An Evaluation of Drivers Using an Ignition Interlock Device: Breath Tests while Driving

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ABSTRACT

The threat of drunk drivers on our nation's highways has led to the proliferation of court-mandated ignition interlock devices (IIDs), which test the driver for alcohol consumption before ignition and during operation of the vehicle. Previous research has already demonstrated the distraction potential of IIDs. Litigation has suggested that this difficulty is particularly severe for individuals with small lung capacity, such as women and smokers. The current research sought to augment the previous distraction finding while also comparing men and women in terms of their ability to successfully use a Lifesafer FC-100 interlock device. Results showed that women had significantly less success in providing adequate breath samples to successfully operate the interlock device while driving, and supported previous distraction findings. Implications as well as suggestions for and challenges of further research are provided.

INTRODUCTION

The National Highway Traffic Safety Administration (NHTSA) estimates 40 minutes elapse between alcohol related deaths on the nation's roads (2008). High rates of recidivism among drunk drivers persist, despite criminal prosecution and the proliferation of state *per se* laws which allow immediate suspension of offenders' licenses (Rauch et al, 2010). A relatively new weapon in the battle against drunk driving is the court mandated installation of ignition interlock devices (IIDs).

An ignition interlock device prevents intoxicated individuals from operating a motor vehicles. Over 200,000 IIDs are installed worldwide, and all 50 US states have programs requiring mandatory IID installation and use (Robertson et al, 2011). A recent meta-analysis came to the conclusion that IIDs were an effective at reducing recidivism among previous offenders while they were installed in the vehicle, although benefits varied widely by study. Furthermore, this protection did not extend beyond the removal of the device. It appears, therefore, that while IIDs may be an effective deterrent while installed, they do not modify behavior (Conbin & Larkin, 2011). IIDs have evolved substantially since pilot programs introduced them in the 1980s. Initially, a breath sample delivered in a manner very similar to police breathalyzers was needed to start the car. However, as users became more adept at disabling these devices, compensatory changes were made (Conbin & Larkin, 2011). Modern IIDs such as that described in the present work, additionally require repeated breath samples at random intervals during vehicle operation, and are capable of disabling the vehicle in-transit and alerting police if the user fails to comply with the machine's request for an in-motion breath test or provides an alcohol-positive sample.

There can be little doubt that IIDs introduce a complex secondary task into the driving environment. The driver is required to lift the device from the dashboard, place it on their lips, vocally match a tone or series of tones that the device emits while simultaneously blowing into the device, wait for confirmation, and then replace the device on the dashboard. If the IID receives an inadequate or inconclusive breath sample, the cycle must be repeated. This process involves manual, visual and auditory tasks (see Wickens, 2002, Sawyer & Hancock, 2013), and is the very definition of a manual – visual secondary task under NHTSA's newly released vehicle distraction guidelines (NHTSA, 2012). Although such tasks may not have an immediate impact on the primary driving task, the increase in workload they incur effectively limits the complexity the driving task can reach before instability leads to degradation of both tasks (Hancock & Warm, 1989). Indeed, a recent study comparing the driving detriment associated with IID use with that of text messaging, and further found that drivers using an IID reported higher subjective workload and were involved in a greater number of crashes (Medeiros-Ward & Strayer, 2011).

Past lawsuits have also claimed the use of an IID to be a factor in loss of control of a vehicle. These cases cite the difficulty of providing enough air to the device and coordinating the use of the device with driving, focusing on the lung capacity issues faced by groups such as women and smokers (AP, 2004). Certainly, there is a physiological basis; on average inspiratory capacity of the human lung varies markedly between men, who enjoy an average of 3.8 L of volume and women, who have only 2.4 (Guyton, Lange & Lange, 2005). This leads to the possibility that IIDs could be a class of device that not only increase driver workload, but which disproportionately affect women.

The present investigation examined both the distraction potential of the interlock device, and the possibility that sex might play a role in the severity of this effect. It was hypothesized that, given their smaller average lung capacity, women would have less success in successfully providing a breath sample to the IID then men. It was further hypothesized that drivers would show more variability on steering and lower speed during use of the device than in pre and post.

METHOD

Participants

A sample of fifteen participants were recruited from the Orlando area (mean age = 26.32 years) were paid $100 for a three hour session. On average, participants had been driving 8.18 years and reported 6.75 hrs of driving each week. None had any specialized driver training beyond normal licensure nor had any previous experience with the Lifesafer device. As described in procedure, three were removed from the final analyses.

Stimuli and Apparatus

The iSim fixed platform driving simulator used in the experiment displayed three channels at 1024 x 768 resolution. The seat, and driving controls of the simulator are that of a full size Crown Victoria. (for more see Sawyer & Hancock, 2012) Participants were placed in a virtual environment; 12 miles of rural two lane highway with light traffic in the oncoming lane and posted at 35mph.

