

The impact of the cognitive demand of the interruption.

Maximum speed. A 2 (zone: 40, 70) × 2 (task: N-back, No-task) within-subjects ANOVA yielded a main effect of zone, $F(1, 31) = 252.6$, $p < .001$, $\eta_p^2 = .89$, no main effect of task, $F(1, 31) = 2.45$, $p = .13$, $\eta_p^2 = .07$, and an interaction between zone and task that approached significance, $F(1, 31) = 3.62$, $p = .066$, $\eta_p^2 = .11$. The increase in the maximum speed reached when the interrupted 40-zones included the N-back task ($M = 51.8$ km/h, 95% CI [50.1, 53.5]) compared with No-task ($M = 48.9$ km/h, [47.2, 50.6]) approached significance, $t(31) = 1.90$, $p = .067$, $d = .34$. There was no difference in the maximum speed reached between

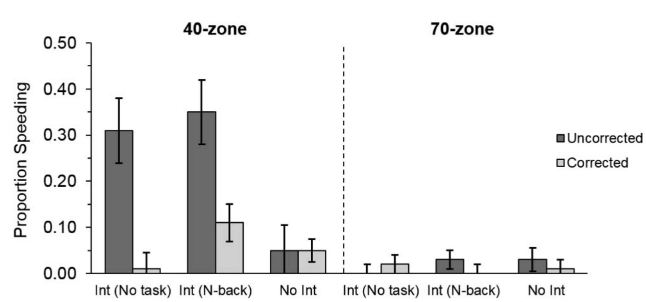

Figure 4. Proportion of interrupted (Int) and uninterrupted (No Int) 40-zones (left panel) and 70-zones (right panel) where speeding occurred in Experiment 2. Interruptions either had no additional task (No task) or an N-back task included. Uncorrected speeding (>5 km/h over limit, no attempt to return below the limit) and corrected speeding (>5 km/h over limit, then reduced by at least 10 km/h) is shown. 95% within-subjects confidence intervals determined by the method recommended by Morey (2008).

the interrupted 70-zones that included the N-back task (M = 70.1 km/h, [69.3, 70.8]) compared with No-task (M = 70.5 km/h, 95% CI [69.7, 71.2]; $t < 1$).

Uncorrected speeding. A 2 (zone: 40, 70) × 2 (task: N-back, No-task) within-subjects ANOVA yielded a main effect of zone, $F(1, 31) = 37.80$, $p < .001$, $\eta_p^2 = .55$, no main effect of task, $F(1, 31) = 1.39$, $p = .25$, and no interaction between zone and task ($F < 1$; see Figure 4). The proportion of 40-zones where uncorrected speeding occurred was not significantly different when the interruption included the N-back task (M = .35, 95% CI [.28, .42]) compared with No-task (M = .31, 95% CI [.24, .38]; $t < 1$). The proportion of 70-zones where uncorrected speeding occurred was not significantly different when the interruption included the N-back task (M = .03, 95% CI [.01, .05]) compared with No-task (M = .00, 95% CI [–.02, .02]) $t(31) = 1.79$, $p = .083$, $d = .45$.

Corrected speeding. A 2 (zone: 40, 70) × 2 (task: N-back, No-task) within-subjects ANOVA yielded a main effect of zone, $F(1, 31) = 5.07$, $p = .032$, $\eta_p^2 = .14$, an effect of task that approached significance, $F(1, 31) = 3.82$, $p = .060$, $\eta_p^2 = .11$, and an interaction between zone and task, $F(1, 31) = 10.26$, $p = .003$, $\eta_p^2 = .25$ (see Figure 4). The proportion of 40-zones where corrected speeding occurred was significantly higher when the interruption included the N-back task (M = .11, 95% CI [.08, .15]) compared with No-task (M = .01, 95% CI [–.03, .05]), $t(31) = 2.98$, $p = .006$, $d = .70$. The proportion of 70-zones where corrected speeding occurred was no different when the interruption included the N-back task (M = .00, 95% CI [–.02, .02]) compared with No-task (M = .02, 95% CI [.00, .04]; $t = 1$).

These results indicate that performing a cognitively demanding task during the interruption increased the likelihood of initially speeding after driving resumption from 1% to 11%, but that participants remembered to correct (reduce) their speed before the end of the postinterruption period (see Figure 4). This finding supports the conclusion that PM failure is involved, since participants initially sped when they had fewer cognitive resources available to retrieve the new reduced speed limit. In contrast, we did not find evidence that performing a cognitively demanding task during the interruption increased uncorrected speeding. In the context of driving, an increase in the probability of initial speeding from 1% to 11% is definitely of practical concern, because it would potentially result in a significantly increased likelihood of injury from collisions or other speed-related accidents.

