SELF-REGULATION MINIMIZES CRASH RISK FROM ATTENTIONAL EFFECTS OF COGNITIVE LOAD DURING AUDITORY-VOCAL TASKS

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Part 1 re-analyzes the simulator data from a recent experimental study of auditory-vocal tasks conducted by Strayer et al. (2013) at the University of Utah (hereafter called “The Utah study”)

1A. The Utah Index

1B. Self-Regulation. Is there evidence in the original Utah data of self-regulation?

1C. Crash Risk. Does the Utah Index predict the relative risk for cellular conversations in naturalistic driving?

Part 2 compares auditory-vocal tasks to visual-manual tasks

• The Utah auditory-vocal response time data are compared to the Crash Avoidance Metrics Partnership Driver Workload Metrics (CAMP-DWM) auditory-vocal and visual-manual response time data [Angell et al., 2006]
The Utah investigators assessed the attentional effects of cognitive load from auditory-vocal tasks during driving, to create a “Cognitive Index”

- They tested 7 auditory-vocal task conditions and 1 “single” task condition (i.e., no secondary task) in 3 experimental venues: standalone with no driving, in a simulator while following a lead vehicle, and in an instrumented vehicle in on-road city traffic at about 25 mph
  - 31 dependent variables were condensed into 13 variables by averaging the scores for the same variable collected in different venues
  - The Index was created from this condensed set of 13 variables by:
    - Standardizing the 13 variables, and summing them to create a single combined score, then transformed into a 5-point scale
      - The low end (“Category 1”) was anchored with the composite score for the “Single” (no secondary task) baseline condition
      - The high end (“Category 5”) was anchored at with the composite score for a complex memorization and mental arithmetic task called “OSPAN”
Fig. 1. Utah Index

<table>
<thead>
<tr>
<th>Category 1: No Task</th>
<th>Category 2: Conversation Tasks</th>
<th>Category 3: Voice Commands</th>
<th>Category 5: Memory &amp; Mental Arithmetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>Book on Tape</td>
<td>Hand-Held</td>
<td>OSPAN</td>
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<tr>
<td>Radio Listen</td>
<td>Passenger</td>
<td>Hands-Free</td>
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<td>Speech-to-Text</td>
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<td>3.06</td>
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<td>5</td>
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Was driver self-regulation present in the Utah study?

- Did the Utah drivers adjust their driving behavior while performing a task to keep their safety margins equal to or better than when not doing the task?

The Utah study claims there was self-regulation was inadequate:

- “Brake RT increased as a function of condition over and above any compensatory effects associated with following distance” [Strayer et al., 2013, p. 18]
  - In other words, the Utah study claims that the following distance did not increase sufficiently to compensate for the increases in Brake Response Time (RT)
  - Is this statement true or false?
1. The mean data for all 31 variables for all 8 task conditions, as well as vehicle speed, were requested from David Strayer, the lead author of the Utah report

2. The mean brake response time (RT) and following distance data were received

3. The speed data were not received as requested

4. However, a workaround was found. The relative time headway is the same as the relative distance headway, because the average speed of the lead vehicle was the same for all task conditions
   - That is, the ratio of the following times equals the ratio of the following distances: $T_1 / T_2 = D_1 / D_2$
   - Hence, if the ratio of the following distances increased proportionately to the brake RT, then the drivers must have compensated for any increased brake RT by increasing their headway time

5. To test if true, RT and Following Distance were converted into percentages relative to their respective Single baselines, and compared
Means and standard errors for the Utah study Brake RT and Following Distance for all task conditions:

![Graph of Brake RT (to Brake Light Onset in Pace Car)](image1)

![Graph of Following Distance (to Pace Car)](image2)

**Fig. 2.** Brake RT (to Brake Light Onset in Pace Car)

**Fig. 3.** Following Distance (to Pace Car)
1B. Self-Regulation: Results (2)

Comparison of the percentage changes from Baseline for Brake RT and Mean Following Distance for all Task conditions:

- Following distance increased proportional to brake RT for all tasks tested
  - Not one task had a % increase in RT (red bars) that was significantly larger than the % increase in following distance (blue bars)

Fig. 4. % change relative to baseline
The current in-depth re-analysis of the Utah data shows that, contrary to claims in the Utah study, the increased brake RTs were fully offset by the increased headways during all tasks in that study.

- Self-regulation in the form of increased headways provided an effective countermeasure against increased brake response times in the Utah study.
  - On average, drivers increased their following distances to compensate for the 50-200 increases in brake RTs while performing auditory-vocal secondary tasks.
This result is confirmed by a new analysis of data in a recent naturalistic driving study (NDS) of cell phone tasks [Fitch et al., 2013]

- Fitch et al. [2013, Table 94] reported that the mean time headway difference score for conversation vs. no conversation for each of three phone types (hands-free, hand-held, and embedded) had individual p-values that were non-significant
  - They concluded that there was no statistically significant effect of conversation on time headway
- However, a new analysis pooled the p-values across the three cell phone types using a meta-analysis program to improve power
  - Now there was a statistically significant effect of conversation at increasing time headways (p = 0.029)
- Thus, the real-world NDS data are consistent with the current re-analysis of the Utah data: Drivers increase their headways during cell phone conversations to fully compensate for increases in RT during auditory-vocal tasks
Some might speculate that increased headway is not self-regulation, but is caused by drivers not being able to perform the primary driving task properly under conditions of cognitive load.

