# Multimodal Cue Combinations: A Possible Approach to Designing In-Vehicle Takeover Requests for Semi-autonomous Driving

Gaojian Huang, Clayton Steele, Xinrui Zhang, and Brandon J. Pitts
Purdue University, West Lafayette, IN

The rapid growth of autonomous vehicles is expected to improve roadway safety. However, certain levels of vehicle automation will still require drivers to ‘takeover’ during abnormal situations, which may lead to breakdowns in driver-vehicle interactions. To date, there is no agreement on how to best support drivers in accomplishing a takeover task. Therefore, the goal of this study was to investigate the effectiveness of multimodal alerts as a feasible approach. In particular, we examined the effects of uni-, bi-, and trimodal combinations of visual, auditory, and tactile cues on response times to takeover alerts. Sixteen participants were asked to detect 7 multimodal signals (i.e., visual, auditory, tactile, visual-auditory, visual-tactile, auditory-tactile, and visual-auditory-tactile) while driving under two conditions: with SAE Level 3 automation only or with SAE Level 3 automation in addition to performing a road sign detection task. Performance on the signal and road sign detection tasks, pupil size, and perceived workload were measured. Findings indicate that trimodal combinations result in the shortest response time. Also, response times were longer and perceived workload was higher when participants were engaged in a secondary task. Findings may contribute to the development of theory regarding the design of takeover request alert systems within (semi) autonomous vehicles.

## INTRODUCTION

The past several decades have witnessed unprecedented changes to the design of motor vehicles. For example, assisted-driving systems, such as navigation, rear cameras, and blind spot warnings, all attempt to make driving safer. However, in 2017, the National Highway Traffic Safety Administration still reported 37,133 vehicle fatalities (National Center for Statistics and Analysis, 2018). This accident statistic has, in part, triggered the rapid development of semi- and fully autonomous vehicles that can operate without continuous human intervention. It is expected that by the year 2030, 25% of cars will be self-driving (Johnstone, 2018).

However, semi-autonomous vehicles present their own set of challenges. One of which is the requirement to ‘take over’ control from partial and conditional vehicle automation, i.e., SAE Levels 2 and 3, respectively (Li, Blythe, Guo, & Namdeo, 2018; Litman, 2018; National Highway Traffic Safety Administration, 2017). For example, in these modes, speed and lane position are controlled by the automation, but system failure can occur for many reasons, such as loss of GPS signal, unclear and/or missing lane markers, construction zone entry or road closure, or high traffic density (e.g., Körber, Prasch, & Bengler, 2018; Molnar et al., 2017). However, under these levels of automation, drivers may decide to engage in non-driving related tasks (such as cell phone use, reading, or eating; Llaneras, Salinger, & Green, 2013). Therefore, reliable in-vehicle warning systems may be critical in order to alert drivers of the need to resume manual control of the car.

To date, there is no consensus on how to best design effective warning systems to capture drivers’ attention in this particular situation. Multimodal information presentation, the presentation of information to the visual, auditory, and tactile sensory channels, represents one feasible approach for creating such interface (Sarter, 2006; Wickens, 2008). One major benefit of multimodal displays is their ability to support effective attention and interruption management (Brickman, Hettinger, & Haas, 2000; Ho, Nikolic, & Sarter, 2001; Latorella, 1999). In particular, redundancy, i.e., the use of two or more modalities for presenting the same information (Sarter, 2006), can significantly increase alertness, and thus response, to warning notifications (e.g., Hecht, Reiner, & Karni, 2008).