A Lifesafer FC-100 ignition interlock device was used for the evaluation (as in Medeiros-Ward & Strayer, 2011). The device was attached to a power supply, and wired so that a request for breath could be elicited on demand. Upon activation, upon activation the green "blow" light illuminated on the unit and to high-pitched beeps sounded. The participants would then take the unit from the Velcro patch that held it on the dashboard of the driving simulator. Holding the tip of the mouthpiece between their lips, they would hum while blowing into the mouthpiece. As they blew, the device would produce a tone indicating that it was receiving a breath

Fig. 1: A Lifesafer FC-100, as used in the experiment.

sample. Participants were required to match that tone. At the end of the breath sample, one of two beep patterns would indicate whether the breath sample had resulted in a ‘pass’ or an ‘abort’. An "abort" light and the accompanying buzzer sound could be triggered by not providing enough air or providing too much air, humming at the incorrect tone or volume, breaks in the hum, or too much humidity or saliva in the breath sample. A successful test would light the "pass" light, a blinking "run" light, as well as play a series of beeps.

The Lifesafer FC-100 unit was accompanied by a handbook and 8 minute instructional video. These are the same materials used to train users of the video who have been mandated to install interlock devices by the court.

Procedure

Following informed consent, each participant was asked to complete a short demographic questionnaire. Participants then read the Lifesafer handbook and watched the instructional video (Lifesafer, 2007).

In the pre-screen portion of the study, participants were seated in the simulator and shown by a researcher proficient in using the device how to operate the interlock. Participants were allowed to attempt to elicit ‘pass’ signals from the device as many times as desired, but only those able to elicit two consecutive ‘pass’ responses from the device were admitted into the driving portion of the experiment. Two females and one male were removed from the study. One of these females failed to elicit a ‘pass’ over forty times before giving up. Some participants commented upon the amount of air the device required to return a ‘pass’. In the drive portion of the experiment, participants were instructed that if the Lifesafer device beeped, they were to provide a breath sample. They were told that coming to a stop was not necessary and that the device did not need to be used immediately.

Half of participants conducted a 10 minute **single-tasking drive** with the interlock in the car but not requesting breath samples, while half completed a 10 minute **multi-tasking drive**, in which the device beeped to request a test four times. These drive types were counterbalanced in order. During the multi-tasking drive, if a breath test resulted in an abort, the system would request another test in 1 minute. If a subsequent pass result was achieved, the next test would take place at the top of the next minute occurring at least two minutes later. Participants were tested until they had passed 4 tests, or until the 20 minute drive time had elapsed. Following the completion of this driving phase, each participant was thanked for their time and then departed the experimental area. For analysis of success in providing a breath sample, the number of ‘abort’ signals in each participant’s drive was recorded.

To ascertain driving quality a lateral measure of driving, steering variance through the **root mean square (RMS) of steering wheel position**, and one longitudinal measure of driving, **average speed**, were analyzed. These continuous driving measures were divided among four device use windows. The **Pre window** was defined as the time from 10 seconds before the Lifesafer unit requested a breath sample until the light came on and the unit beeped, and can be considered the baseline for this experiment. The **Alert**

Table 1: *Number of Aborts Sub-divided by Drive Order and Participant Gender.*

	Males		Females	
	Participant #	*Aborts*	*Participant #*	*Aborts*
Order # 1				
	4	0	9	5
	6	1	10	1
	13	0	14	5
Order # 2				
	7	0	3	3
	8	0	11	2
	15	0	16	0
		1		**16**

window was defined as the time from the first beep until the device was pressed to the participants' lips. The **Test window** was defined as the time from the device arriving at the participant's lips until the confirmation tone (either pass or fail). Finally, the **Post window** was the time from confirmation tone until 10 seconds after, and included the participant returning the Lifesafer unit to the dashboard. Data from the four tests requested was averaged within these windows.

Collisions during both the All aborts and passes returned by the unit were recorded, both in the pre-drive and drive portions of the study. Data recorded by the simulator included speed and steering variance (root mean square of steering wheel position).

RESULTS

The intent behind collecting the single-tasking and multi-tasking drives was to compare number of collisions, but only a single collision was seen in the experiment. Although this was in the multi-tasking drive, it does not bear statistical analysis.

In analyzing number of aborts within the multitasking drive (see Table 1), a ratio scale was constructed by combining the four tests such that a participant who blew a 'pass' at each test would have a score of zero. A 2(sex) x2(drive order) ANOVA revealed a significant main effect of sex (F (1,8) = 9.38), p = 0.02), suggesting that females blew more aborts than men. No significant effect of order or interaction was seen.

