WORKLOAD CHANGES IN TEENAGED DRIVERS DRIVING WITH DISTRACTIONS

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Summary: Workload refers to the amount of cognitive resources necessary to perform a task, and it can be manipulated by incorporating secondary tasks into a primary task such as driving. The present study incorporated answering a phone and removing a plastic bottle top into a driving task for teen drivers. Results showed few performance differences between driving with and without distractions, although subjective workload did increase for the drive that included distractions compared to the non-distraction drive. This indicates that teens may be able to maintain driving performance while performing secondary tasks, although their workload appears to increase.

INTRODUCTION

Workload is the quantity of a person's cognitive capacity necessary to perform a certain task (O'Donnell & Eggemeier, 1986). As defined, workload is task-dependent, because it generally refers to some part of the relationship between an operator and the task being performed. There are three key issues associated with measuring workload. First, workload is subjective in the sense that individuals may use different criteria to judge their own workload, so there is no way to compare subjective workload across individuals. Second, individuals' criteria for judging workload may change over time, as the individual becomes more proficient at the primary task. Third, given that workload is subjective, there is no way to assess whether individuals' subjective ratings include all pertinent aspects of the task. One commonly used measure of workload is the NASA-TLX (Hart & Staveland, 1988). The NASA TLX includes *mental demand*, *physical demand*, *temporal demand*, *performance*, *effort*, and *frustration*, and the participant rates the level of each as part of the overall workload. The questionnaire consists of two sections. The first involves making pairwise comparisons between all possible combinations of the above subscales, with the participant choosing one element from each pair that contributed more to overall workload. The second section involves placing a mark on a low-to-high continuum that indicates how much of that element contributed to overall workload. Thus, TLX scores may be meaningfully compared within an individual on two similar tasks, but not across individuals or tasks (Hart & Staveland, 1988). The focus of the current study was to assess the relationship between subjective ratings of workload and objective measures of driving performance between experienced and inexperienced (novice) drivers.

One way to increase workload for drivers is to introduce secondary tasks that are expected to interfere with the primary task of driving. Relationships between workload and driving performance can then be measured. One specific activity thought to be associated with increased workload while driving is using a cell phone. For example, results of a study conducted by Matthews, Legg and Charlton (2003) indicated an increase in individuals' subjective workload when driving while using a cell phone as compared to driving while not using a cell phone. In addition, Alm and Nilsson (1994) used a driving simulator and found that drivers aged 23 to 61 reported increased subjective workload while driving in both easy and hard driving conditions. Another car simulator study with similarly aged participants (Alm & Nilsson, 1995) showed that subjective workload increased on a car following task when the secondary task of using a cell phone was introduced. Interestingly, Stutts, et al. (2003) demonstrated that merely answering a cell phone seems to affect driving performance due to the fact that attention is diverted from the primary task of driving. Using video monitoring of drivers, Stutts, et al. found that, compared to situations when there was no phone in use, either dialing or answering a cell phone resulted in the drivers having significantly more time with their hands off the steering wheel and significantly more time with their eyes focused inside the car rather than outside the car. In the same study, drivers who were preparing food or drink for consumption also had significantly more instances of no hands on the wheel, eyes focused on the food or drink instead of the road, and adverse events such as weaving within or across lanes or braking suddenly (Stutts, et al., 2003).

The purpose of the current study was to assess both subjective workload and associated driving performance decrements in simulated driving tasks for both experienced and novice teen drivers. Specifcially, the focus was to assess the relationship between subjective workload and various objective measures of simulated driving performance both with and without the introduction of a secondary task involving answering a cell phone while driving. Using this framework, if individuals reported increased subjective workload with the introduction of the secondary task, then it is possible that any decrements in driving performance may be attributed to increased workload in the form of a reduction in cognitive resources afforded to the primary driving task.

Objective performance was assessed using a driving simulator where both velocity changes and lateral position in the lane data were collected at 5 hz (or 5 times per second). Subjective workload was measured with the NASA-TLX (Hart & Staveland, 1988), which asks participants to rate overall workload as well as subscales of workload in the form of self-ratings of the level of mental demand, physical demand, temporal demand, performance, effort, and frustration associated with performance of the task. The NASA-TLX questionnaire consists of two sections. The first involves making pairwise comparisons between all possible combinations of the above subscales, with the participant choosing one element from each pair that contributed more to overall workload. The second section involves placing a mark on a low-to-high continuum that indicates how much of that element contributed to overall workload.