Experiment 3: Increasing the Interruption Lag

The term *interruption lag* is used in the cognitive psychology literature to refer to the duration between being alerted about an upcoming interruption and the beginning of that interruption (Trafton & Monk, 2007). Increasing the interruption lag improves primary task resumption, presumably because stronger encoding strengthens the representation in memory of the primary task goal (Trafton, Altmann, Brock, & Mintz, 2003). More importantly, there is also evidence in the PM literature to suggest that longer encoding times can provide an advantage when it comes to remembering to perform a deferred task action (Brandimonte, Einstein, & McDaniel, 2014; Clark-Foos & Marsh, 2008; Smith & Bayen, 2004).

In the case of driving, we operationalized interruption lag as the duration that the new, reduced speed limit was active (and presumably being adhered to) prior to the interruption. We did not think it was ecologically valid to warn participants of the upcoming interruption, but instead assumed that spending more time traveling at the new speed limit before interruption would strengthen the intention to return to that speed after the interruption. To evaluate this prediction, in Experiment 3 we compared speeding when the interruption lag was 5 s (as in Experiments 1A and 2) compared with 15 s. To the extent that PM failure can contribute to increased speeding after an interruption, we expected to observe a reduced probability of speeding after a 15-s interruption lag compared with a 5-s interruption lag.

Method

Participants. Thirty-two new participants (M_{age} = 22.4 years; 13 males) were recruited. On average they had been licensed for 56.5 months. Three participants were replaced for failing to understand the task instructions. As in Experiment 2, the sample size was twice that of Experiments 1A and 1B to maintain statistical power, because the addition of the interruption lag reduced the number of observations per condition from five to three.

Stimuli and procedure. Participants drove at 70 km/h (70-zone) and they encountered 12 zones where the speed limit was reduced to 40 km/h (40-zone) for 400 m. Note that compared with earlier experiments, we increased the length of both the 40-zones and the 70-zones to accommodate the longer 15-s lag condition. The distance between 40-zones varied between 1,100 m and 1,800 m. Participants spent approximately 70% of their time traveling in the 70-zones. Participants were interrupted by a red traffic light in six of the 40-zones and in six of the 70-zones. Half of these interruptions (three 40-zones, three 70-zones) included a 5-s lag between the 40 sign and the red light interruption, and half included a 15-s lag. All other details were the same as Experiment 2.

Results

The design did not allow us to perform a fully factorial 2 (zone: 40, 70) × 2 (interruption: interrupted, uninterrupted) × 2 (interruption lag: 5 s, 15 s) within-subjects ANOVA because the lag manipulation only occurred during interruptions (i.e., lag was not manipulated under uninterrupted conditions). We therefore used the same analytical approach as outlined for Experiment 2.

The impact of interruption.

Maximum speed. A 2 (zone: 40, 70) × 2 (interruption: interrupted, uninterrupted) within-subjects ANOVA yielded main effects of zone, $F(1, 31) = 1784.7$, $p < .001$, $\eta_p^2 = .98$, and interruption, $F(1, 31) = 7.76$, $p = .009$, $\eta_p^2 = .20$, and an interaction between zone and interruption, $F(1, 31) = 48.1$, $p < .001$, $\eta_p^2 = .61$. The maximum speed reached during the interrupted 40-zones (M = 47.8 km/h, 95% CI [46.5, 49.0]) was significantly higher than in the uninterrupted 40-zones (M = 42.1 km/h, 95% CI [40.9, 43.3]), $t(31) = 5.18$, $p < .001$, $d = 1.15$. Similar to Experiment 2, the maximum speed reached during the interrupted 70-zones (M = 69.2 km/h, 95% CI [68.7, 69.7]) was significantly lower than in the uninterrupted 70-zones (M = 71.4 km/h, 95% CI [70.8, 71.9]), $t(31) = 4.63$, $p < .001$, $d = .88$.

Uncorrected speeding. A 2 (zone: 40, 70) × 2 (interruption: interrupted, uninterrupted) within-subjects ANOVA yielded main effects of zone, $F(1, 31) = 29.52$, $p < .001$, $\eta_p^2 = .49$, and interruption, $F(1, 31) = 12.15$, $p = .001$, $\eta^2_p = .28$, and an interaction between zone and interruption, $F(1, 31) = 15.21$, $p < .001$, $\eta^2_p = .33$ (see Figure 5). The proportion of 40-zones where uncorrected speeding occurred was significantly higher for interrupted zones ($M = .25$, 95% CI [.20, .30]) compared with uninterrupted 40-zones ($M = .07$, 95% CI [.02, .12]), $t(31) = 3.91$, $p < .001$, $d = .85$. There was no difference in uncorrected speeding between the interrupted ($M = .02$, 95% CI [.00, .04]) and uninterrupted 70-zones ($M = .02$, 95% CI [.00, .04]; $t < 1$).