A mixed within-between subjects 2(order) x 2(sex) x 4(window) ANOVA was conducted to determine the effects of sex and order on average speed and steering variance at the four windows of device use (Pre, Alert, Test, Post). Within subjects, a significant simple effect of time was found for speed (F (3,24) = 4.47, p = .01, partial eta squared = .36), such that the pre window differed significantly from the Alert (p = .04), and Test (p = .01) windows and the Post window differed from the Test window (p = .01) (see Fig. 1). The same general pattern was seen for steering variance. No significant effects of order, sex, or use were seen.

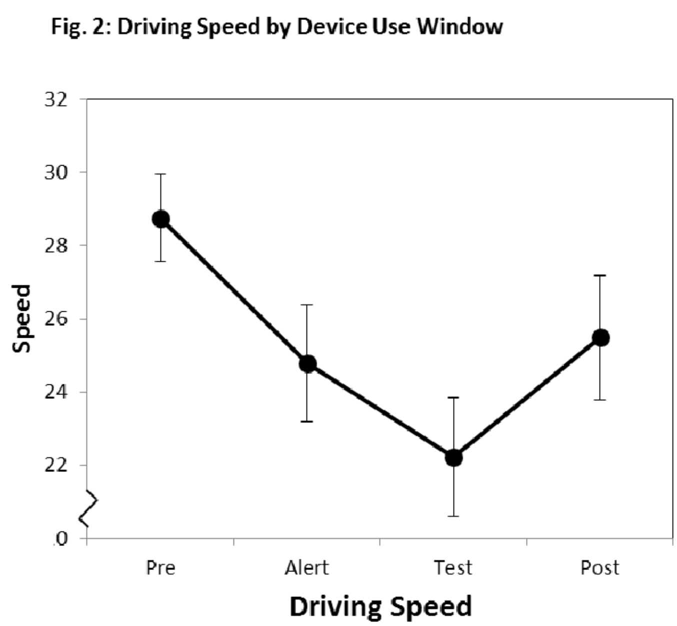

Fig. 2: Participants slowed down from a mean speed of 28.75MPH in the pre window to 24.78MPH alert window and further to 22.14MPH the test window of device use, potentially indicating elevated workload. In the post window, the recovery from device interaction can be seen. Standard error bars are shown.

DISCUSSION

As a measurement of expired air, the device requires both a specific, learned response (i.e., the humming technique) and a threshold flow rate for a specified interval of time. In respect of the latter capacity, it is those of a smaller stature and associated smaller lung capacity that appear to have the greatest problem in providing successful samples. During the course of the pre-drive, it was evident to researchers that women appeared to have a much harder time than men in performing the actual blowing procedure to a successful criterion. In the absence of data to support this view, only this anecdotal account can be provided. However, this issue appears to be revealed under the dual-task situation of driving and requiring a test; women in our sample received far more 'abort' messages than men and as a result spent more time in a dual-task driving situation.

Previous research has showed increased workload and potential for collision of a magnitude comparable to text messaging while driving with an IID (Medeiros-Ward & Strayer, 2011), and our findings support this view; in dual-task driving tasks such as presented in this study, speed level relative to posted limits are indicators of workload of the in-vehicle task (Alm & Nillson, 1994). Participants slowed below the posted speed of 35mph in the alert, and even more so in the test phase of device interaction. Only then, in the post phase did they begin to return to roadway speeds. Notably, no significant differences of sex were seen; although women received more abort messages, their increased interaction with the interlock did not lead to greater impairment.

This study suffers from a low number of participants directly related to the very brief amount of time this laboratory had to evaluate the interlock device. Patterns such as the significant effect of gender upon number of aborts followed by failure to detect gender differences in driving measures must be framed in the resultant lack of power. Subsequent to collecting these data our team made several attempts to secure another interlock device for evaluation. The manufacturer did not provide a unit for further testing, no secondary market exists as all devices are returned to the manufacturer when no longer needed, and in the end the only apparent avenue to securing an interlock was by court order subsequent to arrest for driving under the influence of alcohol. While we feel further evaluation in larger population is very much needed, we have also found that there are limits to our dedication to this line of inquiry.

Our current limited data suggest that women must interact with the device more often in order to provide a successful sample, and are therefore subjected to more interaction with the device than men. All users appear to suffer from elevated workload when using the device and associated risk of dynamic instability and catastrophic failure in the driving task (Hancock & Warm, 1989).

Further research is necessary to extend these findings to other groups with lower than average lung capacity, for example, the elderly (Frank, Mead & Ferris, 1957). Furthermore, additional physiological research is needed to more tightly establish the relationship between lung capacity and difficulty in operating IIDs. Still, the present study provides new evidence that ignition interlock devices may not simply elevate user workload, but function differentially on the basis of sex.

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