# Dynamics of Driver Distraction: The process of engaging and disengaging

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**ABSTRACT** – Driver distraction research has a long history, spanning nearly 50 years, but intensifying over the last decade. The dominant paradigm guiding this research defines distraction in terms of excessive workload and limited attentional resources. This approach largely ignores how drivers come to engage in these tasks and under what conditions they engage and disengage from driving—the dynamics of distraction. The dynamics of distraction identifies breakdowns of interruption management as an important contributor to distraction, leading to describe distraction in terms of failures of task timing, switching, and prioritization. The dynamics of distraction also identifies disengagement in driving (e.g., mind wandering) as a substantial challenge that secondary tasks might exacerbate or mitigate. Increasing vehicle automation accentuates the need to consider these dynamics of distraction. Automation offers drivers more opportunity to engage in distractions and disengage from driving, and can surprise drivers by unexpectedly requiring drivers to quickly re-engage in driving—placing greater importance of interruption management expertise. This review describes distraction in terms of breakdowns in interruption management and problems of engagement, and summarizes how contingency, conditioning, and consequence traps lead to problems of engaging and disengaging in driving and distractions.

## INTRODUCTION

Society has been driving with distraction since the first automobile. Even the specific focus on phone conversations as a source of distraction has a history stretching back almost 50 years (Brown, Tickner, & Simmonds, 1969). Given that distraction and inattention account for an estimated 25% of motor vehicle crashes, distraction remains an important concern and an area of active research (McCartt, Hellinga, & Bratiman, 2006; Regan, Lee, & Young, 2008; Wang, Knipling, & Goodman, 1996).
Rapid changes in information technology suggest that distraction may be an increasingly urgent problem. Smart phones, wearable devices, and internet-enabled vehicle systems all connect drivers to social networks and a rapidly increasing volume of information that has the potential to distract.

Increasing vehicle automation may compound these trends by removing many driving demands, which may tempt drivers to engage in distracting activities (Merat & Lee, 2012). Drivers who succumb to these temptations might be particularly vulnerable to situations that the automation cannot accommodate. More distractions and more opportunities to engage in those distractions combine to make driver distraction a particularly prominent research, design and policy issue (Lee, 2007).

Distraction is often framed in terms of mental workload and so this paper begins with a brief discussion of distraction as instances of excessive mental workload, which provides a context for an alternate perspective that considers distraction as a breakdown in the dynamic process of attending. Two important types of breakdowns include poorly timed interruptions to driving and general disengagement from driving. Vehicle automation may exacerbate those of these breakdowns. The paper concludes by describing mechanisms guiding engagement and disengagement in driving and non-driving tasks.

## ATTENTION AND ATTENDING

Addressing driver distraction demands a clear definition and theoretical orientation. Many definitions of driver distraction have been developed and the following reflects an integration of many of these: “Driver distraction is a diversion of attention away from activities critical for safe driving towards a competing activity.” (Lee, Regan, & Young, 2008, p. 7). As with most definitions of distraction, attention and the process of dividing attention between the road and some competing activity play a central role. Perhaps most critically, attention concerns whether a driver’s eyes are directed toward the road—long glances away from the road are particularly risky (Liang, Lee, & Yekhshatyan, 2012).

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This definition is also consistent with distraction as the division of limited attentional resources, which has provided a theoretical basis for mental workload (Kahneman, 1973; Wickens, 2008). This definition also implies that distraction reflects a process of shifting and engaging attention over time (Horrey, Wickens, & Consalus, 2006; Posner & Petersen, 1990). These complementary theoretical perspectives contribute to understanding distraction: one considers attentional *resources* and the other considers attentional *dynamics*.

Research on distraction has often focused on attentional resources and has considered distraction as excessive workload that overwhelms drivers' limited attentional resources. As a consequence, the information-processing perspective and the dual-task paradigm frame much of distraction-related research, leading much distraction research to share the intellectual foundation of mental workload research of the 1980's (Hancock & Meshkati, 1988; Hart & Sheridan, 1984; Moray, 1979). As an example, a study comparing baseline driving, driving with a single secondary task, and driving with two secondary tasks described the results in terms of excessive workload that was particularly acute with the two secondary tasks (Lansdown, Brook-Carter, & Kersloot, 2004). This and many other studies describe distraction as if it were synonymous with workload, where workload is defined in terms of mental resources or information processing capacity devoted to a task (Birrell & Young, 2011; Brookhuis & de Waard, 2010; Piechulla, Mayser, Gerkhe, & Konig, 2003; Strayer, Cooper, & Turrill, 2013). Some studies even explicitly define distraction in terms of attentional resources (Hurts, Angell, & Perez, 2011).

