



# Imagery-inducing distraction leads to cognitive tunnelling and deteriorated driving performance

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## ABSTRACT

The effects of imagery-induced distraction on hazard perception and eye movements were investigated in 2 simulated driving experiments. Experiment 1: sixty participants viewed and responded to 2 driving films containing hazards. Group 1 completed the task without distraction; group 2 completed a concurrent imagery inducing telephone task; group 3 completed a non imagery inducing telephone task. Experiment 2: eye-tracking data were collected from forty-six participants while they reacted to hazards presented in 16 films of driving scenes. 8 films contained hazards presented in either central or peripheral vision and 8 contained no hazards. Half of the participants performed a concurrent imagery-inducing task. Compared to undistracted participants, dual-taskers were slower to respond to hazards; detected fewer hazards; committed more “looked but failed to see” errors; and demonstrated “visual tunnelling”. Telephone conversations may interfere with driving performance because the two tasks compete for similar processing resources, due to the imagery-evoking aspects of phone use.

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## 1. Introduction

It is well documented that increasing the demands on a driver's attention by means of a mobile telephone conversation can impair driving performance (Alm & Nilsson, 1994, 1995; Brown, Tickner, & Simmonds, 1969; Redelmeier & Tibshirani, 1997; Stein, Parseghian, & Allen, 1989; Stevens & Minton, 2001; Strayer & Drews, 2007). Explanations for this impairment are often couched in terms of an overall increase in cognitive workload, leading to slower cognitive processing and decreased executive control (Amado & Ulupinar, 2005; McKnight & McKnight, 1993). This ‘domain-general’ approach is supported by research demonstrating that, compared to undistracted drivers, dual tasking drivers show decreased hazard perception (Galpin, Underwood, & Crundall, 2009; Strayer & Johnston, 2001), longer reaction times for critical events (Strayer & Drews, 2007), poor lane discipline (Reed & Robbins, 2008) and increased accident risk (Redelmeier & Tibshirani, 1997). Furthermore, dual tasking drivers often use compensatory strategies. They may drive slower, increase headway (Stevens & Minton, 2001) and dispense with tasks such as checking mirrors and using indicators (Reed & Robbins, 2008). These compensatory strategies are consistent with the idea that driving performance is impaired because of a generalised increase in workload: drivers may use these strategies in an attempt to decrease operational demands, so that more resources are available to allow for continued dual tasking (see also Platten, Schwalm, Hülsmann, & Krems, 2014).

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However, an emerging research literature is exploring more 'domain specific' explanations for the observed effects of dual tasking on driving performance. These suggest that performance deteriorates because both tasks share processing components. Multiple Resource Theory (Wickens, 1984, 2002; Horrey & Wickens, 2004) formalises the domain specific approach by highlighting the conditions which must be met for competent dual tasking to be achieved. According to this model, any task has three aspects; the sensory modality via which information is input for processing; a processing "code" (e.g. spatial coding for visual input, verbal coding for spoken input); and a response (e.g. a vocal or manual response). When dual-tasking, the two tasks must involve different modalities, codes and responses if they are not to interfere with each other. Driving involves visual input (focal vision for hazard detection and ambient vision for lane maintenance), spatial coding of information, and manual responses (steering, braking, etc.). Conversing on a phone requires auditory input, verbal coding and vocal responses. Therefore, in theory, it should be possible to combine driving and phone use. However, in practice, the extensive research literature demonstrates emphatically that talking on the phone whilst driving carries serious risk. This implies that resources which are theoretically only assigned to the telephone task might also be required for the driving task, or vice versa, leading to competition for resources (see Collet, Guillot, & Petit, 2010, for a review of research in this area).

