Driver Usage Patterns for Secondary Information Systems

By:
Linda S. Angell
Crash Avoidance System Development
General Motors, Safety Integration
&
Miguel Perez and Jon Hankey
Virginia Tech Transportation Institute

At:
The First Human Factors Symposium on
Naturalistic Driving Methods & Analyses
Virginia Tech Transportation Institute
August 27, 2008

Research Program

- Research Team
  - VTTI Team
    - Miguel Perez, Principal Investigator
    - Jon Hankey, Principal Investigator
  - GM Team
    - Rich Deering, Linda Angell, Brian Repa, Andy Gellatly, Lee Zhang
- Performed in two phases
- Done over 3 years

Study Objectives

- Collect continuous driving data with emphasis on extracting and analyzing infotainment system interactions
- Reduce the totality of the data, marking when system interactions and use of cell phone occur
  - Follow up with detailed reductions describing the goal and duration of each button press
- Examine patterns and frequencies of system use, skill acquisition processes, presence and extent of self-regulation, and eye glance patterns during system use

Application Opportunities

- Frequency-of-use patterns (available for use in planning functionality of future systems, as well as for use in selecting/laying-out controls and displays)
    - Including a clarification of whether frequency-of-use is unique to **specific** user interface implementations (vs. driven more generally by user goals)
- Initial data on the extent to which skill and strategies of use change as drivers become familiar with a unit through their interactions with it over time (for potential use in determining degrees of flexibility/adaptability needed in user interfaces)
- Identification of usage cases that pose difficulty and/or offer opportunities for improvement through innovations of user interface design or function

Study Scope

- Two vehicles were used
- Each was equipped with a different aftermarket infotainment system
- The functionality of these aftermarket systems was comparable to current infotainment products in the market

System X

System Y

Vehicle 1

- 2002 Cadillac STS with the System X device
  - AM/FM
  - CD/DVD/MP3 player
  - Sirius receiver (satellite)
  - iPod interface (iPod provided)
  - Steering wheel controls for volume and fader

Vehicle 2

- 2005 Ford Crown Victoria with the System Y device
  - AM/FM
  - CD/DVD/MP3 player; JPG reader
  - Sirius receiver (satellite)
  - iPod interface (iPod provided)
  - Navigation System (some functions locked out)

Participants

- A total of 17 participants, ages 27 to 57
- Participants had to indicate that they spent more than 5 hrs/week in their vehicle
- Participants were tech-savvy, but new to these particular systems
- Participants received no monetary compensation

	Female	Male
System X	N=5 (M=42.8 years)	N=4 (M=41.5 years)
System Y	N=4 (M=39.8 years)	N=4 (M=44.25 years)

Tech-Savvy

- Participants were intentionally recruited to have some larger than average level of tech-savvy, especially related to music listening
- Percentage time spent listening to audio system:
  - Participant estimate: 89.1% (SD=18.7)
  - Observed was significantly higher: 99.3% (SD=0.8)
  - Stutts et al. (2003) estimate was lower at 72.6%
- Participants spent, on average, 2.43% of their time in the vehicle manipulating the system controls (SD=1.77)
  - The Stutts et al. (2003) estimate is somewhat lower at 1.1%
  - Neurauter (2006; Radio Usage) estimate using 100-Car data was 1.4%
- Participants owned an average of 312 CDs (SD=599) and 438 compressed audio files (SD-1288)

General Protocol

- Participants were brought to VTTI to fill out background questionnaires, informed consent, and information sheets to assist data download
- Each participant used the assigned car during their daily routine for ~4 weeks
- Weekly data downloads, with little or no driver awareness
- Participants did not receive any instruction on the system, and were given the equipment needed for transferring music to the iPod that was installed in their vehicle
  - Information about the specific purpose of the study was not provided

Data Reduction

- Analysts watched all the video collected, and coded:
  - Operations with the system by drivers
    - Function accessed
    - Control actuation (and duration of actuation)
    - Goal
  - Eye glance behavior (for a subset of system operations)

Data Reduction

- Use of each system by drivers was coded into:
  - **Interactions**: system manipulation, starts on first action (e.g., button push), ends when simple goal is completed (e.g. change station)
  - **Events**: succession of interactions with a common goal (e.g. find something to listen to)
    - Events comprised of one or more interactions; a series of operations

Dataset Properties

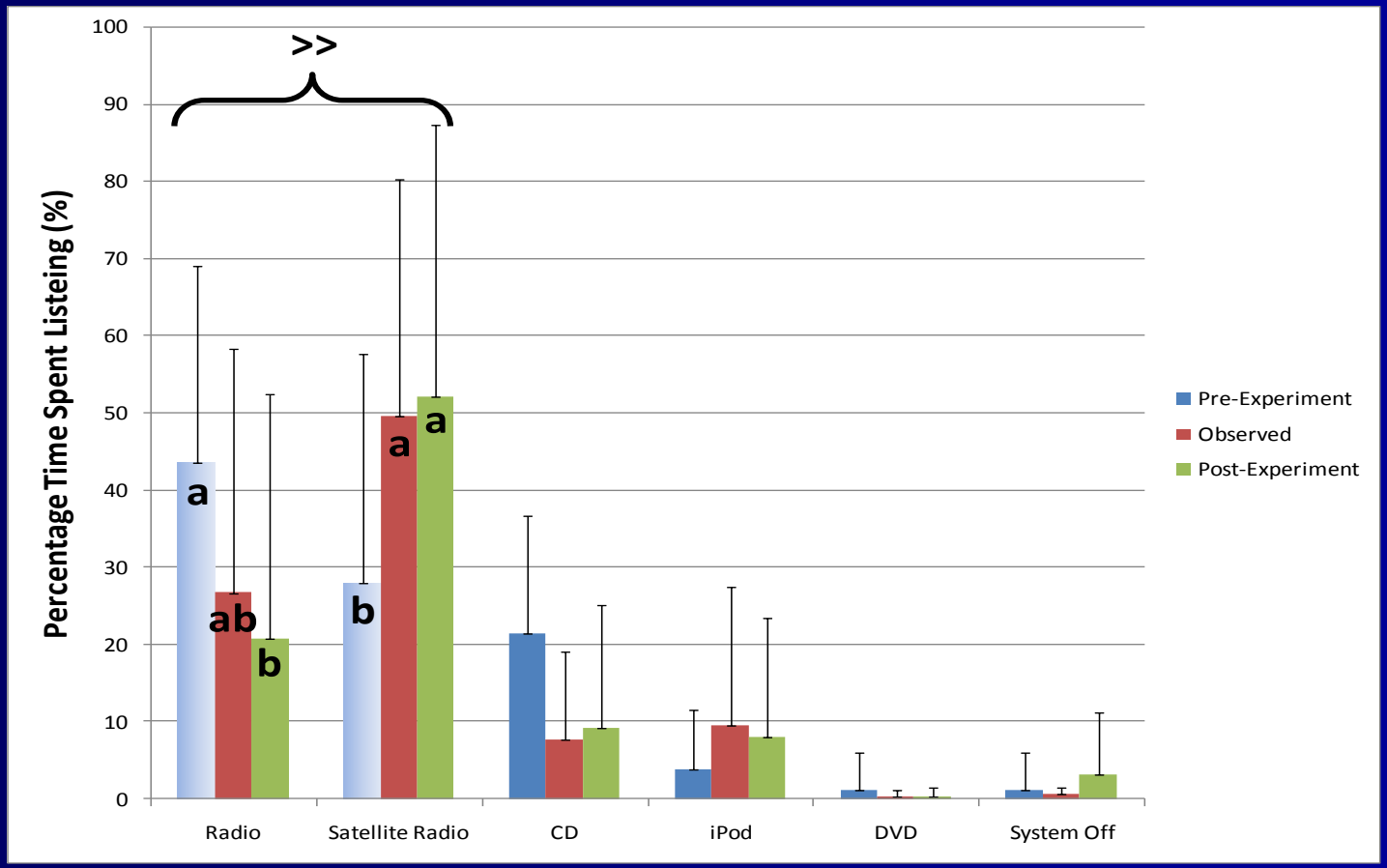
- Dataset included:
  - 694 hours of driving
  - 30,371 vehicle-miles
  - 11,297 interactions
  - 6,675 events