Several research studies have demonstrated the benefits of redundant multimodal signals in driving (e.g., Kramer, Cassavaugh, Horrey, Becic, & Mayhugh, 2007; Lundqvist & Eriksson, 2019; Petermeijer, Bazilinskyy, Bengler, & de Winter, 2017; Pitts & Sarter, 2018; Politis, Brewster, & Pollick, 2014, 2015; Yoon, Kim, & Ji, 2019). In general, these studies report that response time to redundant multimodal signals (that is, bi- or trimodal combinations) are significantly shorter than those of a single (unimodal) stimulus. For example, in manual driving, Lundqvist and Eriksson (2019) and Politis, Brewster, and Pollick (2014), evaluated all uni-, bi-, and trimodal combinations of visual (V), auditory (A), and tactile (T) cues (i.e., V, A, T, VA, VT, AT, and VAT) and showed multisensory performance gains, in terms of response times to signals. Pitts and Sarter (2018) confirmed these benefits, even though they explained that their 7 stimuli were partially redundant. Still, to date, very few studies have investigated the extent to which these findings generalize to the context of autonomous driving, where the attention allocation of a driver disengaged from the driving task may be very different from that of a manual driver. Politis et al. (2015) was one of the first sets of researchers to evaluate the above 7 combinations in autonomous driving. However, here, the authors were more interested in the perceived intensity of different cues and reported that higher urgency warning signals led to quicker takeover transitions. More recently, Yoon et al. (2019) used the same 7 multimodal combinations

 DOI 10.1177/1071181319631053

to examine takeover performance (as opposed to perception time). Their results agreed with previous findings regarding combined signals, independent of the type of non-driving related secondary task drivers were engaged in.

Given the limited number of studies in this area, the aim of the current paper was to evaluate how quickly drivers perceive multimodal takeover requests of equal importance during autonomous driving. This work serves as the initial step towards evaluating the effectivenes of multimodal warning signals for the entire takeover process. Specifically, this study quantified drivers' response times to the 7 cue combinations (V, A, T, VA, VT, AT, and VAT). The study used Level 3 autonomous driving, the lowest level for which a driver may disengage from the driving task, but still be ready to take over at any given time. Additionally, a driving-related secondary task was introduced to determine its influence on cue detection performance. Based on the findings of Pitts and Sarter (2018), Politis, Brewster, and Pollick (2013), Politis et al. (2015), and Politis, Brewster, and Pollick (2017), our hypothesis was that drivers will respond faster to bi- and trimodal cues compared to single cues. Also, the secondary task was expected to induce higher objective and subjective workload and result in longer response time to cues.

## METHOD

### Participants

Sixteen participants volunteered to take part in this study. All participants were students from Purdue University. The average age was 22.8 years (SD = 1.95). The average number of self-reported weekly driving hours was 4.1 (SD = 2.83) and the average number of years of driving experience was 4.7 (SD = 2.2). Eligibility requirements included: 1) possession of a valid driver's license; 2) normal or corrected-to-normal vision; 3) no hearing nor compromised sense of touch impairments; 4) no known susceptibility to motion sickness. This study was approved by the Purdue University Institutional Review Board (IRB Protocol ID: 1802020214).

### Apparatus

*The Driving Simulator*. The experiment was conducted using a medium-fidelity (simplified cab) driving simulator, miniSim, developed by The National Advanced Driving Simulator. The simulator is comprised of three 48-inch monitors, a steering wheel, foot pedals, panel controls and a full LED dashboard (Figure 1). Data was collected in 60 Hz.

*Eye tracker*. The eye tracking device was a 31cm × 40cm FOVIO system developed by EyeTracking, Inc. This desktop-mounted, contact-free device was located behind the steering wheel, below the main center display. It has a sampling rate of 60 Hz.

### Stimulus

*Visual Signal (V).* The visual signal was a red circle displayed on the center display monitor. Its color was similar to that of a stop sign. The circle was 200 × 200 pixels.

Figure 1: MiniSim driving simulator

*Auditory Signal (A).* The auditory signal was a 6-burst, 400-Hz moderately-intensive alert (85 dB).

*Tactile Signal (T).* Tactile signals were created using two C-2 tactors, which are 1" × 0.5" × 0.25" piezo-buzzers (developed by Engineering Acoustics, Inc.) with frequency of 250 Hz. The two tactors were attached to a belt and positioned across the lower back (as in Pitts & Sarter, 2018). When activated, both tactors vibrated at the same time.

