Homework 3
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Instructions

- Read the assigned paper and answer the questions as listed below.
- You can find the papers on Learn – Content – Student presentation - Papers.
- The length of your answer to each question should be within half a page. Concise answers are preferred.
- You can use your own words and/or quote from the paper with "" marks.
- You can add pictures and/or tables if necessary, with statement of the source, i.e., your creation or cited from the paper or another source.
- Upload your completed work in a single file, e.g., .docx or .pdf to Learn drop box.
- Read the drop box description for the deadline.

Paper:
2019-Strayer-Visual and Cognitive Demands of CarPlay, Android [Human Factors]

Questions

1. What are the purposes and objectives of the study? What is the major concern of car Infotainment Systems studied in this paper?

The objective of the study was to compare and contrast "the workload associated with using in-vehicle information systems commonly available in five different automotive original equipment manufacturers (OEMs) with that of CarPlay and Android Auto when used in the same vehicles" (Strayer et al., 2019, p.1371) . Where CarPlay and Android Auto are portable smartphone-based in-vehicle infotainment systems produced by Apple and Google respectively.

The main concern with car infotainment systems is that they require interactions that are complex and multimodal (e.g. pressing buttons, issuing voice commands, viewing a display etc…) which may distract a driver from the primary driving task. To address this, this paper evaluates the cognitive demands, visual demands, subjective workload and task completion times for multiple tasks using different car infotainment systems.

2. Was the study using a simulator or real cars? What considerations did the author use regarding research safety and ethics, e.g., procedure and test location?

Real cars were used for this study. Various considerations were made to ensure research safety and ethics. The research was reviewed and approved by the Institutional Review Board at the University of Utah.

First, prior to running study, participants were required to complete an online defensive driving course. The vision and driving experience qualifications of all participants was verified and they provided informed consent. To prepare the participants for the driving task, they were

also provided onboarding and training to familiarize themselves with the infotainment system. They were required to pass three task trials without any errors before moving on to the driving task.

During the driving task, participants were expected to follow driving legislation and were accompanied by a research assistant who ensured that the participants followed speed limits and other driving rules. The research assistant also paid attention to the road and informed the participants about potential safety hazards and actions for evading them.

Last, safety considerations were also made when selecting the test location. The driving task was performed in a suburban residential area on a straight road with a speed limit of 25mph (40 km/h). The configuration of the road was relatively simple with 4 stop signs and two speed bumps. The selection of this location helped to reduce the risk of accidents and encountering complicated traffic situations which are more likely to occur on main city roads with a higher speed limit. The tasks were also performed during normal daylight hours which avoids safety risks that may be encountered due to low vision at night.

3. What is DRT? Briefly describe it with your own words. What is the purpose of using it in the current study? Why it seems to be a good task for its purpose?

DRT stands for Detection Response Task. It is a task which involves asking participants to detect and respond to a random stimulus while performing other experiment tasks. In the current study, a revised version of the DRT is used with two types of stimulus: a vibrotactile stimulus and a remote visual stimulus. Participants needed to respond to the stimulus while also performing the driving and infotainment system tasks by pressing a microswitch attached to their left index or middle finger whenever they felt a vibration from a device attached below their left collarbone or when a remote LED light placed on the dashboard changed colours.

The purpose of the DRT in this study was to act as a tertiary task to “maximize sensitivity to both cognitive and visual attention” (Strayer et al., 2019, p.1373). The DRT seems to be a good task for this purpose as existing literature and past studies support that the DRT has minimal processing requirements and impact on the primary driving task, decreases variability in driving speed and acceleration and does not add any additional cognitive load on the participant. This makes the DRT a suitable task that engages the participant enough to maximize their attention without unwanted impacts to the visual and cognitive demand measurements of interest for the primary and secondary experiment tasks.

4. In your own words, describe the Auditory N-back task and the SuRT task. What is the purpose of using these tasks in this study?

The Auditory N-back task is used is used in this study to determine the reference value for high cognitive demand. In this task, numbers from 0-9 are played back to the driver as a spoken voice in a random order with a 2.25s interval. The driver then has to complete a two-back task

verbally stating the number that was played back two trials earlier. In this study, the drivers also had to respond to the DRT stimuli while completed the N-back task.

