WHAT IS DISTRACTION?

INTERNATIONAL CONFERENCE ON DISTRACTED DRIVING

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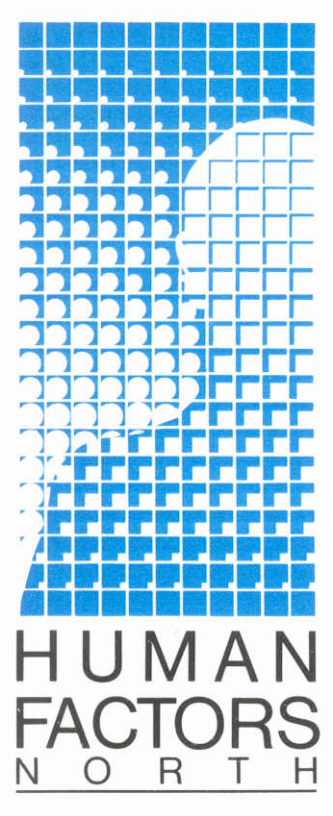

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1 INTRODUCTION

Distraction in driving is a frequently cited factor in crashes. A recent NHTSA study provides compelling evidence of its importance (Neale, Dingus, Klauer, Sudweeks, & Goodman, 2005; Dingus, Klauer, Neale, Petersen, Lee, Sudweeks, Perez, Hankey, Ramsey, Gupta, Bucher, Doerzaph, & Jermeland, 2005). This study involved naturalistic observation of the driving of over 109 primary drivers, using 100 cars, over 43,000 hours, in mainly urban and suburban areas. A total of 76 crashes and 761 near-crashes occurred during this time period for which full details were captured, including video of the driver's face and forward view. Distraction was determined to have contributed to 78% of the crashes and 65% of the near-crashes.

2 DISTRACTION: MISALLOCATED ATTENTION

The purpose of this paper is to describe the human cognitive limitations that underlie the negative impact of distraction. In terms of human cognition, distraction can be defined as misallocated attention. To determine what makes attention "misallocated" requires consideration of the interface between three factors:

- Driver
- Driving Task
- Driving Environment

A driver who is tired, inexperienced or alcohol impaired should not be chatting on the cell phone while driving. Such drivers are already in a compromised state where they take longer to collect driving-critical information and respond more slowly. Talking on a cell-phone exacerbates these effects, and can lead to drivers responding too late to a hazard on the roadway. A tired, or older or inexperienced driver requires all of their attentional resources for driving.

Some driving tasks are particularly demanding, for example, negotiating intersections. The demand is indicated by the fact that about 2/3 of personal injuries occur at or in relation to intersections. A driver who is making a left turn at a signalized intersection with turning traffic and pedestrians has many items of driving related information to process – the state of the traffic signal, oncoming traffic, pedestrians, path through the intersection. This is not the time to be checking out a video advertising sign. In doing so the driver may miss a pedestrian who darts into the intersection just as the light turns red.

Congested traffic creates a demanding driving environment. A driver who is closely following another vehicle in stop-and-go traffic takes a risk when she looks away from the road to put ketchup on her French fries. During the brief second or two that it takes to put the ketchup on, the distance to the vehicle ahead can be reduced so rapidly that by the time the driver notices, she cannot prevent a rear-end collision.

In summary, the impact of misallocated attention depends on the context in which the distraction occurs.

3 COGNITIVE LIMITATIONS THAT MAKE DISTRACTION A PROBLEM

If we had unlimited information processing capacity, distraction would not be an issue. With unlimited capacity, we could perform many tasks in parallel just as well as we could perform each task on its own. Unfortunately we are not designed that way. On the contrary, humans are essentially serial, limited capacity processors of information.

Serial means one thing at a time. We can switch our attention from one task to another rapidly but we cannot **consciously** attend to two different tasks well at the same time. An everyday example of this difficulty can occur at a party where there are many conversations going on. While talking to a friend, you may be suddenly distracted by hearing your name mentioned in another conversation. You start listening to that conversation, and shortly find yourself apologizing to your friend for not hearing what he just said to you, because you became distracted. This is a very common experience which has to do with the fact that we are Aserial processors of information@, that is, we can only consciously attend well to one thing at a time.