*Driving Environment: Road Signs.* Road signs were used as the stimulus for the secondary detection task. During the secondary task condition, these signs appeared periodically along the right side of the road (and at least three seconds before and after each warning signal). Participants were asked to distinguish between the two signs, shown in Figure 2 below, and verbally report when they detected them. In this task, the left and right signs were referred to as "1" and "2", respectively.

Figure 2: Road signs

### Experimental Conditions

A 2 (condition: driving only vs. driving with secondary task) × 7 (cue combination: V, A, T, VA, VT, AT, and VAT) within-subjects full factorial design was used. Participants completed two separate tasks, namely, Condition A (driving only) and Condition B (driving with secondary task). Each condition consisted of a total of 35 cue presentations (i.e., each of the 7 cue combinations repeated 5 times) in random order. The average time between two cue combinations was 15 seconds (range: 8.8-19.9 seconds). Both conditions represented Level 3 autonomous driving on a straight four lane-highway (two lanes in each direction). The same procedure was used for both conditions except that, in Condition B, participants were presented with road signs (as described in the "Stimulus" section) and required to verbally report which sign they detected. A counterbalancing method was used to mitigate the learning effect in which participants either started with Condition A then moved to Condition B, or vice versa.

### Procedure

Each participant followed a standardized experimental procedure which lasted about 45 minutes from beginning to end. First, they were asked to sign a consent form outlining the study purpose and frequently-asked questions. Then, they completed a pre-experimental questionnaire to gather information about their demographics, current in-vehicle equipment, and driving experiences. The experiment began with a 10-minute training session, where they became familiar with the operation of the pedals, steering wheel, and autonomous driving mode. They were instructed to sit comfortably with their feet on the floor of the driving simulator and hands in their lap; no driving was necessary in this autonomous mode as speed and lane position were being controlled by the (simulated) vehicle. During the drive, participants were presented with the 7 cue combinations in random order. Each stimulus combination lasted for 1 second and participants were asked to press the brake as quickly as possible with their right foot (which deactivated the automation), and then immediately reactivate the autonomous mode by pressing a designated button on the steering wheel. We emphasized the importance of responding quickly and accurately. Immediately following each driving trial, a NASA-TLX workload assessment (Hart & Staveland, 1988) was administered to the participants to evaluate their perceived workload. Finally, all participants completed a post-experimental questionnaire to comment about their experience in the study, which included questions regarding their perception of the various stimuli.

### Dependent Measures

The dependent measures in the study included: response time, sign detection accuracy, pupil diameter, and subjective workload ratings.

*Response time*. Response time (in seconds) was calculated as the time difference between the initial pressing of the brake pedal and the presentation of a cue or cue combination.

*Road sign detection accuracy*. Road sign detection accuracy (%) was calculated as the proportion of correct signs identified to the total number of sign presentations (in Condition B only).

*Pupil diameters*. Pupil-diameter (average of left and right eye; in centimeters) data was recorded at the presentation of each cue and road sign. This measure has been cited as a reliable indicator of mental workload (Marquart, Cabrall, & de Winter, 2015; Pomplun & Sunkara, 2013). As such, a larger pupil size suggests an increase in workload.

*Subjective data.* NASA-TLX scores were recorded to compare the perceived workload between experimental conditions A and B. Each individual subscale of the NASA-TLX was rated on a 0-20 scale.

## RESULTS

A two-way repeated measures ANOVA, with post-hoc comparisons, was conducted. Bonferroni corrections were applied for multiple comparisons. The dependent measures used in this model were response time and pupil size, since they were collected under both experimental conditions. Results were considered significant at $p < .05$.

