Overview of Behavioral Adaptation Research and ADAS

Reaching Zero Crashes: A Dialogue on the Role of Advanced Driver Assistance Systems
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Overview

• What is behavioral adaptation?
  – Early ideas
  – OECD definition
  – Early examples

• Behavioral adaptation models in historic context
  – “Zero-risk” theory
  – Risk homeostasis theory
  – Looking beyond motivational theories

• ADAS technologies and new models of behavioral adaptation
  – Fragmentation of the driving task into part-task driver support
  – Part-task automation and driver engagement
  – Driver personality, trust, and understanding ADAS technology
Historical perspective: Behavioral Adaptation (BA) has been a concern since 1938

• In an early study of automobile driving, Gibson & Crooks (1938) noted that:
  – “...more efficient brakes will not in themselves make driving any safer.” Because, they argued:
  • The driver will learn the minimum stopping zone
  • And the driver will adjust braking to maintain the same safety margin as before.

• Behavioral Adaptation has been a key concern for both active and passive safety
  – It is difficult to predict
  – It threatens to undermine expected safety benefits
Examined behavioral adaptation, defining adaptation as:

– “…behaviors which may occur following the introduction of changes in the road-vehicle-user system which were not intended by the initiators of the change”

– The OECD examined adaptation effects on overall safety in a variety of contexts
Most initial improvements were related to performance and occupant protection

- It was argued that behavioral adaptation occurred in response to drivers feeling safer—drivers might offset this perception of reduced risk, by taking more risks in their driving:
  - Increased aggressive maneuvering
    - Speeding
    - Increased lane changing
    - Hard braking
  - Close following distance
  - Small gap acceptance
Initial theories of behavioral adaptation

- Zero-risk theory (Näätänen & Summala, 1974)
  - Drivers monitor subjective risk continuously
    - Risky action is allowed when no risk is detected
    - Risky action is inhibited when subjective risk exceeds a critical point
- Risk Homeostasis (Wilde, 1982)
  - Drivers regulate risk by evaluating the utility of risky behavior and its cost against the utility of safe behavior and its cost.
    - The theory suggests that any measure to improve driver safety is offset by a behavioral change—no net improvement in safety
- Risk Allostasis Theory (Fuller, 2005)
  - Drivers balance their perceived capability to handle a task with perceived difficulty of the task
Motivational theories

- Target level of risk
- Perceived level of risk
- Comparator
- Desired risk adjustment
- Change in behavior

Change in behavior
ADAS has changed the view of behavioral adaptation

- ADAS technologies do more than enhance vehicle performance—they now support and share specific parts of the driver’s task:
  - Control functions:
    - ACC, LKA
  - Lookout functions:
    - Forward collision, Lane departure, Rear cross traffic, Side object
  - Extend driver sensory capability:
    - Night vision pedestrian/animal detection
  - Automatic intervention:
    - CIB, ESC, ABS
New models of BA look for specific behavioral effects

- Adaptation is influenced by the driver’s:
  - *Mental Model* of how the ADAS functions
  - Personality factors
  - Trust/belief

- Effects of BA play out at different performance levels of the driving task:
  - Strategic
  - Tactical
  - Operational
What does BA look like?

- **Change in control behavior**
  - Increased response time to hazards or system failure
  - Shorter following distance
  - Decreased monitoring forward scene

- **Change in tactical behavior**
  - Decreased overtaking maneuvers
  - Cruise speed settings increased when a lead vehicle is present
  - Passing maneuvers begin at greater distance from forward vehicle

- **Change in strategic behavior**
  - Increased engagement in non-driving secondary tasks
  - Loss in situation awareness
  - Preferences for roadways that better support ADAS

*Figure 1. A hierarchical model of the task of driving (from Michon, 1985).*
State of research on BA

• Last 20 years:
  – Mostly simulator-based studies
  – Mostly lateral, longitudinal, or “highly-automated” control studies
  – Mostly limited exposure durations—20-45 minutes
  – Concern focused on over-trust of system; loss of situation awareness

• Recent trends:
  – Interest in driver’s trust and mental model of ADAS
  – More longitudinal studies of how trust and understanding develop
  – More on-road/field studies over longer periods of time
  – Increased interest in longer-term behavior adaptation
Some conclusions about Behavioral Adaptation and ADAS

- Behavioral adaptation to ADAS is highly variable and depends on:
  - How obvious is the ADAS intervention?
  - How much exposure does the driver receive?
  - What does the driver understand about ADAS capabilities (mental model)?
  - If ADAS limits are rarely encountered, drivers will be likely to forget them and be unprepared to intervene
  - Adaptation effects will likely be specific to the ADAS
Thank you

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