FACTORS RELATED TO DRIVERS' PERCEPTION OF INTERFERENCE FROM IN-VEHICLE ACTIVITIES

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ABSTRACT: In-vehicle information systems are becoming more common in vehicles. Yet, safety concerns arise to the extent that drivers are becoming distracted from their driving responsibilities. Examining discrepancies between drivers' perceptions of (and attitudes towards) distractions and actual task involvement is important to our understanding of drivers' engagement in potentially distracting activities. We describe results from a test-track study that examined how drivers' perceived interference (PI) from 11 different in-vehicle activities related to perceptions of their driving skills and other variables. Drivers in our sample considered tasks that incurred higher levels of mental workload to be more detrimental to their driving performance. However, higher PI was not associated with reduced task involvement while driving. A regression analysis found that only ratings of comfort and mental demand were significant predictors of PI. We describe and discuss our findings in the context of driver safety and the application of in-vehicle systems.

1 OBJECTIVE

In-vehicle information systems as well as portable devices are becoming more common- place in vehicles. Intelligent Transport Systems (ITS) can offer many services to drivers, facilitating or enhancing the driving experience as well as increasing driver productivity. However, with more supplementary activities there is the risk of drivers becoming distracted from their primary driving responsibilities. Driver distraction has been studied extensively in laboratory and on-road experiments, as well as in naturalistic settings. In general, these studies suggest that driving performance is degraded and drivers are at increased crash risk when distracted (e.g., [1-6]).

While performance decrements are well-established in the literature, what is less well-understood is how drivers' perceptions relate to their own (actual) degree of distraction. There is evidence from laboratory experiments that drivers may not be fully aware of, or poorly calibrated to, the distracting effects of in-vehicle tasks on their own performance [7-9]. However, studies of driver distraction have been somewhat limited in the tasks examined. Knowledge of the degree of perceived interference of a variety of in-vehicle activities with driving performance may be an important determinant in drivers' decisions to engage in these different activities while driving. For example, drivers that underestimate the impact of distraction on performance may be more likely to engage in distracting activities. Furthermore, while most people are at least aware of the potentially distracting effects of engaging in cell-phone conversations or texting while driving (even though they may not think it applies to them), they may be less aware of the potentially distracting effects associated with tasks such as the use of navigation systems, or even the selection of a CD to play. In this paper, we describe results from a test-track study that examines how the perceived interference from a variety of in-vehicle activities relates to general impressions of workload, driving skill and ability as well as to other variables. We also examine how task characteristics, such as the number of required inputs, relate to this perceived interference.

2 METHOD

2.1 Participants

Ten participants, aged 25 through 55 (M = 43.7 yrs), balanced by gender, were recruited for the study through advertisements in local newspapers. All held a valid driver's license and had normal or corrected-to-normal visual acuity (20/40 min.) and did not suffer from any extensive hearing loss (self-reported).

2.2 Materials

A two-lane 0.8 km closed-loop test track was used for the experiment. The track was divided into several different sections, which varied in terms of driving demands (see Figure 1). Each track section was approximately 120 m (SD = 22). The sections, or required maneuvering, included narrow/precise control, speed/pace control, a variety of curves, signalized intersection, and straight sections (see [10] for a detailed description).

The instrumented vehicle, a 2002 Ford Windstar minivan, was equipped with several sensors and computers which controlled and coordinated the data acquisition and in-vehicle tasks. Data were collected at 30 Hz and video was recorded from multiple camera angles. In-vehicle tasks were presented on a 26 cm High Bright LCD touch screen (Earth Computer Technologies Inc., San Juan Capistrano, CA) that was mounted near the center console, approximately 54 cm diagonal offset from the forward field of view. Two speakers (Sony SRS-T100PC) were mounted behind the driver for the presentation of auditory stimuli.