Similarly in driving we can be inappropriately distracted. We can be distracted by our own thoughts. As we are busy reviewing a conversation we had with the boss, we miss our intended exit. We can be distracted by objects or people in the road environment. A pedestrian acting oddly on the sidewalk may distract us just as the traffic signal turns yellow and we end up running the beginning of a red light. We can be distracted by non-driving related tasks, such as dialling a cell-phone, talking on a cell-phone, personal grooming, inserting a CD into the player. While doing such tasks our mental attention is elsewhere and we can miss a vital signal like rail flashers at a crossing with no barriers or a STOP sign in a rural area, with tragic consequences. We can also be distracted by legitimate driving-tasks, for example looking in the rear-view mirror to make a lane change and then hitting the vehicle in front that stops suddenly while our attention is elsewhere.

3.1 Attentional Resources are Limited

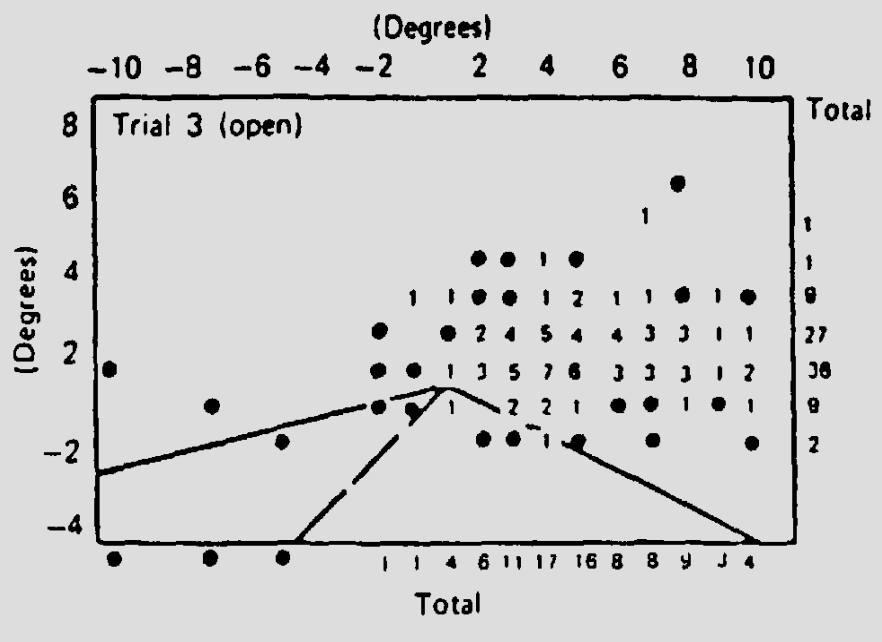
Note I have said that we cannot consciously attend to two different tasks at the same time. Many tasks we do are highly automated because they are so over-learned. We need to pay conscious attention to get the task started e.g. walking, tying shoelaces, driving on a highway, but then the tasks can be carried out on automatic pilot and we can think about other things. As long as we bring our conscious attention back to the task at critical moments, we can perform very well in this automated state.

Attentional resources are limited. Let us consider two people in conversation walking together. As the conversation grows more heated, they slow down and may eventually stop. The conversation task can require so much of the available attentional resources that it is not possible to carry on even a highly automated task such as walking.