METHOD

Participants were teenagers both with and without their drivers' licenses who drove in a driving simulator several times over the course of three weeks. There were 62 participants, with 31 females, 31 males, 27 licensed drivers, and 33 without licenses. Two participants did not report their driving status.

The experimental manipulation consisted of two similar drives, one with and one without two secondary tasks known to compete with the attention and other resources of a driver—answering a cell phone and organizing food or drink to be consumed (i.e., removing the top of a drink bottle; Stutts, et al., 2003). In one drive, the participants drove normally and did not have to perform any secondary tasks. In the other drive, the participants were asked to drive normally and were given audio prompts at two different points during the drive: the first audio prompt instructed participants to answer a cell phone when it rang and later in the same drive, an audio prompt instructed participants to remove the top off of a plastic drink bottle and then to put the bottle down. The drives were counterbalanced so that half the participants experienced the two distractions during their first of two simulated drives and half experienced the two distractions during the second of two simulated drives. Participants completed the NASA-TLX immediately following each of the two drives. Their driving performance in terms of velocity and lane position was assessed for both the 30 seconds approximately following the phone call and the 20 seconds following the instruction to remove the top of the bottle. In addition, driving performance for the same time frames was assessed for the drive that did not include distractions.

The two drives were named Drive A and Drive B and consisted of a similar drive through a simulated urban environment. Drivers were required to turn three times during the drive and were given directions about where to turn. Each participant drove both drives, which were always presented in the same order (i.e., Drive A first and then Drive B). The only difference between the drives was the addition of workload distractions, which could occur in either drive. Thirty of the participants drove with the workload distractions in the second drive and thirty-two drove with the workload distractions first.

Before the participants began Drive A, the phone and empty drink bottle were placed on the passenger seat of the simulator. For the workload drive, the participant was instructed to answer the phone when it rang, and the experimenter called the phone after the participant had been driving for one minute. At approximately three minutes into the drive, a trigger point was inserted and the driver received an instruction to “Take the top off the bottle.” Shortly after that, the simulator instructed the participant to “Put the bottle down.” The participant then drove for another 2 minutes. Following this drive, the participant filled out the NASA-TLX. The non-distraction drive was the same length but did not involve any extra tasks. Drivers also completed the NASA-TLX following this drive.

The NASA-TLX was scored for each participant as follows. First, the number of times each factor was circled in the top portion was counted to determine the weight for that factor. The total number of weights summed to 15. Second, a scoring template was made with the subscales divided into 20 equal portions, and that template was lined up behind each participant’s TLX sheet. The numbered portion in which the participant’s mark intersected the line determined the score for the subscales. In cases where the mark appeared exactly on the line dividing the sections, the higher number was given. In addition, in cases where the mark did not touch the line, a mark was extrapolated, although in most cases the majority of the mark was in the section assigned. In cases where the participant had written a checkmark or an “x,” the corner of the check or intersection of the lines was taken as the mark, and the section in which that appeared was the score assigned. Finally, for scales in which the participant had not marked the subscale, the mean of the other scores was substituted. For each factor, the weight was multiplied by the score on the subscale to get the factor score. Finally, the factor scores were added together and that sum was divided by the number of weights, which was usually 15. This number was the total workload score.

RESULTS

Analysis of the subjective workload of all the drivers as a group showed significantly higher workload in the distraction drive. When analyzed by gender and driving experience, results indicated that females and those with driving experience reported significant differences in workload between drives, while males and those without driving experience reported no significant differences. This indicates that the subjective workload of drivers increases with the addition of secondary tasks, but this may vary with gender and driving experience. The mean NASA-TLX scores are presented in Table 1.

Table 1. Mean Subjective Workload Scores.

	Non-Distraction TLX score	Distraction TLX score
Entire Group	61.88	64.27
Females	65.11	68.99
Males	58.64	59.56
Licensed Drivers	58.20	61.82
Unlicensed Drivers	65.29	66.67

The performance measures were obtained by calculating average velocity and average lane position for each second in the time frames noted above for both the distraction and non-distraction drives. For the bottle top task, results did not differ significantly for either the participants as a whole or for subgroups of gender and driver's license status. The changes in velocity following the instruction to remove the bottle top are presented in Figure 1. The changes in lane position following the bottle top instruction are presented in Figure 2.