Secondary-task reaction measures have been one of the primary tools for assessing mental workload (Fisk, Derrick, & Schneider, 1986; Ogden, Levine, & Eisner, 1979). More recently, secondary-task reaction time has emerged as a promising measure of driver workload (Jahn, Oehme, Krems, & Gelau, 2005) and driver distraction (Engström, 2010; Harms & Patten, 2003; Patten, Kircher, Ostlund, & Nilsson, 2004).

Secondary-task reaction time provides a useful indicator of the cognitive load associated with selecting, interpreting, and responding to information. Excessive cognitive load is one element of distraction, but this approach tends to consider drivers as passive recipients of secondary task demands. Measuring driver distraction in this way does not assess how people choose to engage and disengage in demanding tasks. A review of crash reports showed that over 70% of distractions were discretionary (Beanland, Fitzharris, Young, & Lenné, 2013). Because most distractions are discretionary, addressing the process of task engagement and disengagement is critical.

This paper complements the perspective of distraction as excessive workload, by focusing on attentional dynamics associated with engaging and disengaging in driving and non-driving tasks. This paper suggests the *process of attending* might be a valuable perspective to complement the focus on the *capacity of attention*.

## ATTENDING: TIMING AND CONTEXT

Strategic workload management and task scheduling research considers the process of attending and demonstrates that people do not passively respond to workload demands that are imposed on them (Adams, Tenney, & Pew, 1991; Raby & Wickens, 1994; Tulga & Sheridan, 1980). People adopt strategies for shedding, delaying, and resuming tasks that can result in a profile of performance very different from what one might expect from a carefully controlled study that imposes a specific task timing on people. People do not follow the simple information-processing model of human cognition that underlies the secondary-task measures of mental workload. Instead they actively manage workload, often shedding low-priority tasks in favor of high-priority tasks.

Considering the process of attending, distraction reflects failures of scheduling and shedding tasks. Although drivers have the opportunity to manage task timing they sometimes fail, revealing an important gap in our understanding of distraction (Horrey & Lesch, 2009). Considering distraction in terms of strategic workload management highlights the need to understand the process of attending rather than understand attentional resources.

A large body of research on interruptions also provides a useful basis for considering distraction as a breakdown in the process of attending (Li, Magrabi, & Coiera, 2012; Rivera-Rodriguez & Karsh, 2010; Salvucci & Taatgen, 2009). Driving while interacting with an infotainment system can be thought of as interruption management: managing interruptions to the driving task and interruptions to the interaction with the infotainment system. Similar to strategic workload management, the interruption management perspective focuses on task timing, switching costs, and prioritization.

Considering distraction as a breakdown in interruption management provides different conceptual models that suggest new research issues and opportunities to reduce distraction (McFarlane & Latorella, 2002; McFarlane, 1999). One conceptual model considers interruptions as a series of stages beginning with the *detection* of the interruption indication followed by *interpretation* of the interruption indication. Depending on how the person interprets and prioritizes the interruption, the next stage involves shifting attention to the interruption and the *integration* of it into the ongoing activity. After addressing the interruption, *resumption* occurs when attention shifts back to the ongoing activity. Each stage identifies different effects of interruptions: diversion, distraction, disturbance, and disruption (McFarlane & Latorella, 2002). Early stages describe how easily an interruption can be ignored and later stages describe how easily the driver can integrate the interruption with ongoing activity and recover from the interruption. Considering distraction as poor interruption management strategies or as breakdowns in interruption management provides new ways of managing and measuring distraction.

Considering distraction as a breakdown in interruption management also introduces new metaphors for design and evaluation. Specifically, interaction with the vehicle infotainment system and roadway demands can be framed as a conversation. In a conversation, interruptions are negotiated and reflect coordination of the interrupter and interruptee (Sasse & Johnson, 1999).