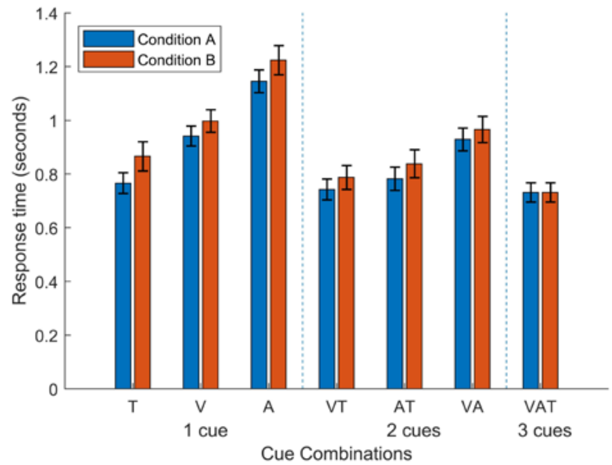


Figure 3. Response time as a function of cue combination for each experimental condition; V = visual cue; A = auditory cue; T = tactile cue.

Overall response times for each cue combination are presented in Figure 3.

*Response time (RT)*. There was a significant main effect of cue combination on response time, ($F\ (6, 90) = 140.947$, $p < .001$, $\eta_p^2 = .904$). Post-hoc comparisons revealed that the single auditory cue (A) produced the longest response time (mean = 1.19 secs, standard error of the mean (SEM) = 0.047), followed by the single visual cue (V) (mean = 0.97 secs, SEM = 0.037), and the combined visual and auditory signal (VA) (mean = 0.95 secs, SEM = 0.045).

With respect to uni-, bi- and trimodal combinations, response time to the VAT combination (mean = 0.73 seconds, SEM = 0.025) was significantly shorter than that of the bimodal cue combinations (VA, VT, and AT) (mean = 0.84 secs, SEM = 0.031) and unimodal cue (V, A, and T) (mean = 0.99 secs, SEM = 0.030; $p < .05$). Also, signals that contained a tactile component (mean = 0.78 secs, SEM = 0.030) were responded to faster than those that did not contain the tactile modality (mean = 1.03 secs, SEM = 0.030; $p < .05$).

There was also a significant main effect of experimental condition on response time, ($F\ (1, 15) = 9.492$, $p = .008$, $\eta_p^2 = .388$). In particular, response time in Condition A (driving only) (mean = 0.86 secs, SEM = .038) was significantly shorter than Condition B (driving with secondary task) (mean = 0.92 seconds, SEM = .045). No cue combination × condition interaction effect was observed.

*Road sign detection accuracy*. A ceiling effect was found on the road sign detection task such that accuracy was 100%.

*Pupil diameters*. There was no significant main effect of cue combination ($F\ (6, 66) = 3.502$, $p = .076$, $\eta_p^2 = .779$), nor experimental condition ($F\ (1, 11) = .397$, $p = .542$, $\eta_p^2 = .035$) on pupil size. Also, no cue combination × condition interaction was found.

*NASA-TLX score*. A paired t-test was used to identify differences in perceived (global) workload between the two driving conditions. For the unweighted global scores, workload in Condition A (mean = 31.81, SEM = 4.571) was significantly lower than in Condition B (mean = 39.56, SEM = 4.959; $t\ (15) = -3.669, p = .002$). To further investigate the subjective measure between the two experimental conditions, a two-way repeated measures ANOVA: 2 (task condition: driving only vs. driving with secondary task) × 6 subscales (mental demand, physical demand, temporal demand, performance, effort, and frustration) was performed (as in Satterfield, Ramirez, Shaw, & Parasuraman, 2012). A significant main effect of subscales $(F(2.93, 44.00) = 6.969, p = .001,\ \eta_p^2 = .317)$ was observed. In particular, post-hoc comparisons showed that mental demand (mean = 8.60, SEM = 0.952), temporal demand (mean = 6.72, SEM = 0.928), and effort (mean = 7.53, SEM = 1.153) resulted in the highest scores. No condition × subscale interaction effect was observed.