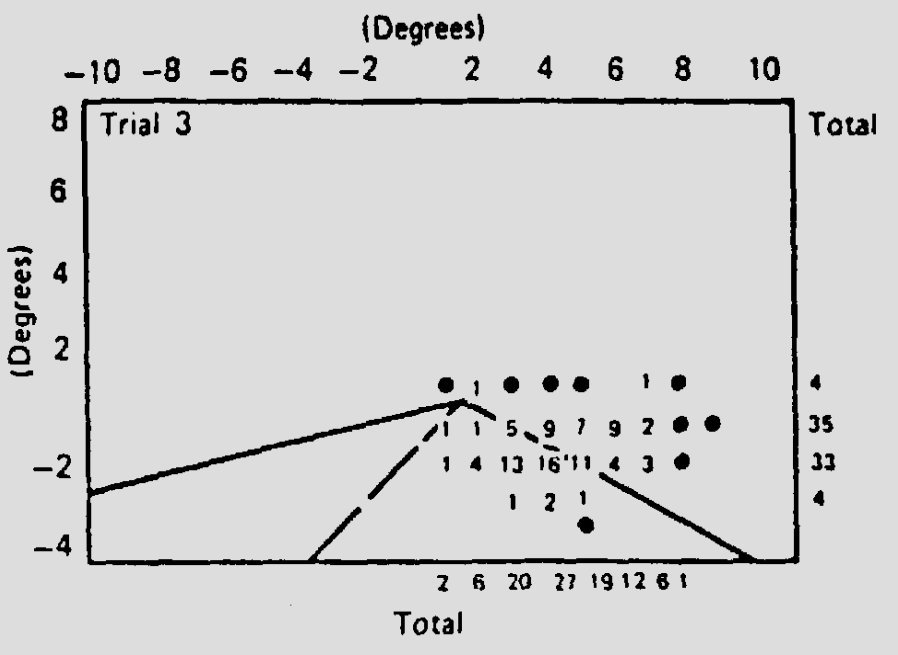
The degree of attention required to the driving task depends on the driver, the driving task and the driving environment. A novice driver has to pay conscious attention to the control task, part of which is keeping within the lane lines. In contrast, an experienced driver's lane keeping behaviour is automated, and conscious attention is available for other tasks such as searching for upcoming hazards. Since more of the novice driver's attention must be given to basic control functions, less is available for monitoring for hazards, or for distracting, non-driving related activities, such as changing a CD.

3.2 Visual Search and Task Demand

Driving tasks differ in the attentional demand required. The diagrams in Figure 1 are drawn from studies in which drivers wore eye movement camera recorders while driving (Mourant, Rockwell, & Rackoff, 1969). Such studies help to reveal how drivers allocate attention while driving.



(a) Driving on an Open Road



(b) Driving Close Behind a Vehicle Ahead

Figure 1: Visual Search and Task Demand

In Figure 1, the distribution of eye fixations is overlaid on a view of the road going off into the horizon. Each number indicates the percentage of eye fixations the driver made at that area. A black dot indicates less than 1% of the fixations were in this area. The first diagram (a) shows eye fixation distributions for driving on a highway with no close-by traffic. The second diagram (b) comes from for driving on the same road, but closely following another vehicle. Notice how visually demanding this is, and how many fixations are on the back of the vehicle ahead.

Another study allowed drivers to take half second looks at the road whenever they pushed a button. Number of looks demanded increased with increases in speed, with reductions in lane width and with sharper curves (Courage, Milgram, & Smiley, 2000).

These results suggest that distraction will be much more of a problem in some driving circumstances than in others. For example, it may not be wise to place video advertising near an urban expressway exit, where there is turbulence due to the mix of drivers accelerating to enter and decelerating to exit while lane-changing. In this location, a second or two of distraction at the wrong moment can easily lead to a side-swipe or rear-end crash.

3.3 Information Processing Capacity is Limited

Even if all our attention is on one task, we still are limited in how much new information we can process. Someone once estimated that we are inundated with on the order of 1 billion bits of information per second. One “bit” of information is defined as the answer to a yes/no question. The information that we are inundated with is visual, auditory, kinaesthetic, tactile, olfactory, and taste. Thus if we are exposed to a scene for the first time, perhaps a city street, for 1 second, there are on the order of 1 billion yes/no questions which could be asked about the sights, sounds etc to which we have been exposed. Of the 1 billion bits of information available to us, we are consciously aware of only a very small portion – on the order of 16 bits of information per second. Now, this will vary from one person to another and from one time of day to another – first thing in the morning, it may be 20 bits per second, later at night, 10. For a very observant person, it may be 30 bits per second, or for one who is less so, 15 bits per second. In any case, it will not be 10000 or 1000 or even 100 per second. We are very limited in our ability to take in **new** information. This is why higher-speed environments are visually simpler than lower speed ones. At 100 km/h we cannot cope with all the new information available as we drive down a city street.