Considering driver-infotainment system interactions as a conversation emphasize temporal conflict as a critical element of distraction. A study considering temporal conflict showed that an e-mail alert occurring 300 ms before a collision warning delayed response to a collision warning, but an e-mail alert occurring 1000 ms before the collision warning speeded response to the collision warning (Wiese & Lee, 2004). A similar finding emerged from a study that considered how the timing of interruptions affected the efficiency of resuming the interrupted task. Interrupting a task during the middle of the task undermined the ability to resume the task more than interruptions at the start of the task (Monk, Boehm-Davis, & Trafton, 2004). More generally, the concepts from communication theory of grounding and back-channel communication can guide design to minimize distraction associated with poor interruption management (Wiese & Lee, 2007).

An essential element of interruption management concerns integration of the interruption into the ongoing activity. In driving, this typically requires that drivers' alternate attention between the interruption and driving. Task perseveration describes drivers' failure to interrupt their interaction with the infotainment system and return their attention to the road. Task perseveration occurs when people become fixated on completing a task (e.g., selecting a song from a playlist) and neglect broader goals (e.g., safe driving) (Zeigarnik, 1938). Task perseveration has received attention from many perspectives in many different contexts; however, several common features define its occurrence (Fox & Hoffman, 2002):

1) Engagement in goal-oriented activity
2) Effort has been expended to reach a goal
3) The goal has not been achieved
4) There is an opportunity to continue investing effort
5) Achieving the goal in timely fashion is unlikely

The factors that influence task perseveration describe contributions to distraction that are not addressed by considering distraction as excessive workload. Three general categories of factors that influence perseveration include: proximal closure, goal emergence, and goal valence (Fox & Hoffman, 2002). Proximal closure refers to the increased motivation to complete a task that occurs as one nears the end of the task (e.g., nearing the end of a playlist search). Goal emergence refers to new goals that occur as one pursues the original goal (e.g., deciding on a new song as the playlist is scanned). Goal valence refers to cognitive inertia and the tendency to continue along a given thought process rather than deviate. This concept of goal valence shares many features of a concept often used to describe interruption dynamics: goal activation (Altmann & Trafton, 2002).

A recent study showed the relevance of task perseveration and goal activation for driver distraction. Goal activation explained the increasingly long glances away from the road when drivers searched for songs in a playlist (Lee, Roberts, Hoffman, & Angell, 2012). According to the goal-activation model, goal activation increases as the time on task increases, and goals with higher activation are more likely to receive attention (Altmann & Trafton, 2002). Activation of an unattended goal decays over time and re-engaging this unattended goal often depends, but is not guaranteed, by cues in the task environment (e.g., looming cues of a braking lead vehicle).

According to the goal-activation model, activation for the goal of searching through a playlist grows once a driver initiates the search, leading to neglect of the driving task. Long search might be particularly distracting because activation for completing the search will grow over time, leading to longer glances and diminished ability to resume the driving task. Automation might further diminish the goal activation of driving tasks by increasing the duration drivers' can neglect the driving task. Consistent with these expectations, glance duration was found to depend on task duration and also on the glance history—long glances are more likely to follow other long glances (Lee et al., 2012).

Interruption management, and the more general focus on the process of attending, reveals important elements of driver distraction that a focus on attentional resources and mental workload neglects.

### ATTENDING: PROFILES OF ENGAGEMENT

A general assumption underlying many discussions of distraction is that drivers are operating at the limit of their attentional capacity: distraction reflects information overload. Similarly, most laboratory and simulator experiments push drivers to fully engage themselves and divide their attention between driving and the secondary task as best they can. The underlying assumption is that in the baseline condition, where the drivers are not performing a secondary task, the driving task receives full attention.

Driving does not always demand full attention and much of the time it does not receive full attention. Drivers sample the forward roadway more intensely as uncertainty in the road situation increases (Senders & Kristofferson, 1966). Recent naturalistic data show that only 46% of the time were drivers “just driving” and not engaged in some secondary task (Fitch, Soccolich, Guo, & McClafferty, 2013). Not fully engaging in driving does not always compromise driving performance. However, as noted in the Indiana Tri-Level study, inattention is a prevalent contributing factor to crashes (Treat et al., 1979). The attentive and fully engaged driver observed in the “baseline” condition of many simulator studies of driver distraction might not actually represent the “baseline” condition for undistracted drivers on the road. Instead, the baseline might be disengaged drivers: a survey reported that 72% of drivers reported a lack of concentration on driving during their most recent trip (McEvoy, Stevenson, & Woodward, 2006). It is inappropriate to assume that drivers who are not distracted are fully engaged in driving.