Repeat
Playlists
Browse
Shuffle
2zone
2:38 am
112of 144
Elapsed: 2:38

Results


5 I-5/GOLDEN STATE FWY
13:56
0.75 mi
5.0 mi
6.7 mi
LOS ANGELES
8.9 mi
0h08m
5 I-5/GOLDEN STATE FWY

Natural Patterns of Listening

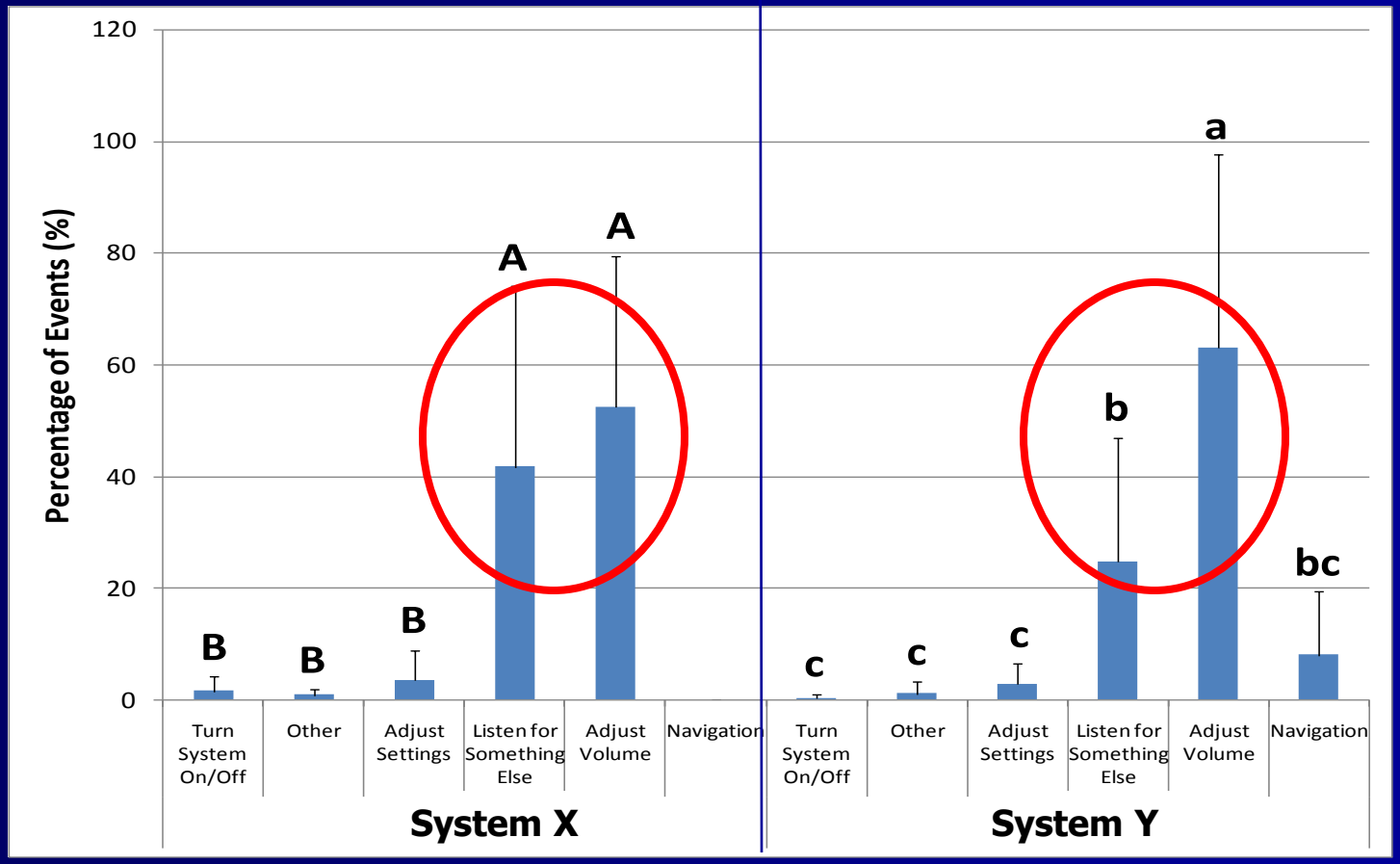


There weren't large differences between infotainment systems in patterns of use

- Differences in usage patterns were mainly due to *the user's goal* (e.g., adjusting volume vs. listening for something else) *rather than* to infotainment system (even though the two systems implemented functions in different ways)
- Naturalistic data revealed frequency-of-use data to be fairly robust across different interfaces (for "goal-level" behavior)

