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Investigating the Impact of In-car Communication on Law Enforcement Officer Patrol Performance in an Advanced Driving Simulator

Executive Summary

Introduction

Driving is a complex task comprising several component tasks including scanning the environment for hazards, monitoring vehicle speed and position, manipulating vehicle controls, and more. While on patrol, law enforcement officers are required to manage not only the driving task but also additional demanding tasks including radio communication, surveillance, and responses to calls for service. Radio communication tasks require that an officer continuously monitor radio traffic for communication of critical instructions and information for response to a call for service and to maintain awareness of the activities of their fellow officers on patrol. In addition to scanning the driving environment for hazards directly relevant to driving, officers are also scanning the environment to recognize traffic violations by other vehicles, suspicious activity on and off the roadway, and individuals in need of assistance. Finally, officers must respond to calls for service that require storing critical information related to the call (purpose of the call, location, and description of principals), planning a route to the call location, and mentally preparing for the actions required once the officer arrives. These additional tasks and their associated demands on officers' attention are necessary and vital components of officers' primary task of maintaining public safety.

The primary objective of this project was to evaluate the impact of radio communication with dispatch on law enforcement officer driving and patrol behaviors. This project evaluated law enforcement officers' driving, visual attention, and situation awareness during patrol driving under varying cognitive loads to determine the impact of the load on officers' ability to execute patrols. In addition, we were interested in how the growing number of in-vehicle technologies may be able to provide additional support to the officer and reduce the impact of cognitive load.

The current project was designed to investigate the impact of two aspects of in-vehicle technology in law enforcement patrol: 1) the availability of dispatch information on the display and 2) dispatch communication presented in either coded (i.e., ten-codes) or naturalistic language format. Analogous to forms of driver multitasking in civilian driving, we anticipated that the need to process information over the radio would lead to changes in driving behavior (e.g., steering and lane position variability), visual attention deployment (e.g., eye movements), and situation awareness (e.g., the comprehension of the current situational state). We also expected that the provision of redundant information via an in-car display (i.e., a mobile data terminal) would reduce the impact of this additional demand on the officer's attention. In order to examine the former, in two of the conditions (ten-codes + dynamic display, naturalistic + dynamic display), dispatch information was presented next to a map of the simulated environment on the display, and in the other two primary conditions, no additional information was presented on the (static) display. In order to examine the effect of the types of communication, we presented radio calls in both ten-codes (e.g. 10-20 = location) commonly used in police departments or in a more natural language structure (e.g., "What is your location?") The ten-codes take advantage of brevity by sacrificing transparency of the message. Whereas natural language structure may be easier to understand, it can require a longer transmission time.

Study

Each participating officer performed a series of short patrols in a simulated environment under three levels of cognitive load: baseline patrol driving, patrol driving with radio calls, and patrol driving with radio calls and an in-car data terminal.

Participants

Fourteen municipal law enforcement officers recruited from three regional law enforcement agencies (Columbus Police Department (PD), Starkville PD, and Tupelo PD) completed the study. The fourteen officers ranged in age from 26 to 45 years with an average of 7 years of patrol duty experience. Twelve of the fourteen officers reported actively using ten-codes. The two other officers reported that they were familiar with ten-codes and had used them in the past.

Design

In order to evaluate the impact of radio communication on law enforcement officer patrol performance, we manipulated three factors: presence of radio traffic, format of radio communication, and redundant display of dispatch communication (see Table 1).

Radio Traffic

In order to evaluate the impact of radio communication on law enforcement officer driving and patrol performance, the first factor manipulated was presence or absence of simulated radio traffic. During four patrol scenarios, a simulated dispatcher communicated with the participant and four other simulated patrol officers. In a single Baseline patrol, the officer patrolled the environment with no simulated radio traffic.

Format of Radio Communication

The second factor manipulated was the format of radio communication: ten-codes or natural language. In the ten-codes condition, all simulated radio traffic used ten-codes to relay call for service and officer status information. In the natural language condition, all simulated radio traffic used natural language to describe calls for service and officer status.

In-vehicle Display of Dispatch Communication

The third factor manipulated was the redundant display of dispatch instructions to the participant on the in-vehicle terminal. In static display conditions, the in-vehicle terminal displayed an empty white column and a static color map of the simulated environment with labeled streets. In dynamic display conditions, dispatch instructions to the officer were displayed verbatim in the white column. For example, when dispatch provided the instruction “We need you to 10-22 at 318 East Main Street,” the information would be displayed on the in-vehicle terminal. During the call for service, the officer could refer to the in-vehicle display to aid in remembering the necessary details of the particular call for service. In the static display condition, the officer had to rely on his or her memory of the call.

Table 1. Experimental Design

Scenario	Patrol Type[a]	Information Presented[a]	Communication Type[a]
1	Familiarization	Not Applicable	None
2	Baseline	Not Applicable	None
3	Patrol	Auditory + Static (No) Display	Ten-Codes
4	Patrol	Auditory + Dynamic Display	Ten-Codes
5	Patrol	Auditory + Static (No) Display	Natural Language
6	Patrol	Auditory + Dynamic Display	Natural Language

[a] Scenarios 2 through 6 are presented in a counterbalanced order including each combination of information type and communication type.