Next, the SuRT (Surrogate Reference Task) was used to determine the benchmark for high visual demand. In this task, drivers had to press a specific target displayed on displayed on an iPad Mini 4 positioned close to the center stack display in the car. The target used in this study was a 1.5 cm diameter black open circle displayed on a white background along with between 21-27 1.2 cm diameter distractor circles. The drivers also had to respond to the DRT stimuli while completing the SuRT.

5. Explain how the overall demand is calculated as shown in Table 4. How is this demand concept here different from the mental workload concept learned in this course (e.g., explain the meaning of their possible values such as 0% or 100%)?

According to Table 4 (Strayer, 2019, p.), overall demand is calculated combining cognitive, visual and subjective demand, and task interaction time following Equation 5:

$$Overall\ Demand = \frac{(cog+vis+subj)}{3} \times Interaction\ Time$$

Where cognitive demand (cog) is a score defined based on reaction times for the vibrotactile DRT, visual demand (vis) is also a score computed based on the hit rate of the remote DRT, subjective demand (subj) is a score between based on the average of ratings on 6 NASA-TLX sub-scales and interaction time is a score based on the "the time participants first initiated an action to the time when the final action for a task was completed and the participant said, "Done." (Strayer, 2019, p.).

This demand concept is different from the mental workload concept previously discussed in SYDE 644 as rather than taking the raw dependent measures, each demand measure is relative and standardized based on reference benchmarks. For each measure in Table 4 " (Strayer et al., 2019, p.1377), a high demand referent was defined. Specifically, for overall demand, the high demand referent was based on the average N-Back and SuRT results. Then, each raw measure was converted to a standardized score by comparing the participant's performance in the driving task to the high demand referent and a baseline measurement measured when participants drove down the route performing the DRT without interacting with the infotainment system. Scores of 0.0 (0%) indicate demand equal to the baseline while, demand equivalent to the high demand benchmark received a score of 1.0 (100%). Scores greater than 1.0 therefore indicate high levels of demand exceeding the high demand referent.

6. What are some limitations of the study and the methods (beyond the ones mentioned by the authors)?

The study and methods have several limitations beyond those mentioned in the Limitations and Caveats section. First, the participant age range is limited to drivers with relatively younger ages between 21 and 36 years of age and with driving experience and no accident history in the

past two years. Therefore, the results of the study cannot be generalized for older drivers and novice/amateur drivers.

Next, mainly for safety reasons, the real car driving study cannot account for more complicated driving conditions or scenarios where distracted driving is a major concern. For example, the driving route for the study does not require turning or lane changes. It also does not account for the visual and cognitive demand differences when driving alone or driving at night.

In continuation, the validity of the measurements is also impacted by the nature of the study as a controlled experiment and the presence of the research assistant. As the participants are aware that they are being observed and measured, their performance and attention levels may be impacted and fail to reflect how they would perform or interact with the infotainment systems when driving alone in their own car.

Lastly, while the paper does discuss the effects of the mode of interaction, it should be noted that the study only examines auditory/vocal input and touchscreen or physical button presses for the central stack. Modes of interaction that were not considered could include buttons embedded into the steering wheel or gesture inputs which as discussed in a paper by Graichen L., Graichen M. & Krems in 2019 may also potentially reduce driver distraction.

References

Graichen, L., Graichen, M., & Krems, J. F. (2019). Evaluation of Gesture-Based In-Vehicle Interaction: User Experience and the Potential to Reduce Driver Distraction. *Human factors*, *61*(5), 774–792. https://doi.org/10.1177/0018720818824253

Strayer, D. L., Cooper, J. M., McCarty, M. M., Getty, D. J., Wheatley, C. L., Motzkus, C. J., … Horrey, W. J. (2019). Visual and Cognitive Demands of CarPlay, Android Auto, and Five Native Infotainment Systems. Human Factors, 61(8), 1371–1386. https://doi.org/10.1177/0018720819836575