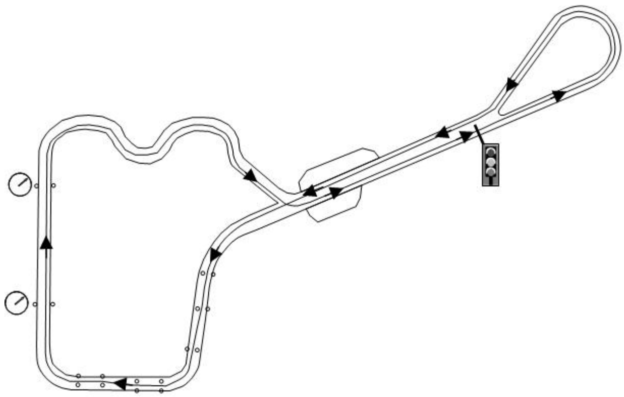

Fig.1. Schematic of test track

2.3 Tasks

The tasks related to cell phone use (different types of dialing, conversation), email (reading, responding), navigation (different search tasks), and finding objects in the car (selecting a CD, looking for an object on the floor). An in-vehicle interface was created that simulated an embedded phone, email and navigation system to support a variety of tasks used in the study (see Figure 2 for sample screen shots). These tasks are summarized in Table 1. Several of the tasks are modeled after [11]. Tasks 1-9 used the touch screen display, while the others (tasks 10, 11) did not involve the touch screen interface.

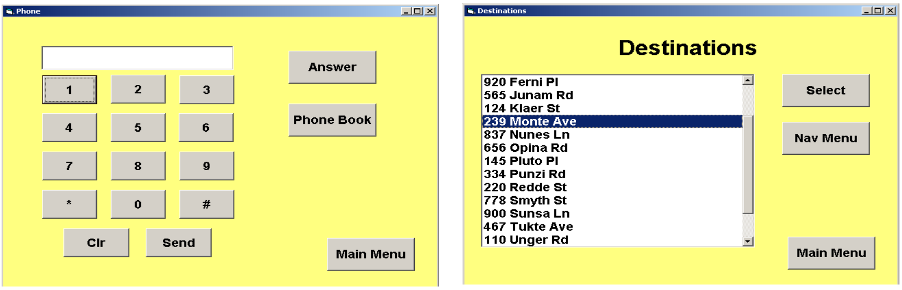

Fig.2. Sample screen shots for tasks using in-vehicle display. Shown are: (a) cell phone system, (b) stored locations in navigation system

Table 1. Summary of in-vehicle tasks used in the study

	Device / System	Task	Description
1	Cell Phone	Dial Known	Dial a 10-digit phone number from memory (e.g., their own number or a commonly dialed one) using the touch screen interface.
2	Cell Phone	Stored Number	Look up a stored phone number from a list of 20 contacts and select the appropriate one.
3	Cell Phone	Dial Unknown	Dial a 10-digit phone number that was written on a Post-It™ note using the touch screen interface.
4	Cell Phone	Conversation	Listen and respond to a pre-recorded message. Drivers listened to two sequences of 5 random letters and for each were asked a true or false question regarding the sequencing.
5	Email	Read Text	Select the appropriate message from a list of 20 and read it. All messages were 2-4 sentences (approximately 87 characters long).
6	Email	Read Text & Respond	Select a message from a list of 20. Read the message and type a short (6 character) response.
7	Navigation System	Stored Address	Look up a stored location in navigation display form a list of 20 addresses.
8	Navigation System	Type Address	Type in a specific address. Address was listed on a Post-It™ note.
9	Navigation System	Restaurant Search	Search for a common restaurant or coffee chain. All search targets were 8 characters long.
10	None	Find CD	Search for a unique CD in a CD-case. CDs were number 1 through 12.
11	None	Object Recovery	Reach for an object (a pen) on the floor and return it to the driver side door pocket.

