The Danger of Loose Objects in the Car:
Challenges and Opportunities for Ubiquitous Computing

Daniel Avrahami[1], Michael Yeganyan[2], Anthony LaMarca[1]

[1]Intel

Seattle, WA 98105. USA

{daniel.avrahami, anthony.lamarca}@intel.com

[2]University of California Irvine

6210 Donald Bren Hall, Irvine, CA 92697

michaely23@gmail.com

ABSTRACT

Every year, loose objects inside cars during crashes cause hundreds of serious injuries and even deaths. In this paper, we describe findings from a study of 25 cars and drivers, examining the objects present in the car cabin, the reasons for them being there, and driver awareness of the potential dangers of these objects. With an average of 4.3 potentially dangerous loose objects in a car's cabin, our findings suggest that despite being generally aware of potential risks, considerations of convenience, easy access, and lack of in-the-moment awareness lead people to continue to place objects in dangerous locations in cars. Our study highlights opportunities for addressing this problem by tracking and reminding people about loose objects in cars.

Author Keywords

Loose objects, in-car safety, unrestrained cargo, awareness.

ACM Classification Keywords

H5.0. Information interfaces and presentation: General.

General terms: Design, Human Factors.

INTRODUCTION

Every year, loose objects inside cars cause hundreds of serious injuries and even deaths during crashes. Recent innovations in depth cameras and object recognition algorithms enable a technical solution that could recognize and notify drivers of possible risk. But before building such a system, one must understand drivers' awareness and attitude towards these risks and whether such a technical solution would be useful in practice. In this paper, we describe findings from a study of drivers and cars looking at the reasons for the presence of objects in the car, whether drivers are at all aware of the dangers that loose objects pose to them and their passengers, and whether or not they act on such awareness. This paper provides two primary contributions: 1) empirically demonstrating the disparity

between awareness of the danger of loose objects and the quantity of in-vehicle objects present, and 2) highlighting opportunities for in-vehicle object tracking and awareness for addressing this problem.

A car crash is often described as having two phases: a *first collision*, between the vehicle and other objects, followed by a *second collision* (or "second impact") between the person and the vehicle or other objects in the vehicle [9]. Most efforts into reducing the effects of this second collision have focused on the impact between passenger and vehicle (*e.g.*, improved seatbelt technology, airbags, side curtains and the ISOFIX/LATCH system for restraining child seats). However, injuries related to unrestrained cargo or other unrestrained passengers are some of the major contributors to total harm in traffic accidents [7].

In an ongoing US study of children involved in crashes, researchers found that of 12,513 children injured by something inside the vehicle, more than 3,000 collided with loose objects, other passengers or both [1]. Unrestrained cargo may even cause death in a frontal crash by striking an occupant's seatback [6]. In fact, loose objects can become lethal not only in a collision but even in emergency braking. The threat posed by objects is not limited only to inanimate objects; in an analysis of 73,893 accidents in Japan, Ichikawa *et al.* show, for example, that an unrestrained passenger in the rear increases five-fold the risk of death for restrained front seat occupants [5]. Finally, the danger that objects pose is not restricted to particularly large and heavy objects. During a collision, impact from a loose object will have a relative force equal to the object's weight multiplied by the speed in which it travels. While prior research has examined the placement and organization of objects and people in vehicles to understand their dynamics during frontal impacts [5] and to estimate their effects on the vehicle's center of mass and stability [2], very little work has been conducted into the rationale for *ad hoc* placement of everyday objects in the car. Thus, in this work, we sought to answer the following questions: Are drivers aware of the dangers that objects pose to them and their passengers? What loose objects do people keep in their car's cabins and where? Why do they choose to place these objects inside the car? How could technology be used to alleviate the problem? How should such technology address the conflicting goals of safety and in-car object use?

THE STUDY

To better understand people's awareness of the dangers of loose objects in the car, whether or not they act on this awareness and why, and also to highlight possible technical solutions for this problem, we conducted a two-part study with 25 drivers. Each driver first participated in an object inventory and open-ended interview, followed by completing a survey of awareness and attitudes. Each session started with logging of objects in the car and their location in the cabin. Pictures of the car's interior were taken. Drivers were then asked for the reason that different objects were in the car and in their particular locations. For safety reasons, sessions took place when cars were parked. We thus asked participants about other objects that they frequently carried in the car, such as their work bag, purse, laptop, or grocery bags. In this first part we intentionally *avoided* asking about the danger of loose objects in the car, so that we don't bias participants' explanations for the reasons they kept objects in the car.