Corrected speeding. A 2 (zone: 40, 70) × 2 (interruption: interrupted, uninterrupted) within-subjects ANOVA yielded a main effect of zone, $F(1, 31) = 7.55$, $p = .010$, $\eta^2_p = .20$, no effect of interruption, $F(1, 31) = 3.21$, $p = .083$, $\eta^2_p = .09$, and an interaction between zone and interruption, $F(1, 31) = 4.43$, $p = .044$, $\eta^2_p = .13$ (see Figure 5). The proportion of 40-zones where corrected speeding occurred was higher for interrupted zones ($M = .05$, 95% CI [.03, .07]) compared with uninterrupted 40-zones ($M = .02$, 95% CI [0.00, .04]), $t(31) = 2.04$, $p = .050$, $d = .51$. There was no difference in corrected speeding between the interrupted ($M = .01$, 95% CI [.00, .01]) and uninterrupted 70-zones ($M = .01$, 95% CI [.00, .02]; $t = 1$).

The impact of interruption lag length.

Maximum speed. A 2 (zone: 40, 70) × 2 (interruption lag: 5 s, 15 s) within-subjects ANOVA yielded a main effect of zone, $F(1, 31) = 352.9$, $p < .001$, $\eta^2_p = .92$, no effect of lag, $F(1, 31) = 2.95$, $p = .096$, $\eta^2_p = .09$, and no interaction between zone and lag, $F(1, 31) = 2.91$, $p = .098$, $\eta^2_p = .09$. However, the planned contrast revealed that the maximum speed reached during the interrupted 40-zones was significantly higher when the interruption lag was 5 s ($M = 49.0$, 95% CI [47.8, 50.3]) compared with 15 s ($M = 46.5$, 95% CI [45.2, 47.8]), $t(31) = 2.24$, $p = .032$, $d = .34$. There was no difference in the maximum speed reached during the interrupted 70-zones when the interruption lag was 5 s ($M = 69.0$, 95% CI [67.9, 70.1]) compared with 15 s ($M = 69.4$, 95% CI [68.3, 70.5]; $t < 1$).

Uncorrected speeding. A 2 (zone: 40, 70) × 2 (interruption lag: 5 s, 15 s) within-subjects ANOVA yielded a main effect of zone, $F(1, 31) = 27.59$, $p < .001$, $\eta^2_p = .47$, an effect of lag that approached significance, $F(1, 31) = 3.92$, $p = .057$, $\eta^2_p = .11$, and an interaction between zone and lag that also approached significance, $F(1, 31) = 3.93$, $p = .056$, $\eta^2_p = .11$ (see Figure 5). The proportion of 40-zones where uncorrected speeding occurred was significantly higher when the interruption lag was 5 s ($M = .30$, 95% CI [.25, .36]) compared with 15 s ($M = .20$, 95% CI [.14, .25]), $t(31) = 2.06$, $p = .047$, $d = .33$. The proportion of 70-zones where uncorrected speeding occurred was no different when the interruption lag was 5 s ($M = .02$, 95% CI [.00, .04]) compared with 15 s ($M = .02$, 95% CI [.00, .04]; $t < 1$).

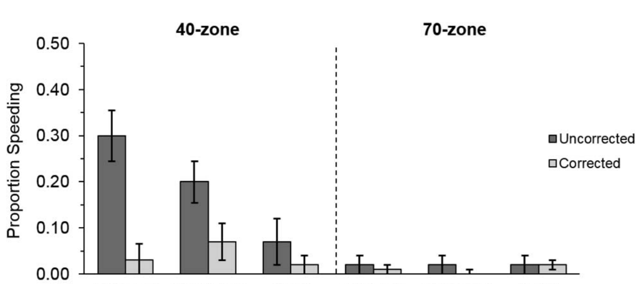

Figure 5. Proportion of interrupted (Int) and uninterrupted (No Int) 40-zones (left panel) and 70-zones (right panel) where speeding occurred in Experiment 3. Interruptions either had a 5-s lag or a 15-s lag. Uncorrected speeding (>5 km/h over limit, no attempt to return below the limit) and corrected speeding (>5 km/h over limit, then reduced by at least 10 km/h) is shown. 95% within-subjects CIs determined by the method recommended by Morey (2008).