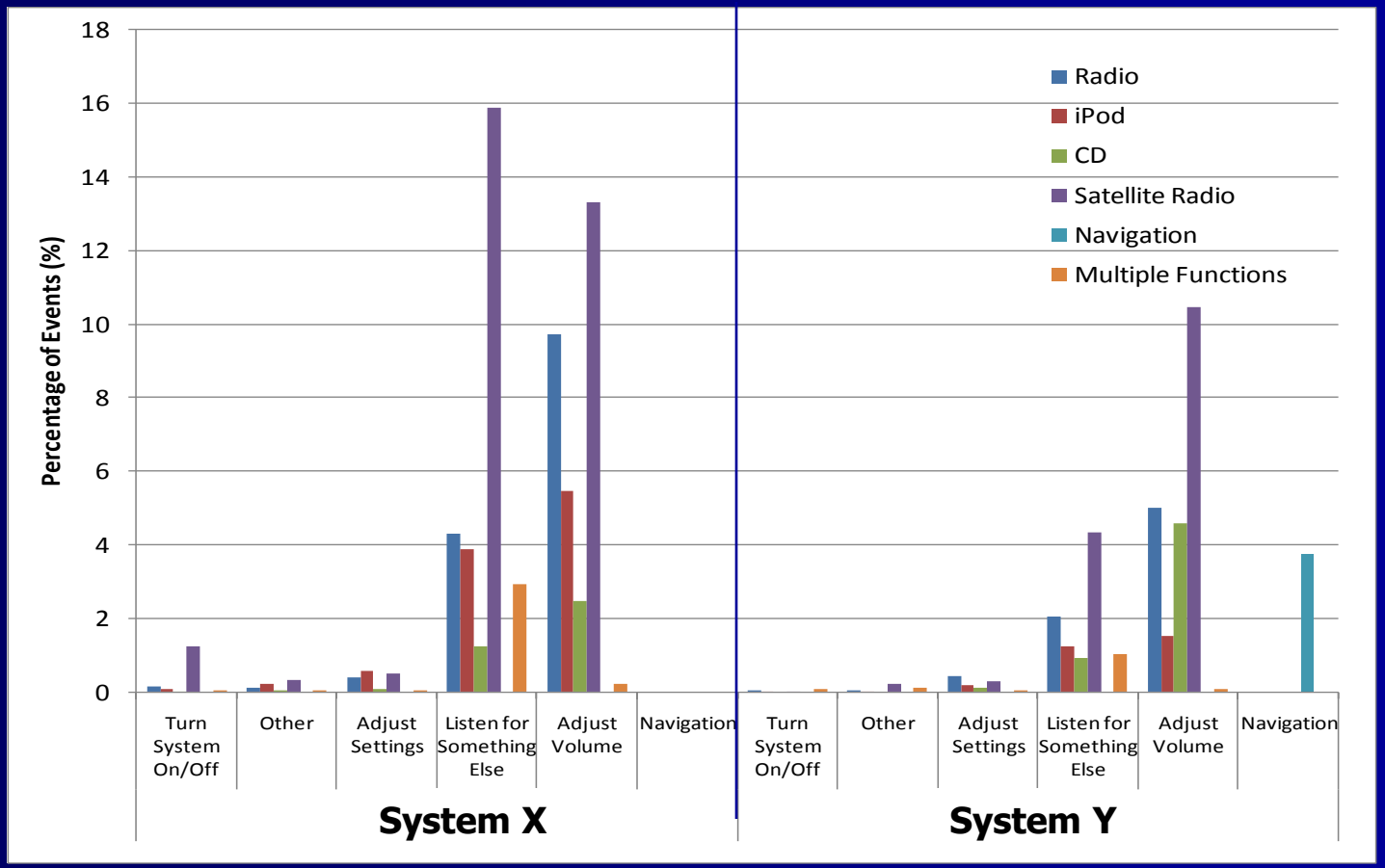
Distribution of "Events"

("goal-based" percentages for Clarion & Pioneer yielded **similar rank orders**)



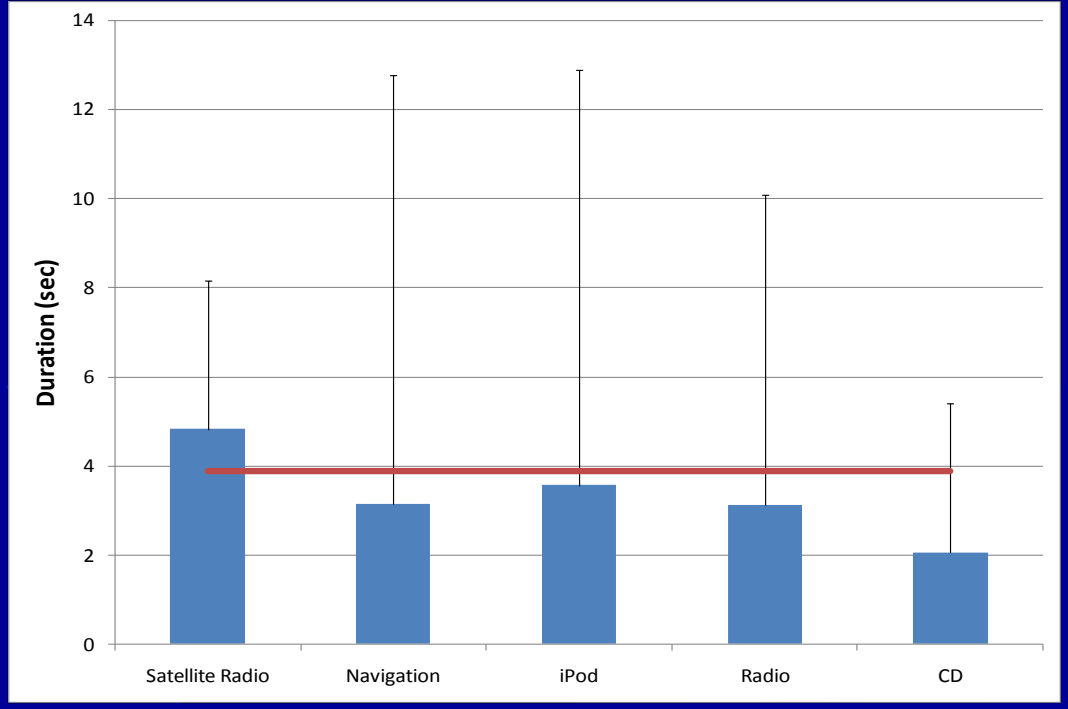
Event Distribution

[Within each goal, Events Broken Down Into Function Used]



Naturalistic patterns for "typical" interactions differ from those that are "rare but risky"

- "Typical" interactions tended to be short, reasonable, frequent
- "Typical" interactions offer insights for improving usability