Several recent studies demonstrate that drivers who are not distracted are not necessarily attentive to driving. A simulator study compared the eye movements of attentive drivers and inattentive drivers and found that inattentive drivers gaze concentrated on the forward roadway in a manner similar to that associated with highly demanding cognitive tasks (He, Becic, Lee, & McCarley, 2011). Even without an overt secondary task drivers’ minds wander to driving-irrelevant thoughts. Mind-wandering or stimulus-independent thought differs from stimulus-oriented thought (e.g., active scanning of the driving environment) and can interfere with processing external stimuli, such as roadway hazards (Li et al., 2012; Mason et al., 2007).

One consequence of mind wandering is that it can undermine driving performance in low workload situations, such as when driving on a familiar route (Yanko & Spalek, 2013). Familiar routes demand less attention and allow drivers’ minds to wander, leaving them less sensitive to external stimuli, such as braking lead vehicles and pedestrians in the periphery. When the experimenters compelled drivers to attend to the road the effects of mind wandering vanished (Yanko & Spalek, 2013).

Mind wandering and the decline of stimulus-oriented thought may reflect the activity of the default network, typical of the brains’ resting state (Morcom & Fletcher, 2007). In driving, the tendency towards this state might be exacerbated by long periods of vigilance associated with uneventful driving. Maintaining attention during periods of vigilance is surprisingly effortful (Grier et al., 2003). Vehicle automation may have a similar effect as route familiarity and uneventful driving, encouraging mind wandering and disengagement from driving.

These results all point towards four situations defined by the degree of stimulus driven throught versus mind-wandering and the degree of attention to driving versus attention to an infotainment system. The typical simulator study of distraction involves a high degree of both stimulus-driven thought and a high degree of attention to an infotainment system. Attentive driving involves a high degree of stimulus-driven thought directed to the road. A situation that has received little attention is one in which there is a high degree of stimulus-independent thought and engagement with an infotainment system. This situation would represent distraction in a low-workload situation. An important research question concerns whether interaction with an infotainment system can sometimes enhance driver engagement with the roadway and combat mind wandering and drowsiness associated with monotonous driving (Takayama & Nass, 2008).

Distraction occurring during low-workload as opposed to high-workload situations may become much more common as vehicle automation relieves drivers of many of the moment-to-moment demands of driving. Automation may make the easy aspects of driving much easier, but will likely be fallible and require driver to intervene in particularly challenging situations. Depending on how the transitions from automatic to manual control are supported, such transitions will make the difficult aspects of driving even more difficult (Cook, Woods, McColligan, & Howie, 1990).

The exposure to long periods of automatic driving might further undermine performance by encouraging mind wandering and reducing drivers’ attentional capacity. A simulator study that considered the effect of different levels of automation on drivers' attentional resources showed that available resources were reduced as the level of automation increased (Young & Stanton, 2002). Vehicle automation can also greatly diminish the effects of distraction. Collision warnings have the potential to reduce reaction times of drivers confronting an imminent rear-end collision situation (Kramer, Cassavaugh, Horrey, Becic, & Mayhugh, 2007; Lee, McGehee, Brown, & Reyes, 2002). With increasing automation, the distraction potential of a particular infotainment system increasingly depends on how the automation exacerbates or mitigates distraction (Merat & Lee, 2012).

## MOTIVATIONS FOR DISTRACTION

Considering driver distraction in terms of a process of attending requires an understanding of what motivates and influences engagement in a non-driving activity and failures to engage in driving activities. The concept of "safety traps" (Fuller, 1991) offers a useful perspective on driver distraction and the self-regulation process.

Three attention traps describe the situations that lead drivers to interrupt driving with infotainment system interactions or otherwise disengage from driving. *Contingency traps* reflect situations where drivers fail to attend because the hazards and roadway demands are difficult to perceive. Novice drivers are particularly prone to contingency traps. *Consequence traps* refer to situations where drivers see the driving demands, but choose to neglect them because the rewards associated with the infotainment task outweigh the expected costs of neglecting the roadway. *Conditioning traps* refer to situations in which drivers neglect driving because a long history of experience with similar situations has produced no negative outcomes. Conditioning traps are more prevalent among experienced drivers.