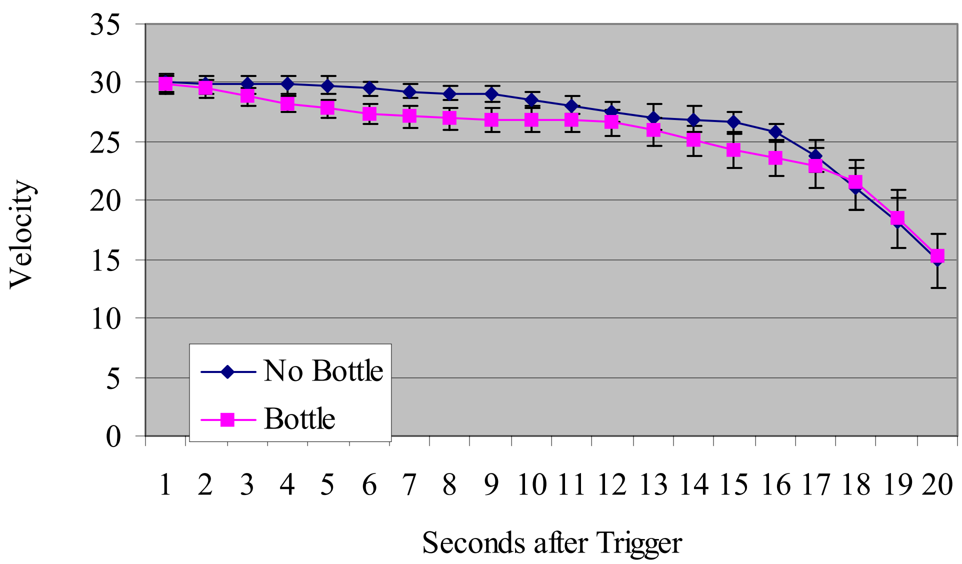

Figure 1. Changes in velocity following bottle top instruction.

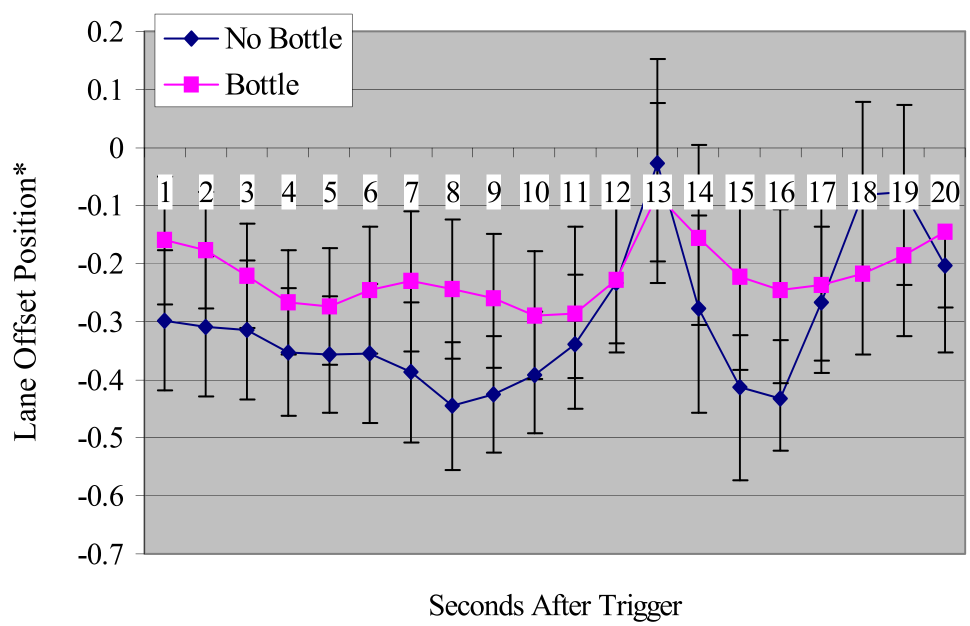

Figure 2. Changes in lane position following bottle top instruction. Zero indicates the middle of the driving lane, with positive numbers to the right of the lane and negative numbers to the left of it.

All participants analyzed as a group did not differ in performance when answering the phone. There were also no differences when females and males were analyzed separately and no differences when licensed and unlicensed drivers were analyzed separately. The changes in velocity following the phone call are presented in Figure 3. The changes in lane position following the phone call are presented in Figure 4.