2.4 Procedure

The experiment was completed during a single hour-long session. At the start of the session, drivers completed an informed consent form and were tested for normal color vision and visual acuity (Titmus Vision Tester, Titmus Optical Inc., Chester, VA). Drivers were then asked to complete several demographic questionnaires.

Next, drivers were introduced to the safety features of the instrumented van and given several minutes (3-4 laps of the track) of practice to familiarize themselves with the handling of the vehicle and the various driving tasks. Drivers were free to select their speed; however, they were instructed not to exceed 48 km/h. Drivers were further instructed to keep the vehicle positioned in the center of the lane, save for the sections when navigating through traffic cones. Following the driving practice, the experimenter explained the in-vehicle tasks and demonstrated them for the drivers. Drivers were given the opportunity to practice these tasks several times.

Drivers completed two experimental blocks. In one block, drivers drove an instrumented van around the test track. In the other block, drivers performed a series of in-vehicle activities while the vehicle was stationary. The order of blocks was counterbalanced across driver.

For the driving block, drivers—after completing 5 laps of the track—were asked to rate their mental workload using a modified NASA-TLX [12], which queried participants along six subscales (mental demand, physical demand, time pressure, own performance, frustration level, mental effort). Ratings were obtained for each section of the track independently though for simplicity's sake, we present the aggregated ratings.

For the other block, the vehicle was parked on the side of the road. Drivers were asked to perform and to rate the demands associated with 11 different in-vehicle activities (described in Table 1). After performing each task four times to completion, drivers rated their perceived mental workload, again using a modified NASA-TLX. They were also asked to estimate the degree of interference on driving performance had they been trying to perform the task while driving (perceived interference, see Item 1, Table 2). Also, they were asked to rate how comfortable they would be performing the task while driving (Item 2, Table 2).

At the end of the experimental blocks, drivers completed a brief post-experimental questionnaire, which included items in which they compared themselves to the average driver with respect to skill, safety and other traits (see Items 3-5, Table 2). They also rated how frequently they engaged in a number of in-vehicle activities during normal, routine driving (Item 6, Table 2). Finally, they were thanked and remunerated for their participation.

Table 2. Select questionnaire items and subjective rating scales for driving and tasks

	Name	Question and Scale Anchors
1	Perceived Interference	"Please estimate your level of driving performance (e.g., steering, speed control, etc.) if you had been performing this in-vehicle task while driving." [Anchors: "Total Failure" to "Perfect"]
2	Comfort	"Please estimate how comfortable you would be performing this task while driving." [Anchors: "Totally Uncomfortable" to "Perfectly Comfortable"]
3	Perceived Skill	"How skillful are you compared to the average driver?" [Anchors: "Much less skilled than average" to "Much more skilled than average"]
4	Perceived Safety	"How safe are you compared to the average driver?" [Anchors: "Much less safe than average" to "Much safer than average"]
5	Perceived Distractibility	"How distractible are you while driving compared to the average driver?" [Anchors: "Much less distractible than average" to "Much more distractible than average"]
6	Frequency of in-vehicle task	"How often do you engage in the following activities while driving?" (18 activities listed) [Anchors: "Never" to "Always"]

3 RESULTS

In the first part of the analyses, we examine the relationships between drivers' perceived interference due to the in-vehicle task with other estimates of workload, skill, and comfort, among other variables. Following this, we examine which workload sub-scales (mental demand, physical demand, time pressure, own performance, frustration level, mental effort) and task characteristics (here defined as the number of manual inputs required to complete the task) are the strongest predictors of perceived interference. Other data concerning performance and workload assessment are reported elsewhere [10].

An analysis of variance of the 11 different in-vehicle tasks established significant differences in composite workload ratings ($F(10,90) = 7.2$, $p < .001$) as well as perceived interference ($F(10,90) = 3.8$, $p < .001$) and comfort level ($F(10,90) = 3.5$, $p = .001$). This confirmed that our chosen tasks indeed differed along these measures. The general pattern of these results can be gleaned from Figure 3, which shows the multi-dimensional ratings for each of the tasks.