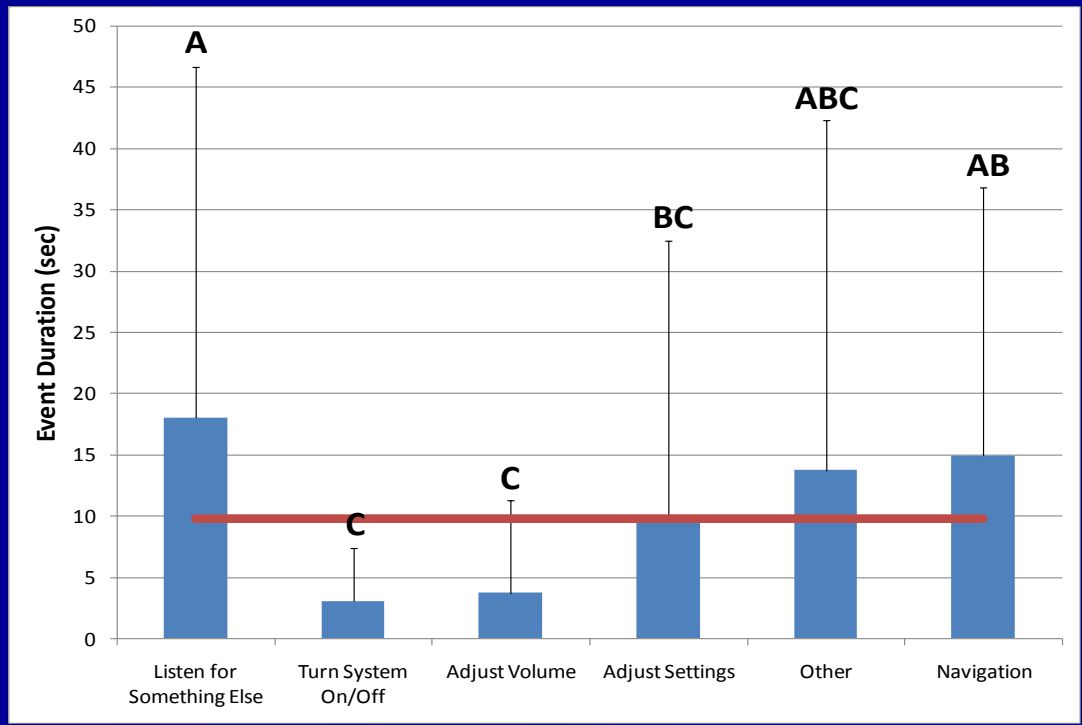


Durations of Single Interactions

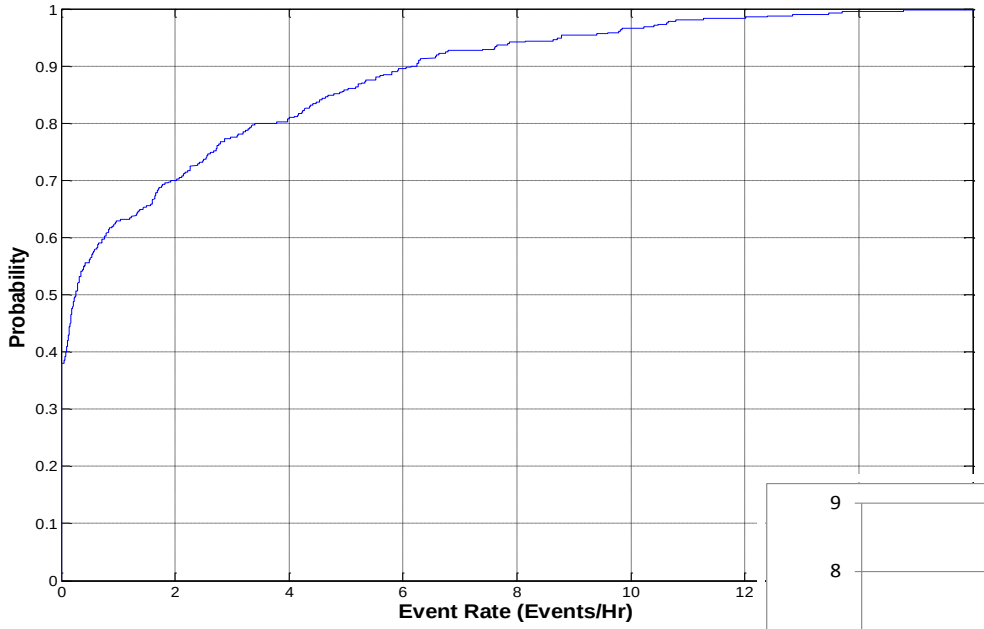
90% were <10 sec
75% were < 3 sec

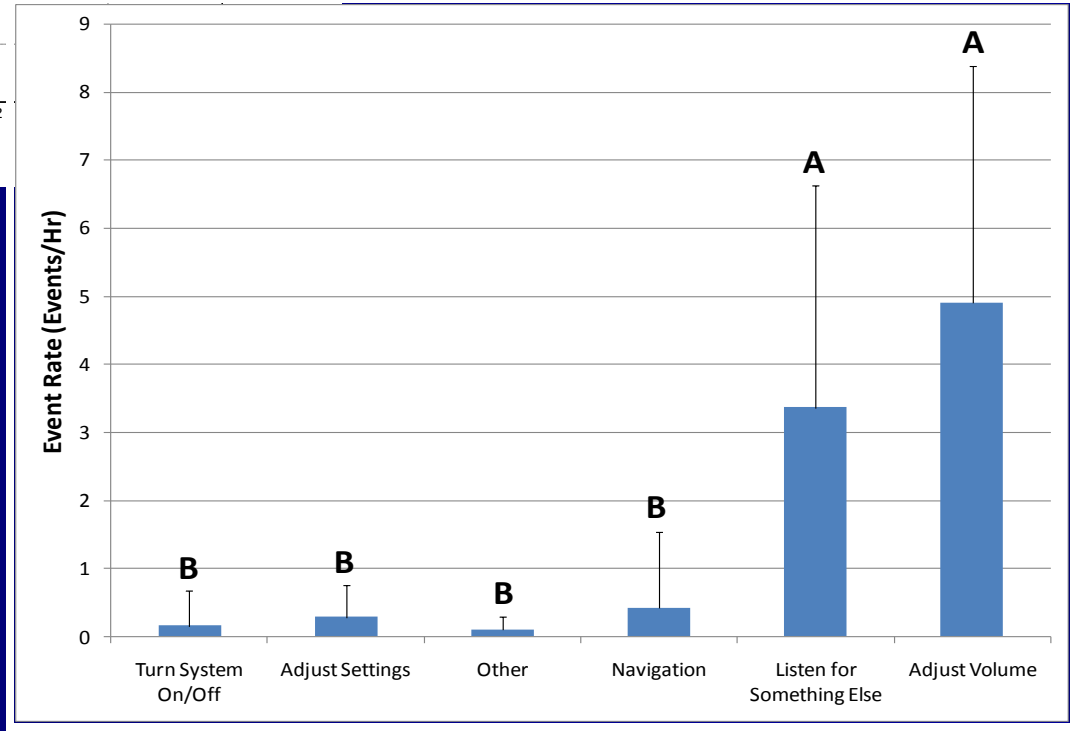
Durations of "Events" (multiple operations)

90% <24.6 sec
65%< 5 sec



Event Rate





Events typically occurred less than 5 times/hour, even for the most frequent.