Contingency traps pose a particular challenge to novice drivers, who are less aware of roadway hazards (Fisher, Pollatsek, & Pradhan, 2006). Not seeing roadway hazards might lead drivers to engage in distractions at inopportune times. Furthermore, novice drivers might not appreciate the risk of distraction. Approximately 32% of drivers between 18 and 24 years of age report being able to safely take their eyes off the road for 3-10 seconds, compared to 27% of drivers over the age of 25 years of age (Tison, Chaudhary, & Cosgrove, 2011).

Consequence traps refer to deciding to be distracted even though the risks are known; however, this decision is not likely to follow normative decision theory in which drivers balance the expected costs associated with distracted driving with the expected gains of engaging in an infotainment system activity. Instead simple heuristics will likely dominate and the salient benefits of infotainment system engagement might dominate. A survey of 1,291 college students found that of the respondents that were drivers, 87% owned a cell phone and 86% reported using their phone at least occasionally while driving. The respondents also reported 762 crashes or near-crashes and that 21% of these incidents occurred while using a cell phone (Seo & Torabi, 2004). Similarly, another survey found that younger drivers used a cell phone more often while driving and were more likely to experience a dangerous situation as a result of using the phone compared to experienced drivers (Poysti, Rajalin, & Summala, 2005). Drivers often engage in behavior where the risk outweighs the benefit.

A comprehensive study assessing the motivations to engage in distractions supports this assertion and found that motivations associated with infotainment tasks rather than driving-related considerations dominated the decision to engage in infotainment system activities (Olsen, Lerner, Perel, & Simons-Morton, 2005). Participants reported being similarly willing to engage in distractions on freeways, arterials, and two-lane roads. The willingness to engage in distractions was particularly strong with young drivers who were more willing to use technology while driving than drivers of other age groups. This tendency was particularly strong for personal digital assistants (PDAs)—a rudimentary equivalent to today's smartphone.

Conditioning traps represent a particularly important area of concern because education and feedback might not affect the habits that underlie them. Habitual texting while driving can occur without the drivers' awareness or intention (Bayer & Campbell, 2012). Habit explained the prevalence of texting more effectively many other factors, including norms and attitudes (Bayer & Campbell, 2012). Because even dangerous activities, such as texting, seldom lead an individual to crash, the lack of feedback can lead driver to develop dangerous habits.

Vehicle automation that leads drivers to further disengage from driving, will likely exacerbate the effects of these contingency traps. Carefully designing vehicle automation to provide drivers with more rather than less information about the roadway environment might promote greater engagement and mitigate the contingency traps.

## CONCLUSION

Trends in vehicle automation and infotainment systems make driver distraction an increasingly prominent research, design, and policy issue. Two theoretical perspectives on attention can contribute to understanding distraction: one considers attentional *resources* and the other considers attentional *dynamics*. Distraction as excessive workload that exceeds drivers' attentional resources has been a prominent, useful, but also limiting perspective. Considering distraction dynamics in terms of breakdowns in the process of attending provides a useful complement.

A focus on the process of attending suggests several novel research directions:

1. Develop measures and design interventions based on distractions as breakdowns in interruption management, such as measuring the tendency of different designs to induce task perseveration.
2. Identify prevalence and consequence of distraction in low and high-engagement situations.
3. Identify how feedback (e.g., smartphone-base measures of driver performance) can mitigate distraction-based safety traps.

Developing the attentional dynamics perspective to complement the well-established attentional resources perspective can help to address the problem of distraction.

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## REFERENCES

Adams, M. J., Tenney, Y. J., & Pew, R. W. (1991). *State of the Art Report. Strategic workload and the cognitive management of advanced multi-task systems.* Wright-Patterson AFB, OH: Crew Systems Ergonomics Information Analysis Center (CSERIAC).

Altmann, E. M., & Trafton, J. G. (2002). Memory for goals: An activation-based model. *Cognitive Science: A Multidisciplinary Journal*, *26*(1), 39–83. doi:10.1207/s15516709cog2601_2

Bayer, J., & Campbell, S. (2012). Texting while driving on automatic: Considering the frequency-independent side of habit. *Computers in Human Behavior*.