Corrected speeding. A 2 (zone: 40, 70) × 2 (interruption lag: 5 s, 15 s) within-subjects ANOVA yielded a main effect of zone, $F(1, 31) = 9.21$, $p = .005$, $\eta^2_p = .23$,) no effect of lag ($F < 1$), and no interaction between zone and lag, $F(1, 31) = 1.71$, $p = .20$ (see Figure 5). The proportion of 40-zones where corrected speeding occurred was no different when the interruption lag was 5 s ($M = .03$, 95% CI [–.01, .07]) compared with 15 s ($M = .07$, 95% CI [.03, .11]), $t(31) = 1.16$, $p = .25$. The proportion of 70-zones where corrected speeding occurred was no different when the interruption lag was 5 s ($M = .01$, 95% CI [.00, .02]) compared with 15 s ($M = .00$, 95% CI [–.01, .01]; $t = 1$).

These results indicate that providing participants with 10 s longer to encode the new speed limit reduced the likelihood of uncorrected speeding after driving resumption from 30% to 20%. In contrast, we did not find evidence that delaying the onset of an interruption decreased corrected speeding. These results are consistent with the notion that PM failure is linked to speeding. They also suggest that increasing the interval between speed limit changes and interruptions could significantly decrease uncorrected speeding and thus the likelihood of serious accidents and accident severity.

General Discussion

Road safety campaigns targeting speeding typically rely on changing drivers' attitudes toward speeding, often by encouraging them to consider the risks involved (Lewis, Watson, Tay, & White, 2007). Such campaigns are based on the premise that speeding is primarily an intentional behavior. The current study sought to determine whether a significant amount of the speeding that occurs after interruptions might be accounted for by unintentional PM failures. Consistent with Gregory et al. (2014), we demonstrated that drivers' speed in a recently reduced speed zone (40 km/h limit school zone) was higher when they were stopped by a red traffic light, compared with when they were uninterrupted. Gregory et al. suggested that the red light was creating a PM task requiring drivers to remember the newly reduced speed when they resumed traveling (Dodhia & Dismukes, 2009). However, as outlined earlier, from a theoretical standpoint the evidence for a PM explanation provided by Gregory et al. was equivocal since their real-world study potentially covaried frustration with forgetting. To address this, we investigated speeding in a simulator environment where many of the real-world factors contributing to frustration were minimized. We could also more closely examine the nature of speeding resulting from PM failure following interruption by partitioning the data into uncorrected and corrected speeding probabilities.

In Experiment 1A, we demonstrated that the probability of speeding increased when participants were interrupted in a recently reduced speed zone (40 km/h limit), but not when they were interrupted at an unchanged speed (70 km/h limit)—an effect that was also very closely replicated in Experiments 2 and 3. We also manipulated driving conditions directly linked to PM storage and retrieval that should increase speeding after interruptions. Experiment 2 showed that performing a cognitively demanding task during the interruption, when compared with unfilled interruptions, increased the probability of initially speeding, but that participants were able to subsequently correct (reduce) their speed. In Experiment 3, providing participants with 10 s longer to encode the new speed limit before interruption decreased the probability of uncorrected speeding after an unfilled interruption.

A significant advantage of a controlled simulator study is that we can determine the probability of speeding after an interruption, rather than just examining the speed at a single time-point after interruption. Thus, in Experiment 1A we not only replicated Gregory et al.'s (2014) average speed increase of ~6 km/h after interruption, but were additionally able to show an increase in the probability of uncorrected speeding (speed limit exceeded by at least 5 km/h with no attempt to return below the limit) from 9% when uninterrupted to 26% when interrupted. To confirm that participants were forgetting the newly encoded speed limit, we conducted Experiment 1B to show that forgetting was not biased toward traveling more quickly. In other words, we know that drivers will forget and go too fast, but will they also forget and go too slow? Our results showed that this was the case, and forgetting was just as likely to cause underspeeding as it was overspeeding—with 23% of interrupted drivers forgetting and traveling too slowly compared to 1% of uninterrupted drivers. Therefore, even in an environment where potential frustrating factors are controlled, participants were still forgetting to resume driving at the new speed following an interruption.

Forgetting is a relatively binary outcome—drivers either remember to drive at the new speed limit, or they forget. However, forgetting could also lead to two different kinds of speeding behavior where drivers either return to the previous speed limit or, alternatively, are uncertain and choose a speed somewhere between the new and previous speed limit (e.g., the mean of the two speeds). The current results provide more support for the former explanation, with speeders on average in Experiment 1A traveling nearly 20 km/h over their limit of 40 km/h, and underspeeders on average in Experiment 1B traveling nearly 20 km/h under their limit of 70 km/h. Therefore, not only is speeding after interruptions relatively common, but when it occurs drivers are likely to try and revert to their previous speed. As such, we expect speeding to be a particular problem when real-world drivers are interrupted shortly after the speed limit has been substantially reduced (e.g., 70 km/h down to 40 km/h). These findings have implications for the careful selection of routine speeds (e.g., 50 km/h in residential areas) because this speed is likely to be what drivers default to when they are uncertain or have been interrupted.