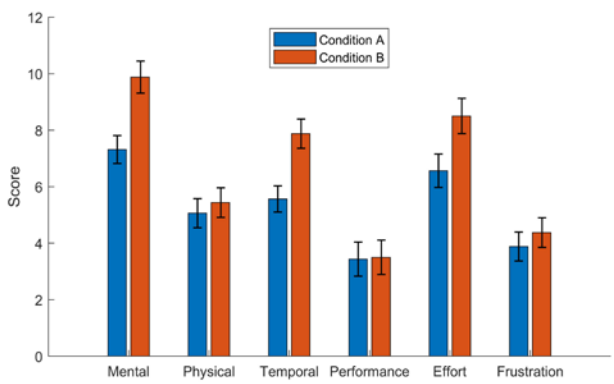


Figure 4. Unweighted subjective workload scores from the subscales of the NASA-TLX for driving conditions A and B

## DISCUSSION AND CONCLUSIONS

The goal of this paper was to examine the effect of singles, pairs, and triples of multimodal signals on response times to semi-autonomous driving takeover requests. Uni-, as well as redundant bi- and trimodal combinations of visual, auditory, and tactile cues were employed to alert drivers to takeover events during Level 3 autonomous driving. Overall, response time to cues was affected by the number of signals presented to drivers at once, as well as whether or not a person was engaged in a secondary task.

The findings of this study were highly consistent with those of previous studies (Lundqvist & Eriksson, 2019; Pitts & Sarter, 2018; Politis et al., 2013; Yoon et al., 2019) and suggest the occurrence of intersensory facilitation (Forster, Cavina-Pratesi, Aglioti, & Berlucchi, 2002). In our experiment, the average response time to the combined VAT cue (mean = 0.73 secs) was shortest, followed by bimodal cues (VA, VT, or AT: mean = 0.84 secs), followed by the unimodal cues (V, A, or T; mean = 0.99 secs). Although a prior study employed directional cues (Lundqvist & Eriksson, 2019) and a different one focused on the execution of takeover actions as opposed to the perception of the 7 warning signals (Yoon et al., 2019), results across studies appear to reach consensus. One possible explanation for this convergent pattern is that information presented to more than one modality might implicitly communicate higher urgency to drivers (Politis et al., 2013; Suied, Susini, & McAdams, 2008), even though the signals had no inherent hierarchy. Another possible explanation involves the presence of tactile cues. In our study, response times to cues that contained a tactile signal were 0.25 seconds faster than cues that did not contain a tactile signal. Pitts and Sarter (2018) reported the same finding and described this phenomenon as response time being dominated by the sensory channel with the quickest stimulation rate (the tactile modality in this case).

One interesting finding from this work was the discrepancy between participants' perception of the cues and their actual performance. Specifically, during the post-experiment debriefings, drivers reported that single visual signals were more difficult to detect than single auditory cues. However, according to our data, response times were faster to visual cues than auditory ones. This seems contradictory to previous studies that have found reaction times to auditory information to be faster than that of visual (e.g., Ghuntla, Gokhale, Mehta, & Shah, 2014; Jain, Bansal, Kumar, & Singh, 2015; Shelton & Kumar, 2010). One possibility is that participants, unknowingly, took slightly more time to delineate the auditory alert from the constant background noise of the driving simulation (i.e., wind and tires-on-road sounds), even though these tones were at different sound frequencies. Visual signals, on the other hand, were projected onto the forward driving scenery (close to focal vision) and, as a result, might have led to less interference with the background scene.

With respect to the driving-related secondary task, as expected, response times were significantly longer when drivers had to divide their attention between the multimodal cue and road sign detection tasks (in Condition B). This suggests that performing the two tasks – even without manually controlling the vehicle – still increased overall task and attentional demands, which is much more representative of how drivers are expected to behavior during real-world autonomous driving operations. Though the millisecond difference appears relatively small, in the driving environment, it is large enough to increase the chance of a near-miss and/or crash.