Five measures of driving performance were recorded using the Mississippi State University Center for Advanced Vehicular Systems (CAVS) Driving Simulator. These included measures of longitudinal (velocity, throttle pressure, and brake pressure) and lateral (steering angle, lane offset) control. Eye movements were also recorded throughout all drives by a dash-mounted, video-based eye tracking system. Eye movement measures were overlaid on video of the driving environment and analyzed in combination with video from the interior of the car in order to capture moments when officers were looking at the in-car display compared to when they were looking through the windshield at the driving environment. The final measure of interest was an assessment of participants' situation awareness, based on responses to a four-alternative forced-choice recognition test. Questions were designed to assess officer awareness of characteristics of the call or event, subjects or vehicles present at the scene, and the status of other (simulated) officers on patrol – all characteristics that officers would be expected to note in actual patrol circumstances.

Analysis of variance plus post-hoc planned comparisons were used to evaluate the impact of cognitive load and language structure on driving behavior, visual attention, and situation awareness measures.

Results

Driving Performance Measures

There was no evidence that steering angle variability, mean lane offset, mean throttle pressure, brake pressure, or vehicle velocity was impacted by presence of radio communication, the format of the radio communication, or the use of the in-vehicle terminal to display dispatch instructions.

When ten-codes were used for radio communication, variability in lane offset was reduced compared to the baseline (no radio communication) patrol condition and the naturalistic language patrol conditions for both static and dynamic display conditions. There was no evidence of any difference between the baseline patrol condition and the naturalistic language conditions.

There were some differences in brake pressure and lane offset between early patrol drives and later patrol drives as participants accommodated to the simulator. This indicates that full accommodation to the driving simulator requires an adjustment period beyond the 8 minute familiarization drive. Since patrol conditions were counterbalanced, these order effects should have no impact on the analysis of patrol conditions.

Eye Movement Measures

There was no evidence that the breadth of eye movements was significantly impacted by presence of radio communication, the format of radio communication, or the use of the in-vehicle terminal to display dispatch instructions. There was evidence that participants looked at the in-vehicle display more often and for longer durations in patrol conditions that included radio communication. There was no evidence that the format of radio communication or the use of the in-vehicle terminal significantly impacted looks at the display.

Situation Awareness Measures

Officer performance on the situation awareness measures were impacted in certain patrol conditions. Situation awareness performance was worse in the ten-code with static display condition and in the naturalistic language with dynamic display when compared to the baseline patrol condition. In addition, performance in the ten-code with static display patrol condition was also worse than performance in the ten-code with dynamic display condition. Interestingly, there was no evidence for a significant difference between the display conditions when radio communication used naturalistic language.

Findings

The driving performance measures provide the most direct assessment of the potential impact of officer multitasking on safety during patrol. Communication with dispatch when using ten-codes did lead to reduced variability in lane offset when compared to the baseline drive. Lower variability in lane offset may indicate a shift from automated control of lane monitoring to conscious control (e.g., Kubose, Bock, Dell, Garnsey, Kramer, & Mayhugh, 2006) which could indicate reduced attention to other aspects of the driving task.

- Monitoring and participating in radio communication with dispatch using ten-codes may increase cognitive load on officers and distract them from some aspects of the driving task.

Radio communication resulted in increased gazes and increased long looks (> 2 seconds) at the terminal. These long looks are considered particularly dangerous (Green, 1999). At 45 miles per hour, a two second look is equivalent to 132 feet traveled by the vehicle. There was no evidence that eye movements were impacted by communication format or the use of the in-vehicle terminal to display dispatch instructions. This suggests that the increased gazes and long looks may be due to the inclusion of calls for service. In the baseline drive condition, there is no radio communication and therefore officers receive no calls for service from the simulated dispatcher. Instead, officers in the baseline condition are presented with four patrol events that appear as they navigate through the simulated environment. The increased number of glances and long looks at the in-vehicle terminal may be due to officers looking at the map to determine where a call for service is located and how best to reach the location. It is possible that this effect would be significantly reduced if the officers were patrolling a familiar environment.

- Officers in our study looked at the in-vehicle terminal more in patrol conditions that included radio communication with dispatch.

There is evidence that radio communication reduced performance on the situation awareness measures. When using ten-codes with a static display and naturalistic language with a dynamic display, situation awareness performance was worse than in the baseline drive. In addition, situation awareness performance when using ten-codes with a static display was worse than using ten-codes with a dynamic display.

- Officer situation awareness was reduced in certain patrol conditions, particularly when using ten-codes with a static display.

The combined impact on variability in lane offset and on situation awareness measures indicate that ten-codes with a static display had the largest impact on officer performance. This is surprising given that this is the normal operating condition for at least twelve of the fourteen participants in the study. The apparent improvement in situation awareness performance when using ten-codes with the dynamic display and the lack of difference in the display conditions for naturalistic language indicates that the use of a dynamic display in the vehicle does not necessarily result in increased risk to officers on patrol. For example, while the difference did not reach statistical significance, there were fewer long looks to the dynamic display compared to the static display when using ten-codes.