In the second part of each session, participants were asked to complete a short survey either on paper or online. Participants marked their agreement with a series of statements on a 7-point scale. In this survey we captured participants' stated awareness of the risk from loose objects, their attitudes towards basic safety features (seatbelts), seatbelt warning indicators, and finally an indication of their willingness to adopt a system that will warn them of objects that are dangerous to them and their passengers. Participation in the study was voluntary.

Participants

Twenty-five drivers, 10 women and 15 men, participated in the study. Six of the drivers (4 women, 2 men) were parents to children younger than driving age. Kids' ages ranged from 7 months to 8 years, with a median of 4.1 years. The 25 vehicles observed included 15 sedans, 3 SUVs, 3 hatchbacks, 2 coupes, and 2 pickup trucks. 14 of the participants were co-workers (none of whom work on this project) and 11 were recruited through our social network.

RESULTS

In this section, we first describe the types (and quantity) of objects found in the cars. We then describe where these objects were found and the reasons given for their placement in the cabin versus the trunk (almost none of which related to safety). Finally, we report people's stated awareness of the dangers that objects pose to them and their passengers, contrasting with their observed behavior, and we describe people's attitudes towards in-vehicle safety and safety reminders. The disparity between awareness and action, shown by our study, highlights the need and the potential for a real-time awareness system.

Objects in the Car

We recorded 145 objects in the 25 vehicles' cabins, of which 44 objects were both loose and have the potential to become dangerous to driver and passengers in a collision
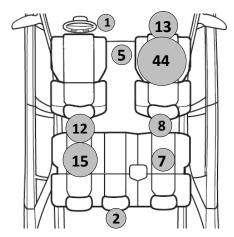

Figure 1. The total number of objects in each location in our study participants' cars.

(M=1.8, SD=1.5), while 8 objects were secured (those included child-seats, and car-racing instruments). The remaining objects include clothing, empty plastic bottles, papers, food, tissue boxes, etc. In addition to the objects present in the cars at the time of the study, participants listed 63 (M=2.5, SD=1.1) objects that they frequently carry in the car, such as laptops, briefcases, and groceries, bringing the total of potentially dangerous objects to 107 (M=4.3, SD=1.9). We focus our results on these objects.

Many of the loose objects were everyday items (*e.g.,* drink bottles, bags, groceries) or things commonly found in cars (*e.g.,* tool-boxes, car-battery chargers). Others were less expected (large books, and even a 17" LCD monitor). Many of these objects were placed in the car, typically in the rear, and left there for a long time rather than being moved to the (safer) trunk. Because these objects stay in the rear of the car for extended times, awareness of their presence and the danger they pose could subside. This dangerous habituation suggests the potential for an awareness system that reminds drivers of objects' presence.

Mobile and Portable Technology

Phones, laptops, GPS, music players and cameras, accounted for 18 of the 107 objects (17%). All 18 objects were placed in the front of the cabin (15 of them on the passenger seat). The main reasons participants cited for placing these objects next to them were convenience and ability to quickly access information. However, placing such devices next to the driver can prove deadly in a side collision [8,10]. An implication is, thus, that enabling drivers to access their information and devices (phone calls, music, etc.) through alternate channels would allow these devices to be placed in a more secure location.

Groceries and Other Bags

Twenty participants reported that if they only have one or two grocery bags, they tend to place them in the cabin rather than the trunk. As one participant said, *"For groceries, if I just have a couple bags, I put them in the back seat..."* (P11). However, a bag of groceries in the car

can be fatal (for example, when a 2kg bag of rice flies through the car during a collision [4]). Similarly, other bags, such as backpacks, briefcases, and purses could easily be dangerous to driver and passengers. In our data, 15 of 25 bags in the cabins typically contained a participant's laptop.

This particular category of objects poses a technical challenge for an in-car awareness system because a grocery bag (or any other bag) is a *collection* of items, some of which may by dangerous while others, possibly those visible on top, may be light and harmless. Different approaches may overcome this problem, such as the use of weight sensors (similar to sensors in front passenger seats), mm wave radio to distinguish dense from light objects, or volume-based visual recognition, such that a grocery bag is represented as a single large item on an awareness display.

The Location of Objects in the Car
The placement of an object in the car and its physical relation to driver and passenger plays a critical role in the threat of the object. Figure 1 shows the location of observed and listed objects in participants' cars. We describe a number of themes that emerged from the interviews and highlight implications for system design.