Finally, we also expected the road sign detection task to increase both objective (i.e., physiological measurement) and subjective (i.e., self-reported) mental workload. In the latter case, using the NASA-TLX ratings, participants did report an increase in overall workload between the driving only versus driving with secondary task conditions. However, with respect to pupil size – our objective indicator of workload – no differences were found between the two conditions. One possible explanation for this finding is that since overall workload was lowered during Level 3 autonomous driving, participants now had more available mental resources to devote to the detection task. Here, only some of these resources were being utilized to complete the secondary task, which still did not impose high cognitive demands equivalent to those that may be seen in lower levels of vehicle automation (i.e., Levels 0-2). The observed ceiling effect on the road sign detection task may further infer the low level of difficulty associated with this task. Also, most participants self-reported proficiency with multitasking (in general), and this ability could have helped drivers manage the increased task load.

There are some limitations of this study. First, crossmodal matching, the process of equating the perceived intensities of visual, auditory, and tactile stimuli, was not performed prior to the experiment. Instead, through pilot testing, and given that redundant cues were being evaluated, the experimenter selected values for each stimulus that would be perceptible by participants. Also, additional eye tracking measures, such as fixations and saccades might have helped to better highlight the attention allocation of drivers between the two task conditions.

In summary, trimodal signals may be the most effective way to alert drivers to critical takeover situations. However, additional research is needed to explore this display format under a wider range of independent variables, such as road/traffic conditions, visibility, and various demographic factors. Overall, the results of this study may help to inform the design of next-generation human-machine interfaces for autonomous vehicle systems.

## ACKNOWLEDGEMENTS

This work was supported by a grant from the National Science Foundation (NSF grant #1755746; Program Manager: Dr. Ephraim Glinert).

## REFERENCES

Brickman, B. J., Hettinger, L. J., & Haas, M. W. (2000). Multisensory interface design for complex task domains: Replacing information overload with meaning in tactical crew stations. *International Journal of Aviation Psychology*, *10*(3), 273–290.

Forster, B., Cavina-Pratesi, C., Aglioti, S. M., & Berlucchi, G. (2002). Redundant target effect and intersensory facilitation from visual-tactile interactions in simple reaction time. *Experimental Brain Research*, *143*(4), 480–487.

Ghuntla, T., Gokhale, P., Mehta, H., & Shah, C. (2014). A comparison and importance of auditory and visual reaction time in basketball players. *Saudi Journal of Sports Medicine*, *14*(1), 35.

Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research. *Advances in Psychology*, *52*, 139–183.

Hecht, D., Reiner, M., & Karni, A. (2008). Multisensory enhancement: gains in choice and in simple response times. *Experimental Brain Research*, *189*(2), 133–143.

Ho, C.-Y., Nikolic, M. I., & Sarter, N. B. (2001). Supporting Timesharing and Interruption Management Through Multimodal Information Presentation. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *45*(4), 341–345.

Jain, A., Bansal, R., Kumar, A., & Singh, K. D. (2015). A comparative study of visual and auditory reaction times on the basis of gender and physical activity levels of medical first year students. *International Journal of Applied & Basic Medical Research*, *5*(2), 124–127.

Johnstone, B. (2018). The autonomous vehicle rollout: current state of play | eeNews Automotive. Retrieved November 10, 2018, from http://www.eenewsautomotive.com/news/autonomous-vehicle-rollout-current-state-play

Körber, M., Prasch, L., & Bengler, K. (2018). Why Do I Have to Drive Now? Post Hoc Explanations of Takeover Requests. *Human Factors*, *60*(3), 305–323.

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: The Journal of the Human Factors and Ergonomics Society*, *49*(5), 935–949.

Latorella, K. A. (1999). *Investigating Interruptions: Implications for Flightdeck Performance*. Hampton, VA.

Li, S., Blythe, P., Guo, W., & Namdeo, A. (2018). Investigation of older driver's takeover control performance in highly automated vehicles in adverse weather conditions. *IET Intelligent Transport Systems, 12(9)*, 1157-1165.