With this in mind, research is now investigating how so-called 'crosstalk' (Pashler, 1994) between tasks affects performance, by identifying the component parts of the two tasks which require common resources. The type of conversation engaged in has been examined. Findings suggest that driving performance can be impaired by greater conversational complexity (Alm & Nilsson, 1994, 1995; Almahasneh, Chooi, Kamel, & Malik, 2014) and increased emotional involvement in a conversation (Briggs, Hole, & Land, 2011). Bergen, Medeiros-Ward, Wheeler, Drews, and Strayer (2013) suggest that the way in which we comprehend different types of sentence may explain the crosstalk and the consequent dual tasking difficulties. Bergen, Lindsay, Matlock, and Narayanan (2007) showed that subject nouns and verbs in a sentence can trigger mental imagery, which is used to aid sentence comprehension. By using concurrent tasks of sentence comprehension and visual categorisation, they showed that sentences denoting upwards and downwards motion selectively interfered with a participant's ability to categorise objects in the same part of the visual field. This implies that the same visual resources were required for both tasks. Research has also shown that as well as mental imagery, language about actions can trigger both actual movement (Glenberg & Kaschak, 2002) and activation in motor areas of the brain (Tettamanti et al., 2005). Similar findings have been reported for sentences with visual and auditory components (Just, Newman, Keller, McEleney, & Carpenter, 2004; Zwann, Stanfield, & Yaxley, 2002).

Bergen et al. (2013) proposed that the content of a sentence could differentially affect driving performance, with sentences focusing on actions or visual items being more distracting than abstract sentences. Participants in a driving simulator were asked to follow a lead vehicle at a set distance and react when the vehicle braked. At the same time, they completed a sentence verification task. The sentences were either "action" (e.g. 'to open a jar you turn the lid counter clockwise'), "visual" (e.g. 'the letters on a stop sign are white') or "abstract" (e.g. 'the capital of North Dakota is Bismarck'). Reaction times in response to the lead vehicle's braking were similar for all language conditions (with all dual taskers showing longer RTs than controls). However, there were significant differences in following distance between the three language conditions. Participants who were distracted by the visual and action statements showed far greater deviation in their headway distance than those distracted by abstract statements and controls. Bergen et al. (2013) claim that these findings demonstrate how different types of secondary task can differentially affect driving performance: whilst a domain-general approach could explain the increased reaction times shown by dual taskers compared with controls, it cannot explain why those distracted by visual statements showed greater deviation in following distance than any other participants. Instead, Bergen et al. (2013) argue that crosstalk between the two tasks caused deterioration in driving performance: those responding to visual statements were already using the resources required for the driving task.

If conversation has a "visual" component, this has implications for drivers talking on the phone. The use of "visual" language could lead to the creation of mental imagery, which in turn might draw on cognitive resources required for normal visual perception of a scene. The suggestion that mental imagery and visual perception use similar resources and cortical areas is not new. Whilst there is disagreement regarding specifically which areas of the visual cortex are used in imagery (D'Esposito et al., 1997; Farah, 1988) brain scanning data have identified that perception and imagery produce similar neural activation patterns. In an attempt to explain the consequences of an interaction between imagery and visual perception, Craver-Lemley and Reeves (1992) argue that mental imagery lowers sensitivity to changes in a visual display (see also Rensink, O'Regan, & Clark, 1997). This disruption persisted for up to six seconds after participants reported having stopped visualisation (see also Kosslyn & Thompson, 2003). In the context of driving, these findings could have serious consequences for hazard perception. Indeed, research on eye movements in dual tasking drivers has revealed that they demonstrate cognitive and visual tunnelling (Briggs et al., 2011; Recarte & Nunes, 2002); and can 'look but fail to see' pertinent items in the driving scene (Langham, Hole, Edwards, & O'Neil, 2002; Mack & Rock, 1998; Strayer, Drews, & Johnston, 2003).

The current investigation attempts to isolate how conversation-induced mental imagery might impair driving performance in dual-tasking drivers. Experiment 1 investigates the relationship between imagery-inducing distraction and hazard detection. Experiment 2 explores further the impact of imagery based distraction on hazard perception and visual awareness.

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