Some driving tasks are so demanding that we have little spare capacity for non-driving tasks. For example, a driver making a left turn on a green light at an urban intersection must make many brief visual fixations in a short time: at the traffic light, at oncoming traffic, at traffic directly ahead, at pedestrians and at the path through the intersection. This is not the time to be answering a cell phone.

4 MEASURES OF DISTRACTION

Distraction, or misallocated attention can be detected by observing where drivers look, or by recording how performance of individual drivers is affected when they are distracted. Distraction can also be assessed through looking at changes in safety outcomes, that is traffic conflicts or crashes that arise after a distracting feature is known to have come into effect.

A recent study of the effect of video advertising signs on the safety of downtown Toronto intersections measured distraction using all these different methods (Smiley, Persaud, Bahar, Mollett, Lyon, & Smahel, 2005). Video recordings of driver eye movements were made in order to determine how drivers searched the road environment as they approached busy downtown intersections, with video advertising signs on one of the two approaches. The video recordings showed that the driver fixations were brief, generally lasting of 1/5 to 3/5 of a second. As has been found in other studies, the vast majority of fixations were at the road scene ahead; only 10% of glances were within the vehicle or directed away from the roadway. Drivers who looked at the video signs made two fixations, each lasting an average of 0.5 seconds, similar to what has been found for glances at traffic warning signs (Luoma, 1991; Zwahlen, 1987).

Video recordings are also useful in determining the circumstances in which drivers are willing to engage in non-driving tasks that are potentially distracting. The Toronto study of video advertising signs found that drivers' glances at static billboard signs were actually made in less safe conditions than were glances at the video signs, in that, on average drivers were closer to the vehicle in front when the glances were made. (Smiley et al, 2004). Traffic conflicts and crashes were assessed at the same intersections before and after installation of the video signs, however consistent effects that could be attributed to distraction due to the signs were not found.

Distraction can be auditory as well as visual in nature. Studies of visual search patterns during cell phone conversation have found drivers making fewer and more concentrated fixations of the road ahead while engaged in talking on the phone (Harbluk et al., 2002). By reducing the amount of visual search, and taking longer for each fixation, drivers reduce the mental demand associated with vehicle control and guidance tasks. However, by narrowing their focus they are more likely to have delayed responses to hazards on the roadway.

The impacts of distraction can be measured on driver performance, for example on increased variability of lane position or speed or following distance as drivers devote their attention to the distracting task and are less vigilant in maintaining vehicle control. Drivers can also reduce speed and increase following distance in an attempt to reduce driving task demand and information processing load. Alternately some drivers, in their distraction, allow the vehicle speed to increase beyond what they intended.

Finally, distraction can result in increased risk of conflicts with other vehicles and increased crashes. While conflicts are frequent events, crashes are rare and random events with multiple causes, and while a particular source of distraction may contribute to individual crashes, it can be difficult to link it directly to an increase overall in the crash rate.

5 SUMMARY

Distraction, resulting from varied sources, is a frequently cited factor in crashes, with a recent study indicating it was involved in about 3/4 of crashes. Distraction can be considered to be "misallocated attention" within the context of the driver's state, the driving task and the road environment. Distraction results in accidents because humans are essentially serial, limited capacity processors of information, easily over-loaded in the driving environment. We do best if we are only required to pay conscious attention to

one task at a time. The impact of distraction on drivers can be assessed by observing where drivers look, or how well they maintain control of their vehicle's speed, lane position and headway. More global measures of distraction are traffic conflicts or crashes that arise after a distracting feature is known to have come into effect.

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