Litman, T. (2018). *Autonomous Vehicle Implementation Predictions Implications for Transport Planning* (No. 15-3326).

Llaneras, R. E., Salinger, J., & Green, C. A. (2013). Human factors issues associated with limited ability autonomous driving systems: Drivers' allocation of visual attention to the forward roadway. *Proceedings of the Seventh International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design*, 92–98.

Lundqvist, L. M., & Eriksson, L. (2019). Age, cognitive load, and multimodal effects on driver response to directional warning. *Applied Ergonomics*, *76*(January), 147–154.

Marquart, G., Cabrall, C., & de Winter, J. (2015). Review of Eye-related Measures of Drivers' Mental Workload. *Procedia Manufacturing*, *3*, 2854–2861.

Molnar, L. J. (2017). Age-Related Differences in Driver Behavior Associated with Automated Vehicles and the Transfer of Control between Automated and Manual Control: A Simulator Evaluation. *University of Michigan.*

National Center for Statistics and Analysis. (2018). *2017 fatal motor vehicle crashes: Overview*.

National Highway Traffic Safety Administration. (2017). *Automated Driving Systems 2.0: A Vision for Safety*. *U.S. Department of Transportation*.

Petermeijer, S., Bazilinskyy, P., Bengler, K., & de Winter, J. (2017). Take-over again: Investigating multimodal and directional TORs to get the driver back into the loop. *Applied Ergonomics*, *62*, 204–215.

Pitts, B. J., & Sarter, N. (2018). What You Don't Notice Can Harm You: Age-Related Differences in Detecting Concurrent Visual, Auditory, and Tactile Cues. *Human Factors*, *60*(4), 445–464.

Politis, I., Brewster, S., & Frank Pollick, glasgowacuk. (2013). Evaluating Multimodal Driver Displays of Varying Urgency. *In Proceedings of the 5th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (pp. 92-99)*. ACM.

Politis, I., Brewster, S., & Pollick, F. (2014). Evaluating multimodal driver displays under varying situational urgency. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, (ACM), 4067–4076.

Politis, I., Brewster, S., & Pollick, F. (2015). Language-based multimodal displays for the handover of control in autonomous cars. In *Proceedings of the 7th International Conference on Automotive User Interfaces and Interactive Vehicular Applications - AutomotiveUI '15* (pp. 3–10).

Politis, I., Brewster, S., & Pollick, F. (2017). Using Multimodal Displays to Signify Critical Handovers of Control to Distracted Autonomous Car Drivers. *International Journal of Mobile Human Computer Interaction*, *9*(3), 1–16.

Pomplun, M., & Sunkara, S. (2013). Pupil Dilation as an Indicator of Cognitive Workload in Human-Computer Interaction. *Proceedings of the International Conference on HCI*, (May), 542–546.

Sarter, N. B. (2006). Multimodal information presentation: Design guidance and research challenges. *International Journal of Industrial Ergonomics*, *36*, 439–445.

Satterfield, K., Ramirez, R., Shaw, T., & Parasuraman, R. (2012). Measuring workload during a dynamic supervisory control task using cerebral blood flow velocity and the NASA-TLX. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *56*(1), 163–167.

Shelton, J., & Kumar, G. P. (2010). Comparison between Auditory and Visual Simple Reaction Times. *Neuroscience and Medicine*, *01*(01), 30–32.

Suied, C., Susini, P., & McAdams, S. (2008). Evaluating warning sound urgency with reaction times. *Journal of Experimental Psychology: Applied*, *14*(3), 201–212.

Wickens, C. D. (2008). Multiple Resources and Mental Workload. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *50*(3), 449–455.

Yoon, S. H., Kim, Y. W., & Ji, Y. G. (2019). The effects of takeover request modalities on highly automated car control transitions. *Accident Analysis and Prevention*, *123*(November 2018), 150–158.