Practical Implications

Unfortunately, many of the techniques for reducing the detrimental effects of interruptions (e.g., introducing attention capturing reminder signs) have the unintended consequence of increasing demand on drivers' limited cognitive and visual resources (Boehm-Davis & Remington, 2009; Bowden et al., 2017; Logan & Gordon, 2001). It is therefore vital that nonintrusive interventions are also used to counter the PM-induced speeding reported here. In addition to providing support for the PM explanation of postinterruption speeding, the current research allowed us to evaluate the benefits of two different nonintrusive interventions: reducing driver distraction during interruptions and increasing the time between speed limit changes and interruptions.

Using a mobile phone while driving is still a very common practice, particularly among young adults (Nelson, Atchley, & Little, 2009), with many drivers believing it is safe to do so when stopped in traffic (Atchley, Atwood, & Boulton, 2011). Our findings suggest that performing a cognitively demanding task during interruptions, such as texting while stopped at traffic lights, could increase the chance of forgetting to resume at a recently reduced speed limit. In Experiment 2, we showed that the probability of corrected speeding increased from 1% to 11% when an additional task was introduced, where corrected speeding refers to drivers initially speeding but then remembering to drive at the new reduced limit and slowing down some time later. These findings suggest that while unprompted recall of the reduced limit did occur shortly after interruption, it occurred more slowly for drivers who engaged in distracting tasks while stopped at traffic lights.

It is crucial to note that just because these drivers eventually corrected their speeding, their driving was not necessarily less dangerous. There is a much higher likelihood that pedestrians will be stuck by vehicles immediately after traffic lights (Palamara & Broughton, 2013), where vehicle speed is directly related to accident severity (Rosén & Sander, 2009). Our findings highlight the importance of continuing current education and enforcement campaigns aimed at reducing driver distraction (McEvoy, Stevenson, & Woodward, 2006), even when drivers are stopped in traffic.

Another nonintrusive intervention, which we show can help counter forgetting-induced speeding, is increasing the time between a speed limit change and an interruption. This intervention helps reduce forgetting by increasing the time available to encode the new speed intention (Smith & Bayen, 2004; Trafton et al., 2003). In Experiment 3, increasing the time spent traveling at a new lower speed before interruption from 5 s to 15 s decreased the likelihood of uncorrected speeding after an interruption from 30% to 20%. This suggests that shifting existing speed limit transitions at known problem locations could help reduce speeding by a third. A major benefit of this kind of intervention is that it would place no additional demands on drivers and would be relatively low cost. Ensuring adequate separation between interruptions (e.g., traffic lights, stop signs) and speed limit transition points should be a consideration in future planning of roads and improvements to existing roadways.

As mentioned previously, the current study recruited a sample of younger, more inexperienced drivers since they are disproportionately represented in accidents where speeding is involved (Palamara, Kaura, & Fraser, 2013). This group may be more at risk of forgetting after interruptions because they have been shown to be more susceptible to distractions (Klauer et al., 2014) and their lack of experience means they may need to dedicate more resources to the driving task itself (Crundall & Underwood, 1998; Fisher et al., 2002; Triggs & Regan, 1998). As such, inexperienced drivers could be more likely to forget and speed than more experienced drivers. However, research also suggests that PM performance declines with age, particularly for older adults over 70 years of age (Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Maylor, 1990). It is therefore likely that both inexperience and age-related declines may affect the extent of postinterruption speeding. Future studies should investigate the relative impacts of each of these factors on forgetting induced speeding.

Conclusions

Although there is no doubt that some drivers are choosing to speed (Bolderdijk, Knockaert, Steg, & Verhoef, 2011; Machin & Sankey, 2008), the current experiments make the case that PM failure also plays a crucial role in speeding under certain driving conditions. We show here that interrupted drivers are approximately three times more likely to speed after a recent speed limit decrease than those who are not interrupted. The probability of speeding is potentially further increased when drivers fill their interruption with an additional task, such as conversing with a passenger or using an in-vehicle communication or entertainment system. We suggest that a simple way of reducing this forgetting-induced speeding would be by increasing the separation between speed limit transitions and interruptions to give drivers more time to encode a stronger PM intention.

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