Beanland, V., Fitzharris, M., Young, K. L., & Lenné, M. G. (2013). Driver inattention and driver distraction in serious casualty crashes: data from the Australian National Crash In-depth Study. *Accident Analysis and Prevention*, *54*, 99–107. doi:10.1016/j.aap.2012.12.043

Birrell, S. a., & Young, M. S. (2011). The impact of smart driving aids on driving performance and driver distraction. *Transportation Research Part F: Traffic Psychology and Behaviour*, *14*(6), 484–493. doi:10.1016/j.trf.2011.08.004

Brookhuis, K. a, & de Waard, D. (2010). Monitoring drivers' mental workload in driving simulators using physiological measures. *Accident; analysis and prevention*, *42*(3), 898–903. doi:10.1016/j.aap.2009.06.001

Brown, I. D., Tickner, a H., & Simmonds, D. C. V. (1969). Interference between concurrent tasks of driving and telephoning. *Journal of Applied Psychology*, *53*(5), 419–424.

Cook, R. I., Woods, D. D., McColligan, E., & Howie, M. B. (1990). Cognitive consequences of "clumsy" automation on high workload, high consequence human performance. In *SOAR 90, Space Operations, Applications and Research Symposium*. NASA Johnson Space Center.

Engström, J. (2010). The tactile detection task as a method for assessing drivers' cognitive load. *Performance Metrics for Assessing Driver Distraction: The Quest for Improved Road Safety*.

Fisher, D. L., Pollatsek, A. P., & Pradhan, A. (2006). Can novice drivers be trained to scan for information that will reduce their likelihood of a crash? *Injury Prevention*, *12*, 25–29.

Fisk, A. D., Derrick, W. L., & Schneider, W. (1986). A methodological assessment and evaluation of dual-task paradigms. *Current Psychology*, *5*(4), 315–327.

Fitch, G., Soccolich, S., Guo, F., & McClafferty, J. (2013). *The Impact of Hand-Held and Hands-Free Cell Phone Use on Driving Performance and Safety-Critical Event Risk, DOT HS 811 757*. Washington, D.C.

Fox, S., & Hoffman, M. (2002). Escalation behavior as a specific case of goal-directed activity: A persistence paradigm. *Basic and Applied Social Psychology*, *24*(4), 273–285. doi:10.1207/S15324834BASP2404_3

Fuller, R. (1991). Behavior analysis and unsafe driving: Warning -- Learning trap ahead! *Journal of Applied Behavior Analysis*, *24*(I), 73–75.

Grier, R. A., Warm, J. S., Dember, W. N., Matthews, G., Galinsky, T. L., Szalma, J. L., & Parasuraman, R. (2003). The vigilance decrement reflects limitations in effortful attention, not mindlessness. *Human Factors*, *45*(3), 349–359.

Hancock, P. A., & Meshkati, N. (1988). *Human Mental Workload* (pp. 185–218). Amsterdam: North Holland.

Harms, L., & Patten, C. J. D. (2003). Peripheral detection as a measure of driver distraction. A study of memory-based versus system-based navigation in a built-up area. *Transportation Research Part F: Traffic Psychology and Behaviour*, *6*(1), 23–36. doi:10.1016/S1369-8478(02)00044-X

Hart, S., & Sheridan, T. B. (1984). Pilot workload, performance, and aircraft control automation.

He, J. B., Becic, E., Lee, Y. C., & McCarley, J. S. (2011). Mind wandering behind the wheel: performance and oculomotor correlates. *Human Factors*, *53*(1), 13–21. doi:10.1177/0018720810391530

Horrey, W. J., & Lesch, M. F. (2009). Driver-initiated distractions: Examining strategic adaptation for in-vehicle task initiation. *Accident Analysis & Prevention*, *41*(1), 115–122. doi:10.1016/j.aap.2008.10.008

Horrey, W. J., Wickens, C. D., & Consalus, K. P. (2006). Modeling drivers' visual attention allocation while interacting with in-vehicle technologies. *Journal of Experimental Psychology: Applied*, *12*(2), 67–78.

Hurts, K., Angell, L., & Perez, M. (2011). The Distracted Driver Mechanisms, Models, and Measurement. *Reviews of Human Factors and Ergonomics*, *7*, 3–57. doi:10.1177/1557234X11410387.

Jahn, G., Oehme, A., Krems, J. F., & Gelau, C. (2005). Peripheral detection as a workload measure in driving: Effects of traffic complexity and route guidance system use in a driving study. *Transportation Research Part F: Traffic Psychology and Behaviour*, *8*(3), 255–275.

Kahneman, D. (1973). *Attention and Effort*. Englewood Cliffs: Prentice-Hall.