Of greater interest for the current paper were the associations between perceived interference and the other variables. As illustrated in Figure 3, a correlation analysis showed that the perceived interference (PI) based on performing the in-vehicle tasks was positively associated with workload ratings ($r = .79$, $p < .01$) and anticipated discomfort ($r = .83$, $p = .003$). That is, those in-vehicle tasks that were considered to be more demanding were also thought to result in a greater amount of interference to driving performance and those with higher PI would cause greater levels of discomfort for drivers.

Further, drivers who rated higher PI from tasks also tended to rate driving on the track as more challenging ($r = .73$, $p = .01$). We did note, however, that PI was not associated with age, gender, years driving experience ($r = .11$ to $.20$, $p > .58$), perceived driving skill ($r = -.38$, $p = .28$) or perceived safety level ($r = .03$, $p = .92$). Drivers' perceived level of safety was positively associated with their perceived skill level ($r = .65$, $p = .04$), but negatively associated with their perceived distractibility (i.e., how often they become distracted while driving; $r = -.73$, $p = .02$). Interestingly, PI was not associated with the self-reported frequency in engaging in in-vehicle activities during their normal driving routine ($r = -.11$, $p = .76$). Similarly, drivers' perceived safety level was not associated with the reported frequency of performing in-vehicle tasks ($r = .09$, $p = .80$), suggesting that drivers are perhaps failing to associate the safety implications of "distraction" (interference) with the performance of routine in-vehicle tasks.

In a subsequent analysis, we examined the degree to which interference ratings could be predicted by task characteristics and subjective ratings of the NASA-TLX subscales. A forward stepwise regression analysis, revealed that comfort in performing in-vehicle tasks ($p < .001$) and mental demand ($p = .002$) were significant predictors of PI ($R2 = .77$). Interestingly, the number of task steps ($p = .61$), physical demand ($p = .35$), and time pressure ($p = .45$) did not emerge as significant predictors, along with other TLX sub-scales.

4 DISCUSSION & CONCLUSIONS

In-vehicle information systems and other ITS applications carry enormous potential for providing drivers with timely information, not only enhancing the driving experience but increasing productivity. That said, the advent of new technologies and tasks can create distractions that place drivers at an increased risk of a motor vehicle crash. Many studies have documented the performance decrements and safety implications of driver multi-tasking (e.g., [1-6]). Further evidence from experimental settings suggests that drivers are not well-calibrated to the effects of distraction on their level of performance while driving [7, 8, 13]. This implies that drivers that underestimate the impact of distraction on performance may be more likely to engage in distracting activities.