Also, though not shown here, individual control interactions typically occurred at rates of less than 10 per hour.

Long interactions are a contrast:
They were infrequent, more rare

Long interactions were infrequent, more rare

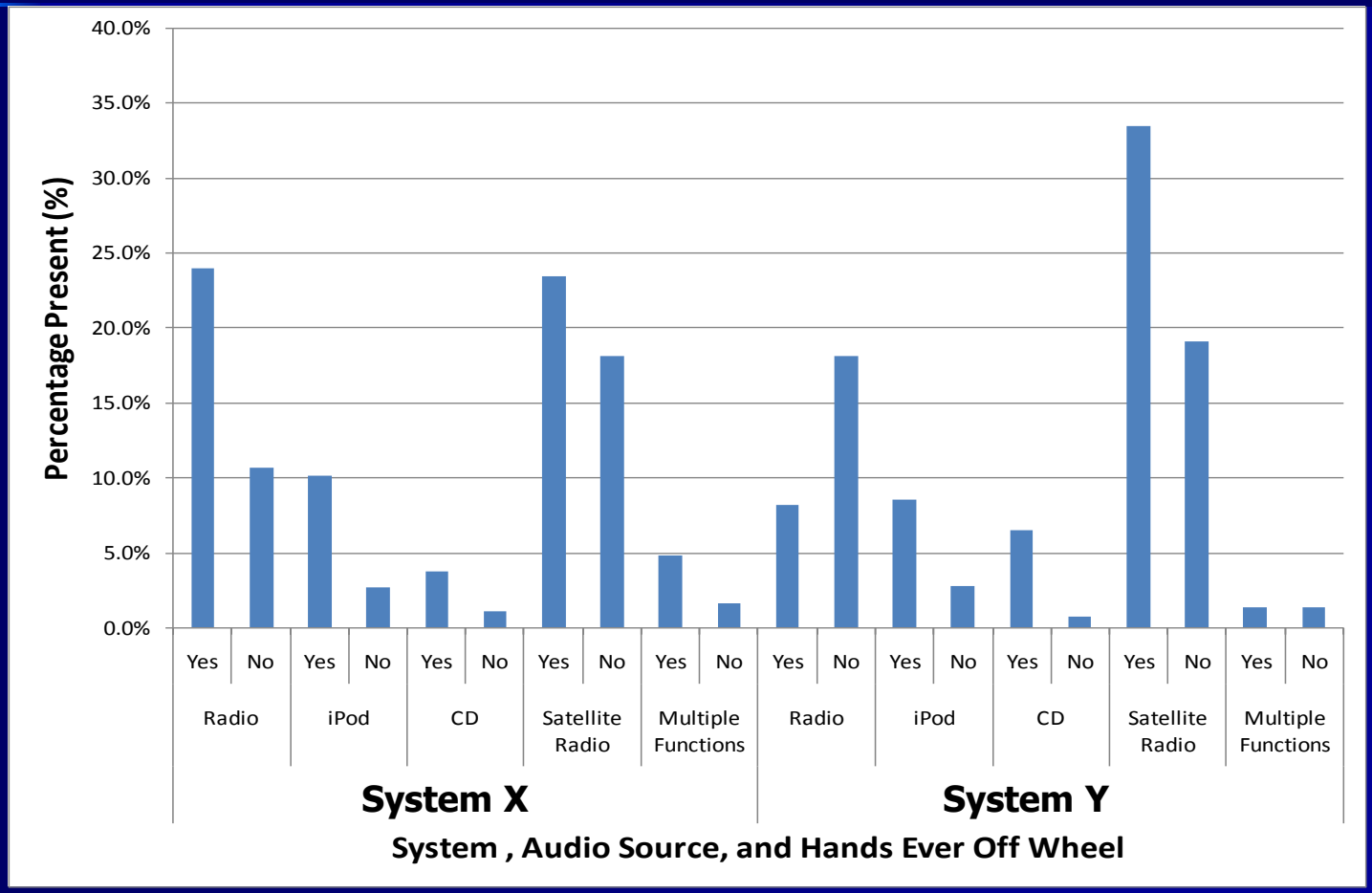
- Such interactions were associated with longer streams of both visual and manual interactions with the devices-- and/or may have been initiated or continued at inopportune times
- **Both** types of interactions/events (both the typical and the rare) are important for evaluating eyes-off-road-time and crash risk
  - However, to evaluate crash risk ALSO requires extracting frequency-of-use and conditions-of-use data in a **formal** way
  - For this, a SEPARATE project is underway within VTTI's Surface Transportation Safety Center of Excellence

Multitasking and hands-off-wheel behavior

- Many interactions are assigned to the "hands" in some systems
- Devices which customers carry-in to the vehicle and other tasks (such as eating, drinking, grooming) also involve the hands
- Instances of multi-tasking where many demands were placed on the hands were analyzed to examine "hands-off-wheel" behavior
- Caution should be exercised in interpreting results
- However, findings suggest there may be opportunities for "planning-ahead" for extra customer use of hands for tasks other than secondary-device use (e.g., considering alternate input-modalities for devices, where possible)

Distribution of Hands Off Wheel Instances

(Based on use cases involving cell phone and in-vehicle device)



Naturalistic patterns revealed different kinds of interaction (different from that which is often tested based on task analyses)