Kramer, A. F., Cassavaugh, N., Horrey, W. J., Becic, E., & Mayhugh, J. L. (2007). Influence of age and proximity warning devices on collision avoidance in simulated driving. *Human Factors*, *49*(5), 935–949. doi:10.1518/001872007x230271

Lansdown, T., Brook-Carter, N., & Kersloot, T. (2004). Distraction from multiple in-vehicle secondary tasks: vehicle performance and mental workload implications. *Ergonomics*, *47*(1), 91–104.

Lee, J. D. (2007). Technology and teen drivers. *Journal of safety research*, *38*(2), 203–13. doi:10.1016/j.jsr.2007.02.008

Lee, J. D., McGehee, D. V, Brown, T. L., & Reyes, M. L. (2002). Collision warning timing, driver distraction, and driver response to imminent rear-end collisions in a high-fidelity driving simulator. *Human Factors*, *44*(2), 314–334.

Lee, J. D., Regan, M. A., & Young, K. L. (2008). Defining driver distraction. In M. A. Regan, J. D. Lee, & K. L. Young (Eds.), *Driver Distraction: Theory, Effects, and Mitigation* (pp. 31–40). Boca Raton, FL: CRC Press.

Lee, J. D., Roberts, S. C., Hoffman, J. D., & Angell, L. S. (2012). Scrolling and Driving: How an MP3 Player and Its Aftermarket Controller Affect Driving Performance and Visual Behavior. *Human Factors*, *54*(2), 250–263. doi:10.1177/0018720811429562

Li, S. Y. W., Magrabi, F., & Coiera, E. (2012). A systematic review of the psychological literature on interruption and its patient safety implications. *Journal of the American Medical Informatics Association : JAMIA*, *19*(1), 6–12. doi:10.1136/amiajnl-2010-000024

Liang, Y., Lee, J. D., & Yekhshatyan, L. (2012). How dangerous is looking away from the road? Algorithms predict crash risk from glance patterns in naturalistic driving. *Human Factors*, *54*(6), 1104–1116. doi:10.1177/0018720812446965

Mason, M. F., Norton, M. I., Van Horn, J. D., Wegner, D. M., Grafton, S. T., & Macrae, C. N. (2007). Wandering minds: the default network and stimulus-independent thought. *Science*, *315*(5810), 393–5. doi:10.1126/science.1131295

McCartt, A. T., Hellinga, L. A., & Bratiman, K. A. (2006). Cell phones and driving: Review of research. *Traffic Injury Prevention*, *7*, 89–106.

McEvoy, S. P., Stevenson, M. R., & Woodward, M. (2006). The impact of driver distraction on road safety: results from a representative survey in two Australian states. *Injury Prevention*, *12*(4), 242–247.

McFarlane, D. C. (1999). Coordinating the Interruption of People in Human- Computer Interaction, (Ntsb 1988).

McFarlane, D. C., & Latorella, K. (2002). The scope and importance of human interruption in human-computer interaction design. *Human-Computer Interaction*.

Merat, N., & Lee, J. D. (2012). Preface to the Special Section on Human Factors and Automation in Vehicles: Designing highly automated vehicles with the driver in mind. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *54*(5), 681–686. doi:10.1177/0018720812461374

Monk, C. A., Boehm-Davis, D. A., & Trafton, J. G. (2004). Recovering from interruptions: Implications for driver distraction research. *Human Factors*, *46*(4), 650–663.

Moray, N. (1979). *Mental workload: Its theory and measurement.* New York: Plenum.

Morcom, A. M., & Fletcher, P. C. (2007). Does the brain have a baseline? Why we should be resisting a rest. *NeuroImage*, *37*(4), 1073–1082. doi:10.1016/j.neuroimage.2006.09.013

Ogden, G. D., Levine, J. M., & Eisner, E. J. (1979). Measurement of workload by secondary tasks. *Human Factors*, *21*(5), 529–548.

Olsen, E. C. B., Lerner, N., Perel, M., & Simons-Morton, B. G. (2005). In-car electronic device use among teen drivers. *Transportation Research Record: Journal of the Transportation Research Board*, 1–21.

Patten, C. J. D., Kircher, A., Ostlund, J., & Nilsson, L. (2004). Using mobile telephones: cognitive workload and attention resource allocation. *Accident Analysis & Prevention*, *36*(3), 341–350. doi:10.1016/S0001-4575(03)00014-9

Piechulla, W., Mayser, C., Gerkhe, H., & Konig, W. (2003). Reducing drivers' mental workload by means of an adaptive man-machine interface. *Transportation Research Part F: Traffic Psychology and Behaviour*, *6*, 233–248.