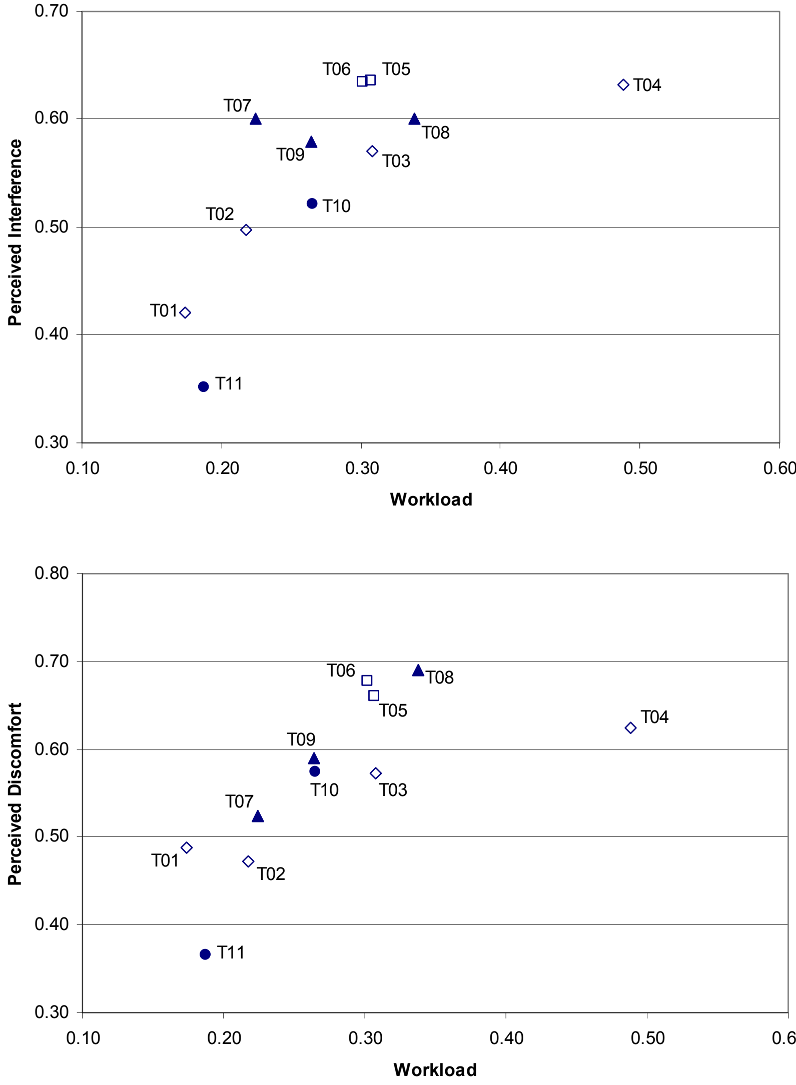

Fig.3. Scatter plots of the workload ratings and perceived interference (top) and discomfort (bottom). Task numbers follow from those listed in Table 1.

In the current paper, we explore how drivers' perceived interference resulting from a variety of in-vehicle activities relates to general impressions of workload, driving skill and ability as well as other variables. Understanding potential discrepancies between drivers' perceptions of (and attitudes towards) distractions, as measured through a number of subjective rating scales, is an important precursor to understanding drivers' willingness to engage in potentially distracting activities while driving.

In our study, drivers were cognizant that more demanding tasks would lead to worse performance outcomes and that they would be less comfortable in performing them concurrently with driving. In spite of these results, however, it was also shown that those drivers that rated in-vehicle tasks as being highly disruptive to driving did not alter their performance of these tasks any (i.e., as reflected in self-reports, they did not reduce their exposure to the tasks). Moreover, drivers who considered themselves to be safer did not demonstrate any curtailing of in-vehicle activities relative to others. These results may be suggestive of a failure to connect in-vehicle tasks to performance and safety in situ, or a willingness to accommodate the additional risks in undertaking additional tasks while driving (i.e., aware of the risks).

Finally, we determined which task components were contributing to the perceived interference of the task (as reflected by workload ratings and task characteristics). Our analyses found mental demand and perceived comfort in dealing with distraction to be the only significant predictors. None of the other factors, which included time pressure, physical demands, and the physical number of steps required in performing the task appeared to drive perceptions of interference. While we tried to include an array of in-vehicle and ITS-related tasks, many involved similar perceptual, cognitive and manual (physical) requirements; in particular, those using the touch screen interface. It is possible that other tasks that vary along these dimensions more systematically might yield different results.

While the current study revealed some interesting patterns of results, we advise some caution in interpreting the results due to our limited sample size. As such, we recommend continued investigations in this area as the perception of interference may be an important influence in drivers' decisions or their willingness to engage in distracting activities while on the road. Additionally, understanding perceived interference (and especially erroneous perceptions) may inform the application of ITS aimed at mitigating distraction (e.g., [14]). The existence of gaps between drivers' estimates of distraction effects and their actual performance decrements might play an important role in determining the degree of user trust, reliance and compliance with such systems [15, 16].

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