- They might conjecture that increased headway thus indicates “impairment” of the driver, with increased crash risk.
  - However, increased headway is associated with fewer crashes and traffic violations, not more [Evans and Wasielewski, 1982].
  - Increased headway (i.e., the reverse of tailgating) is a safety benefit in real driving.

- It is invalid and misleading for the Utah report to include following distance in an index that is claimed to be correlated with increased crash risk, when in fact it is correlated with decreased crash risk [Evans and Wasielewski, 1982].

- Further questions about the validity of the Utah Index are raised by current knowledge about the real-world relative risk of the Utah conversation tasks.
The Utah report [2013] says Utah Index scores indicate worse impairment and higher crash risk

- “It is reasonable to assume that there would be a monotonic relationship between cognitive distraction and crash risk.” – [p. 30]
- The Category 2 conversation tasks – passenger, hand-held phone, and hands-free phone – are, “… significant impairments to driving that stem from the diversion of attention from the task of operating a motor vehicle” [p. 30]
- The Category 3 speech-to-text voice task, “…may have unintended consequences that adversely affect traffic safety” [p. 30]
- The driving impairments, “…may rise to the level associated with drunk driving” [p. 29]
- Their deliberate use of the 5-category hurricane scale is intended to convey the message that safety concerns for auditory-vocal tasks approach catastrophic levels
  - The average reader is left with the impression that auditory-vocal tasks performed while driving increase crash risk by enormous amounts
The relative risk for cellular conversation tasks during real-world non-experimental driving was compared with the Utah Index predictions

- The relative risks were from 3 major studies of the relative risk of cellular conversation in passenger vehicles
  - Young and Schreiner (2009): Integrated Hands-Free
  - Young (2014): Hand-Held (meta-analysis of 5 real-world studies)
- These data are plotted against the Utah Index
Relative risk (RR) decreases with an increase in the Utah index from the Single Baseline (Index 1) to Cell Phone Conversation (with Indexes between 2 and 3), contrary to the Utah study assumption.

Fig. 5. Relative risk of Hand-Held (HH), Personal Hands-Free (PHF), and Integrated Hands-Free (IHF) Talk vs. No Talk in passenger vehicle real-world driving studies compared to Utah Index.

Key:
[109] Klauer et al. (2014)
Real-world crash data available for hand-held and hands-free cellular conversation tasks and the baseline single task indicate that crash RR does not increase as the Utah Index score increases, but actually decreases

- The real-world data shows that there are decreases rather than increases in crash risk as the Utah Index increases from Category 1 to 2, contrary to the Utah study assumption

Older driver data further contradicts the Utah study assumption about crash risk

- Older drivers have longer RTs than younger drivers
  - Yet older drivers are the safest on the road (i.e., they have the lowest crash risk per driver when mileage driven is controlled for) [Langford, 2006]
- Thus safer drivers have longer RTs, opposite the prediction of the Utah Index
The mean brake response times to a lead vehicle braking were compared between:

- Auditory-vocal tasks in the Utah simulator [Strayer et al., 2013]
- Auditory-vocal tasks on the track [Angell et al., 2006]
- Visual-manual tasks on the track [Angell et al., 2006]
2. Results

Fig 6. RT for auditory-vocal tasks in Utah simulator (gray bars), compared with auditory-vocal tasks on the track (Angell et al., 2006) (green bars) and visual-manual tasks on the track (blue bars).
Every auditory-vocal task tested, whether on the simulator or on the track, had a lower (better) absolute mean response time than every visual-manual task tested on the track.

The Utah study’s claim that auditory-vocal tasks performed while driving cause serious impairment is not consistent with the results for visual-manual tasks in the Angell et al. (2006) study.

- The Utah auditory-vocal tasks had negligible effects on response time compared to visual-manual tasks with socially-acceptable crash risk, such as manual radio tuning.
- The cognitive load from the auditory-vocal tasks about which the Utah report raises major concerns are well within the boundaries of tasks considered acceptable in normal driving by the public.
Re-analysis of the Utah data suggests that, when averaged over drivers, self-regulatory behavior compensates for distraction from auditory-vocal tasks for key driver performance variables in the Utah Index

- However, some drivers may have poor self-regulation and hence may be more crash prone
  - Thus, while the current study and others indicate that the attentional effects of cognitive load do not increase crash risk on average (likely due to appropriate self-regulation on the part of the typical driver), some individual drivers may fail to adequately regulate their behavior and thus increase their crash risk

- Individual subject data, not just mean data, are needed to examine these individual differences, and these were not published in the Utah report
  - Further studies are needed to explore individual differences in driver self-regulation and the strategic management of multitasking while driving
Claims that auditory-vocal tasks impair real-world operation of an automobile and increase crash risk to catastrophic levels are not supported by the data in the Utah study, and are contradicted by real-world crash data.
Overall Recommendations

• Public and private funding sources for driving safety research spent on efforts intended to eliminate or ban the general use of voice interactions in vehicles will not reduce the number of crashes in the overall driver population.

• Research funding aimed at reducing crash risk will be more productively spent by investigating methods to screen for drivers who do not self-regulate their driving appropriately, whether from drowsiness, drug abuse, drunk driving, driving inexperience, illness, or medical impairments.

• Efforts should be made to improve self-regulation and strategic management of multitasking by drivers, rather than in efforts to curtail auditory-vocal tasks while driving, which will not reduce crashes per current research knowledge, contrary to the assumptions in the Strayer et al. (2013) report.
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References


References