- In-vehicle terminals with simple dynamic displays do not appear to significantly impair driver performance and, in some cases, may improve performance.

Limitations

There are a number of caveats and limitations to the current project. First, although the presentation order of the conditions was counterbalanced, the events that participants responded to within each condition were not counterbalanced. Although the original assignment of events to conditions was randomized, there is the possibility that some events were more difficult to find or respond to than were others. In addition, the environment navigated by participants was unfamiliar to them, which is unlikely to be the case for actual officers on patrol. This was a necessary limitation due to time and resource constraints, but it may have impacted the dependence of the participants on the in-vehicle terminal. A majority of the available screen space was dedicated to this static map on an otherwise very simple display. Actual in-vehicle terminals are likely to differ dramatically from the version used here.

Although mobile data terminals are being replaced in many jurisdictions with fully functional laptop computers, the current project used a very simplified terminal interface. Our goal by presenting a simplified version was to examine effects of even minimal distraction resulting from a device in the vehicle. If there was an effect of this simplified display, one can assume that a more complex display will have a greater impact. However, as we noted earlier, the display presented here did not substantially decrease (and in some cases improved) performance. In addition, the shift to in-car computers has not reached many municipalities in the local area (i.e., northeast Mississippi), so even improvements in the ecological validity of the interface might have been undermined by the lack of familiarity for the participating officers.

The simplicity of the display may factor in to the relative lack of impact of the display on officer performance, in contrast to other studies (e.g., Ma & Kaber, 2007, Victor, Harbluk, & Engström, 2005). The display had only a static map for aiding in navigation, and this map always presented reliable and accurate information. More dynamic systems will provide more challenges in maintaining reliability in system performance, which is known to impact driver situation awareness and performance (Ma & Kaber, 2007). Actual mobile terminal displays are likely to differ from the version used here.

The current project was also limited by the small sample size, which inevitably is reflected in a number of non-significant results that may have become clearer with a larger group of participants. This is a product of multiple factors: a specialized population and a challenging simulation that increases the potential for simulator adaptation syndrome (simulator sickness). Given that the original intent of the project was to simulate the experience of law enforcement officers on patrol, these limitations were necessary. Future work in this area should leverage current law enforcement driver training programs that use simulators to both improve statistical power and simplify scenario development. In addition, a second (or perhaps even primary) eye tracking and/or video recording system should be located near the display to more directly observe attentional shifts to the display and thus away from the forward roadway.

Implications

Based on our findings, there is some evidence that law enforcement officers performance when driving is impacted by radio communication with dispatch, particularly when using ten-codes. There is also evidence that a dynamic display providing redundant dispatch instructions would not impair performance and, in the case of ten-codes, may improve performance.

Given the limited population available and the technological constraints, the considerable convergence across measures and conditions in this project permits some basic conclusions on the implications of mobile technology use on officer performance. Law enforcement officers are required to operate in a cognitively demanding situation. Previous demonstrations of the impact of distraction on driving in “civilian” populations clearly show that attention demanding tasks lead to worse driving performance. However, officers have extensive practice driving and in-vehicle technologies are being integrated to aid with these cognitively demanding situations.

Given the increasing number of devices present in the law enforcement vehicle, there is significant concern regarding the costs and the benefits of such devices. This research aimed to determine whether and how in-car communications are affecting law enforcement officer performance in a manner similar to the impact of cellular phone conversations. In addition, our evaluation of the use of a simplified in-vehicle terminal for computer-aided dispatch in the auditory + dynamic display conditions offers insight into whether the external memory benefits of the device mitigate any reduction in performance due to in-car communication and whether the addition of the mobile data terminal itself actually impairs performance. The results of the current study did not indicate that there was a substantially negative impact of the type of in-vehicle devices we were testing on either driving performance or on situation awareness. In fact, the dynamic display condition led to improved performance when communications were presented in the most demanding fashion (ten codes). This data lends preliminary support to the use of in-vehicle technology that can be used by officers to help remember the current situational data.

On a second issue, the content of the information processed by the officers, we manipulated the type of information broadcast to the officers. The current study quantitatively assessed the costs and benefits of ten-codes in terms of officer attention and situation awareness. In the end, we found that ten-codes appeared to be most cognitively demanding communication type as indicated by both driving and situation awareness measures. However, this demand was also mediated by the implementation of in-vehicle technology. Thus, the current results do not favor one type of communication over another when officers are provided technological support. However, in the absence of this support, the current results indicate that there may be a slight advantage to using natural language communication rather than the more memory intensive ten-codes. This recommendation will need to be studied more completely before being implemented.

- Preliminary support for use of in-vehicle technology that will help officers maintain awareness of their situation and instructions from dispatch.
- Preliminary finding that using ten-codes for radio communication increase attentional demands and may impair some aspects of performance.