Posner, M. I., & Petersen, S. E. (1990). The attention system in the human brain. *Annual Review of Neuroscience*, *13*, 25–42. doi:10.1146/annurev.ne.13.030190.000325

Poysti, L., Rajalin, S., & Summala, H. (2005). Factors influencing the use of cellular (mobile) phone during driving and hazards while using it. *Accident Analysis & Prevention*, *37*(1), 47–51.

Raby, M., & Wickens, C. D. (1994). Strategic workload management and decision biases in aviation. *The International Journal of Aviation Psychology*, *4*(3), 211–240.

Regan, M. A., Lee, J. D., & Young, K. L. (2008). *Driver Distraction: Theory, Effects and Mitigation*. Boca Raton, Florida: CRC Press.

Rivera-Rodriguez, A. J., & Karsh, B. B.-T. (2010). Interruptions and distractions in healthcare: review and reappraisal. *Quality & Safety in Health Care*, *19*(4), 304–312. doi:10.1136/qshc.2009.033282

Salvucci, D. D., & Taatgen, N. A. (2009). Toward a Unified Theory of the Multitasking Continuum : From Concurrent Performance to Task Switching , Interruption , and Resumption, 1819–1828.

Sasse, A., & Johnson, C. (1999). Coordinating the interruption of people in human-computer interaction. *Human-Computer Interaction*, (Ntsb 1988).

Senders, J., & Kristofferson, A. (1966). The attentional demand of automobile driving. *Highway Research Record*, *195*, 15–33.

Seo, D. C., & Torabi, M. R. (2004). The impact of in-vehicle cell-phone use on accidents or near-accidents among college students. *Journal of American College Health*, *53*(3), 101–107.

Strayer, D., Cooper, J., & Turrill, J. (2013). *Measuring Cognitive Distraction in the Automobile*. Washington D.C.

Takayama, L., & Nass, C. (2008). Assessing the effectiveness of interactive media in improving drowsy driver safety. *Human Factors*, *50*(5), 772–781. doi:10.1518/001872008x312341

Tison, J., Chaudhary, N., & Cosgrove, L. (2011). *National phone survey on distracted driving attitudes and behaviors*. doi:10.1037/e562822012-001

Treat, J. R., Tumbas, N. S., McDonald, S. T., Shinar, D., Hume, R. D., Mayer, R. E., … Castellan, N. J. (1979). *Tri-level study of the causes of traffic accidents: executive summary*. *DOT HS 805 099*. Washington, D.C.: NHTSA, U.S. Department of Transportation.

Tulga, M. K., & Sheridan, T. B. (1980). Dynamic decisions and work load in multitask supervisory control. *IEEE Transactions on Systems, Man, and Cybernetics*, *SMC-10*(5), 217–232.

Wang, J., Knipling, R. R., & Goodman, M. J. (1996). The role of driver inattention in crashes; new statistics from the 1995 crashworthiness data system (CDS). *40th Annual Proceedings: Association for the Advancement of Automotive Medicine*, 377–392.

Wickens, C. D. (2008). Multiple resources and mental workload. *Human Factors*, *50*(3), 449–455.

Wiese, E. E., & Lee, J. D. (2004). Auditory alerts for in-vehicle information systems: The effects of temporal conflict and sound parameters on driver attitudes and performance. *Ergonomics*, *47*(9), 965–86. doi:10.1080/00140130410001686294

Wiese, E. E., & Lee, J. D. (2007). Attention grounding: a new approach to in-vehicle information system implementation. *Theoretical Issues in Ergonomics Science*, *8*(3), 255–276. doi:10.1080/14639220601129269

Yanko, M. R., & Spalek, T. M. (2013). Route familiarity breeds inattention: A driving simulator study. *Accident Analysis & Prevention*, *57*, 80–6. doi:10.1016/j.aap.2013.04.003

Young, M. S., & Stanton, N. a. (2002). Malleable attentional resources theory: A new explanation for the effects of mental underload on performance. *Human Factors*, *44*(3), 365–375. doi:10.1518/0018720024497709

Zeigarnik, B. (1938). On finished and unfinished tasks. *A source book of Gestalt psychology*, (1), 1–15.