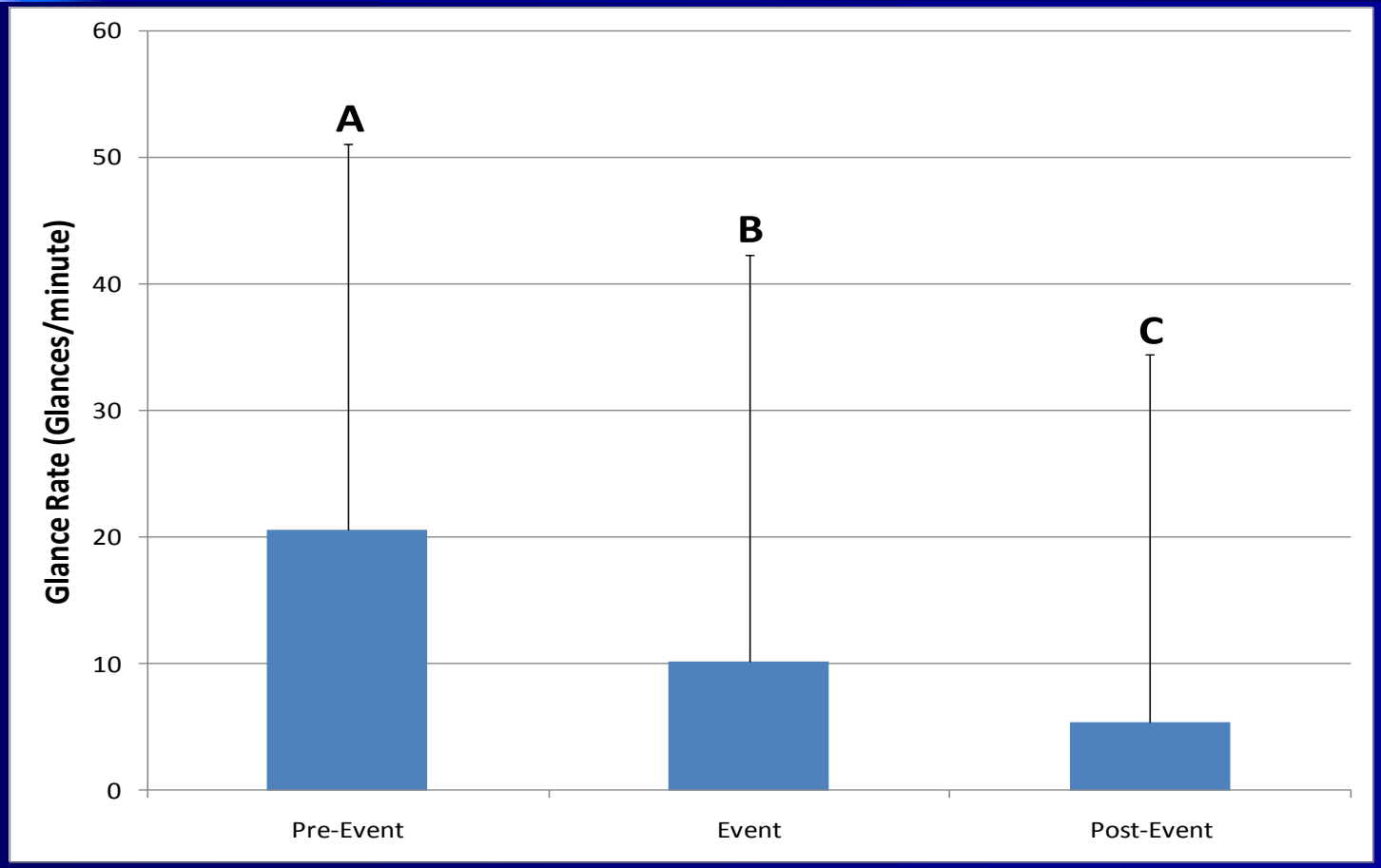
- Natural task behavior on secondary systems sometimes has a more "random-walk" quality to it than task analyses typically capture
- Natural goals can be related to satisfying a personal need ("I'm searching for a song that matches **my** tastes")
- And may result in "hunting" or "searching" and/or "wandering/exploring" behavior until the need is met -- or the goal abandoned
- Many task analytic methods do not capture this type of exploring/searching behavior to satisfy a uniquely personal need . . . so naturalistic data suggest that techniques for identifying use cases and modeling them may benefit from updates and enhancements

Naturalistic patterns reveal "explore" vs. "use" driver behaviors/strategies

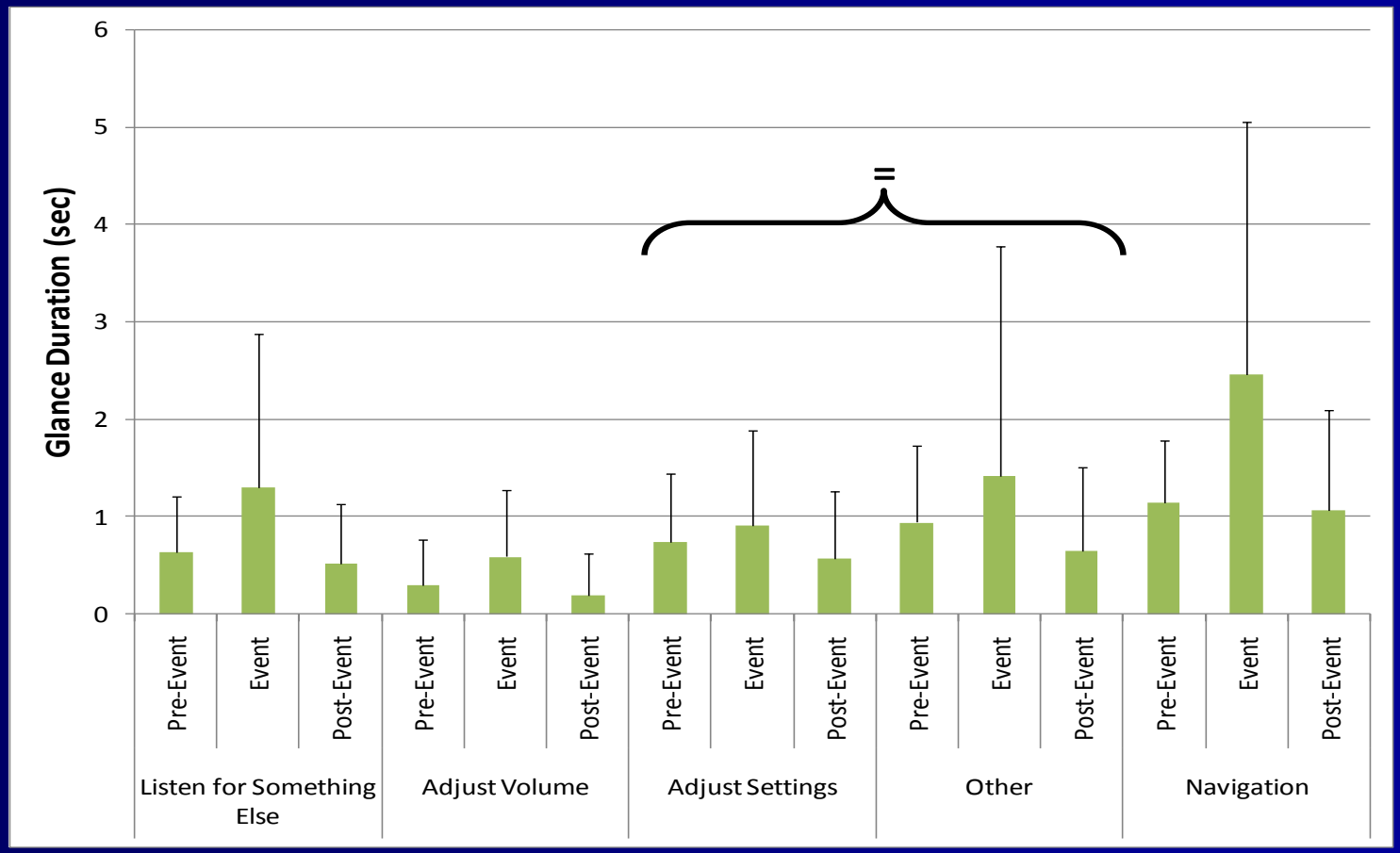
Glance Behavior

- Revealed the importance of
  pre- and post- event periods of glancing
- These are often only partially captured by standard methods of task evaluation (usually glances are scored from task command to last control input)
- Yet both "before" and "after" periods can be very informative indicators of
  - Usability
  - Eyes-Off-Road Time & Crash Risk