Easy access during the drive: The need for easy access to an object was cited as a key reason for placing it inside the cabin. *"I place it on the front passenger seat next to me if I'm in a hurry and need quick and easy access to it. It's convenient that way."* (P4). Primary locations for objects in these cases were the front passenger seat (n=44), and rear foot-wells (n=12). However, these objects can pose a direct threat to the driver if they need to be within arm's reach. This is important since these objects are unlikely to be stored in the trunk.

In-and-out: The desire to enter and leave the car quickly is another reason for the choice of object placement. *"It's too much work to open the trunk. I put it on the seat behind my seat so that I can get out, open that door then leave."* (P11) Typical behavior included dropping a bag in the rear behind the driver seat, or "flinging the bag" over to the front passenger seat when entering the car; *"For the passenger seat, I'll just throw the backpack in...throw it across the middle thing to the passenger side, I just don't want to have to go to the passenger side to do anything."* (P13). Obviously, the danger of the two locations (front passenger seat vs. rear left passenger seat) differs significantly.

External constraints: Finally, for some, the choice of where to place objects was imposed by external factors. As one participant said: *"I have little space to open my trunk at home, so I'm used to placing [the grocery bags] on the back seats"* (P15). For others, small parking spaces actually led to safer behavior in putting objects in the trunk. The implication, however is that an awareness system should warn, but not nag, since moving objects to the trunk is not always possible.

Statement	Agreement (1..7) mean [sd]
1. How aware are you that certain objects in the car can become dangerous during a car-crash?	**5.0** [1.4]
2. I take into account the danger of objects when I decide whether to place objects in the cabin or trunk.	**3.7** [1.8]
3. I put objects in the trunk because I am safer this way.	**3.4** [1.8]
4. I wear a seat-belt to keep me safe.	**6.8** [0.7]
5. I wear a seat-belt because it is the law.	**5.3** [2.1]
6. I ensure passengers in the <u>front</u> wear a seat-belt.	**6.7** [0.6]
7. I ensure passengers in the <u>back seat</u> wear a seat-belt.	**6.0** [1.4]
8. I find the seat-belt audible reminder annoying.	**4.3** [2.2]
9. I find the seat-belt audible reminder useful.	**4.9** [2.0]
10. If your car warned you of objects in the car that could be dangerous to <u>you</u>, how likely are you to move it to a safer location (e.g., the trunk)?	**5.6** [1.0]
11. If your car warned you of objects in the car that could be dangerous to <u>your passengers</u>, how likely are you to move it to a safer location (e.g., the trunk)?	**5.8** [1.1]

Table 1. Survey responses. Ratings are on a scale of 1=Completely Disagree/Unware...7=Completely Agree/Aware.

Awareness and Attitudes
We now turn to participants' responses to the survey filled out in the second part of the study. Table 1 summarizes participants' responses to the 11 survey statements S1-S11.

Awareness vs. Behavior
Generally, participants indicated awareness of the danger of loose objects. In response to statement S1 "*How aware are you that certain objects in the car can become dangerous during a car-crash?*" 18 of the 25 participants reported at least some awareness of the danger: 7 selected "5 - *Somewhat Aware*", 8 selected "6 - *Aware*", and 3 selected "7 - *Completely Aware*" with an average of 5.0. This is surprising given the large number of objects we observed earlier. To contrast, participants expressed low agreements with S2 "*I take into account the danger of objects when I decide whether to place objects in the cabin or trunk.*" (M=3.7) and S3 "*I put objects in the trunk because I am safer this way.*" (M=3.4). A planned paired-samples t-test showed that participants claimed to be aware of the danger significantly more than they claimed to act on it (S1 vs. S2: t(24)=3.89, p<.001; S1 vs. S3: t(24)=4.07, p<.001)[1]. Additionally, we found no correlation between reports of awareness and the number of objects in the car (p=.2, *n.s.*).

Attitudes towards Seatbelts and Seatbelt Reminders
We next asked participants about their use of seatbelts (S4-S7) – since those are the most common in-car safety system – and attitudes towards seatbelt reminders (S8 and S9). A

---

[1] Testing with only participants aware of the danger of loose objects (rating>=5) showed similar significant differences (t(24)=3.62, p<.001 and t(24)=4.04, p<.001).

comparison shows that safety was rated significantly higher (M=6.8) than requirement by law (M=5.3) as motivator for using seatbelts (t(24)=3.49, p<.001). This is encouraging since an awareness system for objects in the cabin is unlikely to be required by law. Participants indicated that they ensure passengers in the front wear a seatbelt (S6; M=6.7 with all response at least '*Somewhat Agree*') more than passengers in the back seat (S7; M=6.0; t(24)=2.52, p<.001), possibly again suggesting reduced awareness of the back seats. The parents of small children showed a marginally significant difference from the rest of the drivers in ensuring that passengers in the back seat wear seatbelts (M=6.8 vs. M=5.7; F[1,23]=3.22, p=0.086). We found no significant difference between finding seat-belt audible reminders to be useful (M=4.9) or annoying (M=4.3).