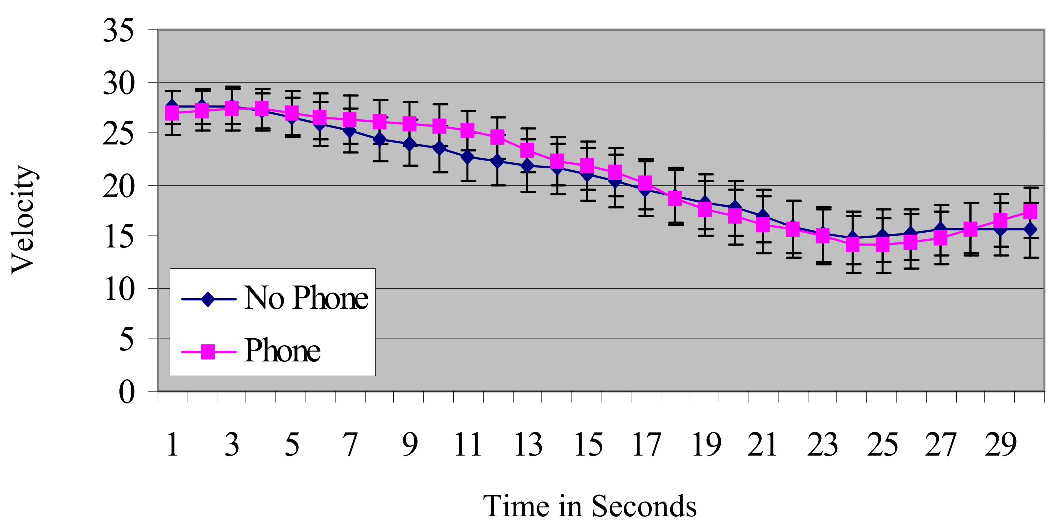

Figure 3. Changes in velocity following the phone call.

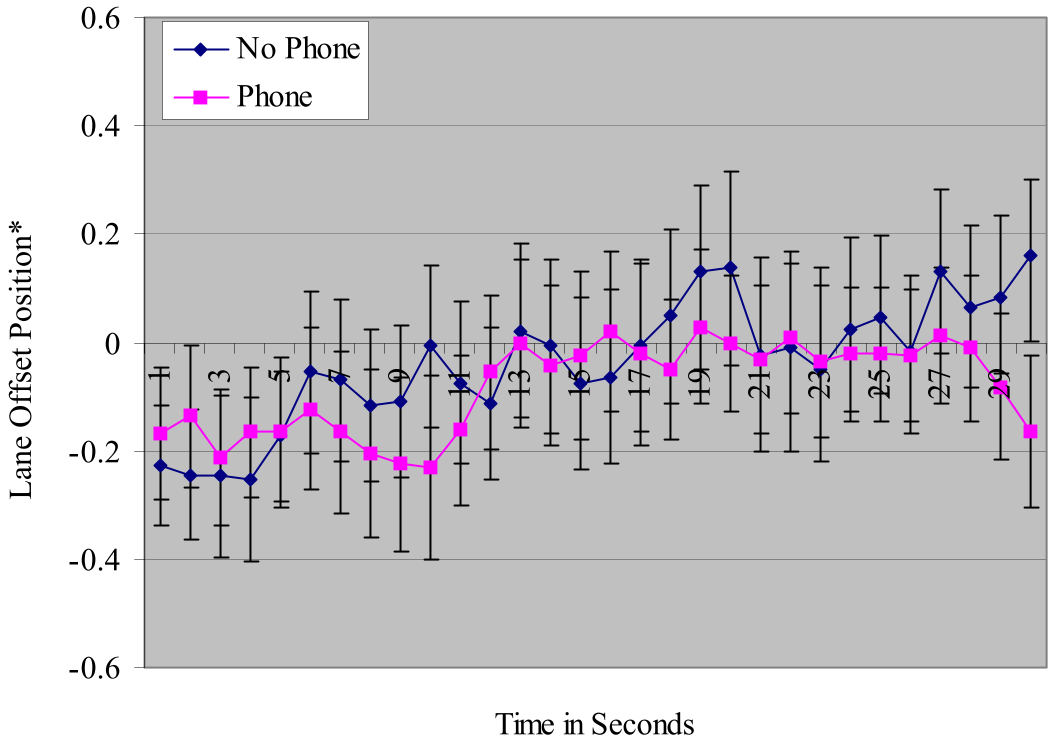

Figure 4. Changes in lane position following the phone call. Zero indicates the middle of the driving lane, with positive numbers to the right of the lane and negative numbers to the left of it.

CONCLUSIONS

In summary, although the participants felt that their workload increased while answering a phone and removing a bottle top during the driving task, their performance in terms of velocity and lane position did not change. This may indicate that although these tasks may interfere with the primary task of driving, teen drivers can maintain performance at the expense of increased subjective workload.

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