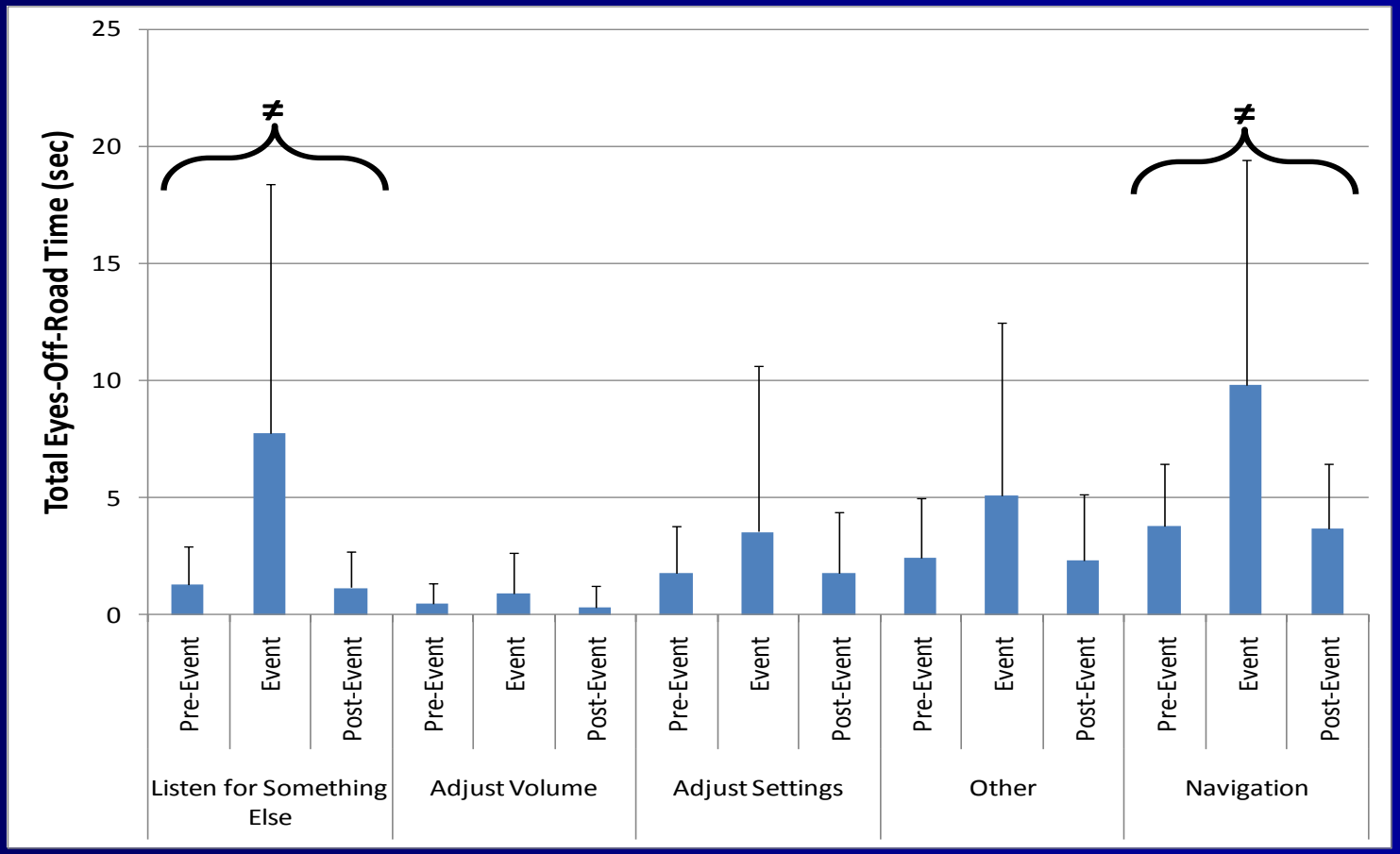
Glance Rate – Events



Glance Duration – Events



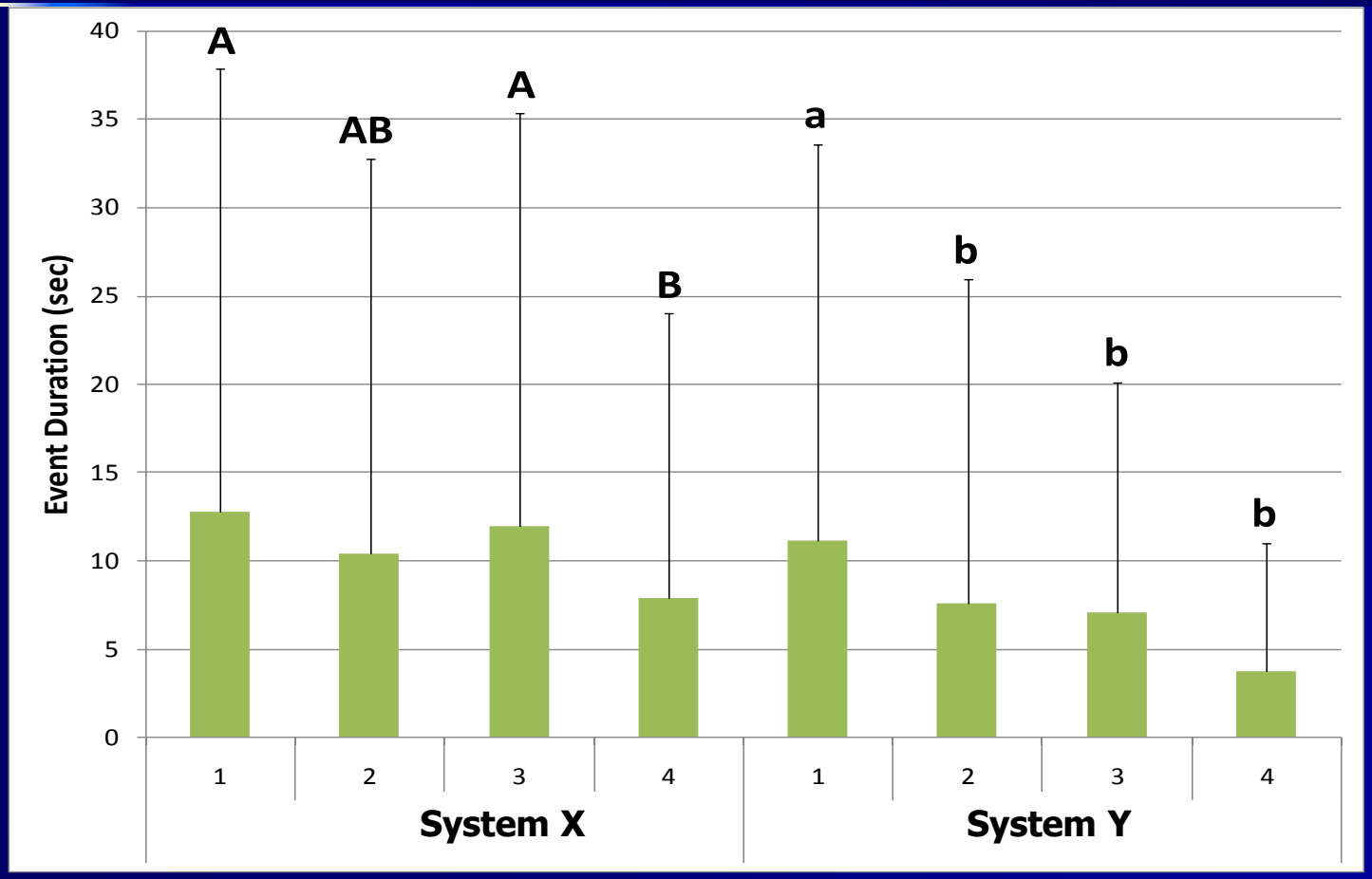
Total Eyes-Off-Road-Time: Events By Goal