DISCUSSION

As we've shown, despite being generally aware of potential risks, considerations of convenience, easy access, and lack of in-the-moment awareness led our participants to continue to place objects in dangerous locations in their cars. Our study suggest that merely increasing drivers' general awareness (e.g., through an always present warning label in the car) would not solve the problem. Instead, an awareness system that tracks and warns drivers of loose objects in the car may be necessary. Our results also show the frequent presence of backpacks, purses, and grocery bags in cars, the presence of which presents a technical challenge for a vision system. Thus, we envision a system that would, for example, track objects and people in the car using a combination of depth cameras and weight sensors (see Figure 2 for an illustration), label them as secure or loose (using seatbelt sensors) and warn drivers, for instance, using the car's console.

Just as a well positioned sign can get people to choose taking the stairs instead of the escalators (c.f., [3]), so might an awareness system of loose objects lead drivers to safer behavior. While the design of such a system is an area for future work, our findings provide a number of insights as to when, and how often to alert the driver. For example, our data show that ease of access is a key factor in the choice of placement of objects in the car. This finding has two implications: First, since convenience is a dominant factor in object placement, alerting drivers when they turn on the car, after they are seated and likely buckled up, may be too late (although such a notification may still affect future behavior). Second, if easy access to an item is important (e.g., to be able to hand to a child in the back) then drivers

are unlikely to use the trunk and a system must notify, but not nag, lest drivers start ignoring it.

CONCLUSIONS

This paper presented findings from a field study that details reasons for the presence of loose objects in the car, and demonstrates the disparity between drivers' awareness of the problem in general, and their actions in practice. These findings provide an understanding of the problem of loose objects in the car and challenges ubicomp researchers to solve this important problem. We highlighted both technical and behavioral challenges, such as the need to correctly distinguish between secure and loose objects, or accommodating users' desire for quick access to belongings during a drive. While the cost of a technical solution must be weighed, reducing the number of injuries and deaths caused by loose objects could outweigh such costs.

REFERENCES

1. Adlam, E. Hidden Dangers in your Car: When everyday objects turn deadly. *Readers Digest*. (2003), 550-557.

2. Arndt, M.W., Dickerson, C.P., Arndt, S.M., Mowery, G.A. and Shapiro, S.C. Effects of Passenger and Cargo Loading on a Motor Vehicle's Mass Properties. *Society of Automotive Engineers*. SAE Paper #952676. 1995.

3. Brownell K. D., Stunkard A. J., Albaum J. M. (1980) Evaluation and modification of exercise patterns in the natural environment. *AJP*, 137:1540-1545.

4. Hudson, J. (2007) Reverse the toll. *The Sydney Morning Herald*, February 23, 2007.

5. Ichikawa, M., Nakahara, S. and Wakai, S. Mortality of Front-Seat Occupants Attributable to Unbelted Rear-Seat Passengers in Car Crashes. *The Lancet 359, 9300* (2002), 43-47.

6. Samuel P. Mandell, S.P, Kaufman, R., Mack, C.D. and Bulger, E.M. Describing a Problem: Rear Seatback Failure and Unsecured Cargo. *Prehospital and Disaster Medicine 25, 2* (2010).

7. Schaper D. and Zech G. (1986). Cargo Retention in Passenger Cars Under Accident Conditions. *Society of Automotive Engineers* SAE Paper# 860206. 1986.

8. Unrestrained Objects Deadly While Driving. *ABC News*. January 2010. http://abcnews.go.com/GMA/story?id=128062

9. Waters, W., Macnabb, M.J. and Brown B. A Half Century of Attempts to Re-Solve Vehicle Occupant Safety: Understanding Seatbelt and Airbag Technology. In *Proc. Enhanced Safety of Vehicles (ESV'98)*. 1337-1346.

10. Woman killed by laptop in Surrey crash. *CBC News*. http://www.cbc.ca/canada/british-columbia/story/2009/04/15/bc-surrey-laptop-crash-kills-woman.html

Fig 2. System illustration: Cameras and sensor monitor the cabin to identify loose objects (e.g.: a laptop and backpack)