Skill Acquisition:
Most usage patterns were remarkably robust over time

- There was less change as a function of time with device than expected
- There was some initial novelty effect that declined somewhat over the 4 weeks
- However, at the level of goal-oriented behaviors, rates of usage changed very little over time
- Some skill with each system was acquired over time

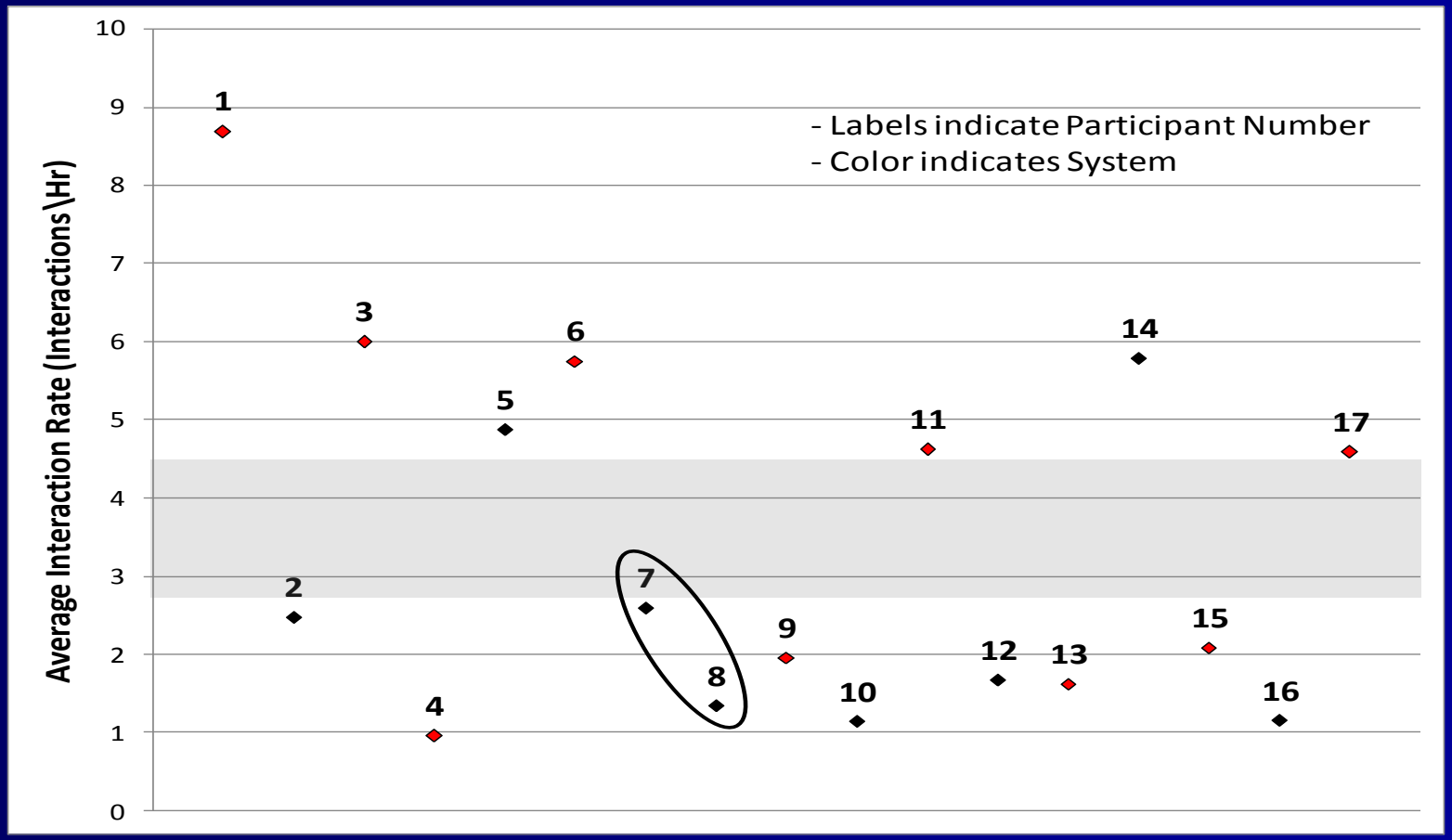
Event Duration Shortened
As Skill Was Acquired Over Weeks



Different types of users

- Low usage
- High usage
- Are there also “risky” and “conservative” sub-types of users?

Clustering of Interaction Rates: Two Groups of Users



Conclusions

- Naturalistic data is rich with information that can be applied during development of new vehicle systems and capabilities
  - New information & entertainment systems
  - New driver assistance systems
  - Introduction of autonomous capabilities to the driver-vehicle system
- As more new technologies enter the automobile, the opportunities for applying naturalistic data on driver usage patterns will continue to expand

Thanks!

linda.s.angell@gm.com
miperez@vtti.vt.edu