Active Safety Needs Teen Drivers

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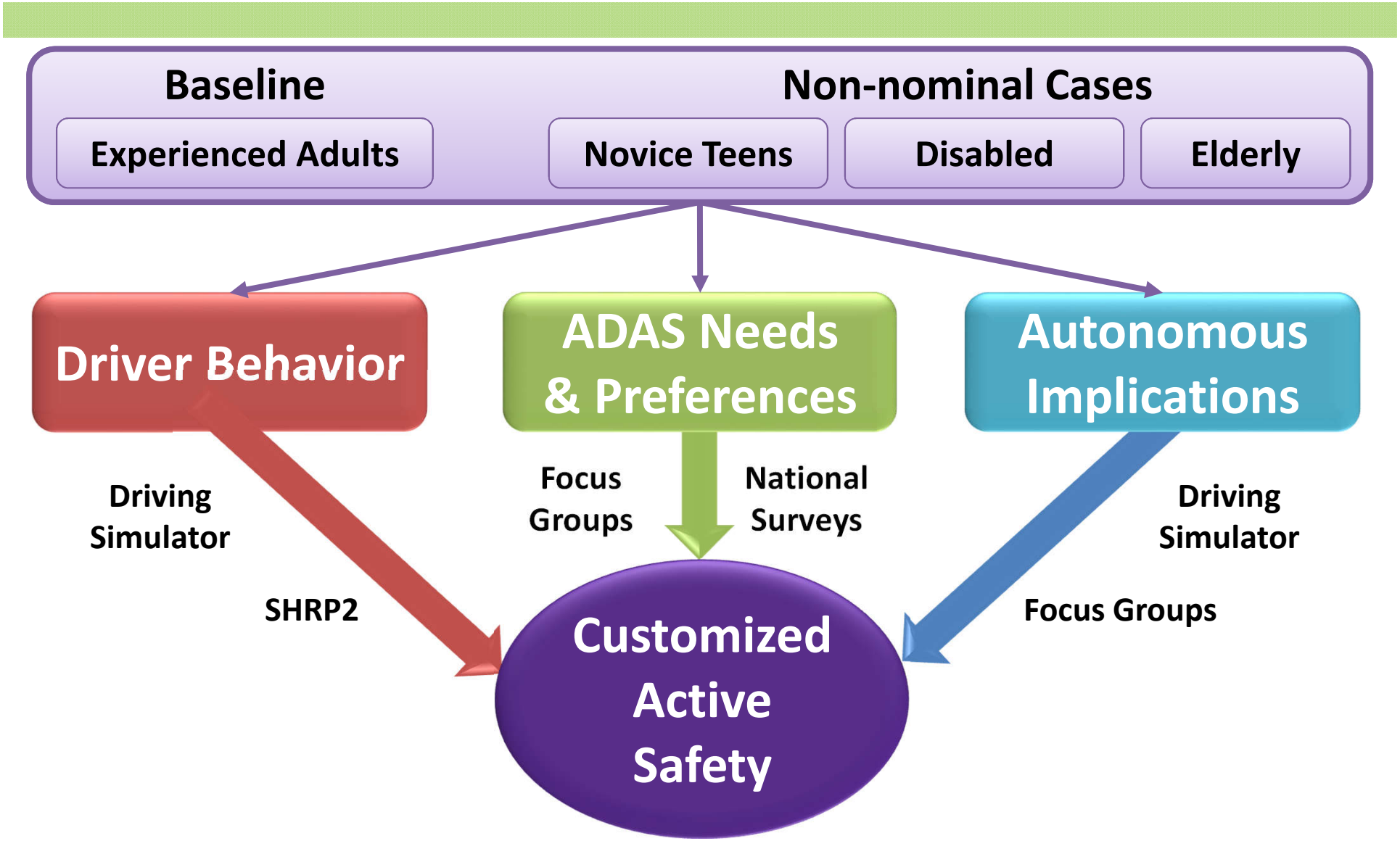
Customized Active Safety



Burden of MVC for Teen Drivers

- More than 35,000 people died in motor vehicle crashes (MVCs) in 2015 (+7.2%)
  - Early 2016 estimates +10% from 2015
- Teens disproportionately represented in MVCs
  - 2,632 MVC deaths in 2014
  - Fatal crash rate 3 times drivers 20+ yrs (IIHS 2014)

Limitations of Existing Data

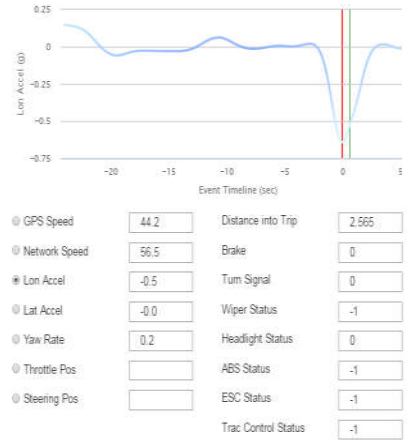
- Current crash rates focus on fatal or police reported crashes only
  - 30% of all crashes, particularly non-injurious crashes, are not reported to police (M. Davis 2015)
- Crash rates normalized by miles driven
  - Difficult to obtain accurate measure; often estimated
- Large scale naturalistic driving studies can be used to compute accurate crash rates
  - Inclusive of all crashes; exact miles driven

Previous Teen Naturalistic Studies

- 100-Car Study (Dingus et al. 2006)
  - Driving behavior of 18+ yrs for one year
  - No crash rates reported
  - Only 20% of crashes were reported to police
- Teen IVBSS Study (Buonarosa et al. 2013)
  - 40 teen drivers
  - Did not calculate crash rate
- Simons-Morton et al. (2011)
  - 42 teens/parents for first 18 months of licensure
  - Teen crash rate nearly 4 times greater than parents'

Strategic Highway Safety Program 2 (SHRP2)
Naturalistic Driving Study

- SHRP2 NDS – largest ever undertaken
  - Over 3000 drivers (Ages 16-99 yrs)
  - Six sites (Urban & Rural)
  - Fully instrumented vehicles
  - Collected data for 3 years
  - Data managed by VTTI
- Crashes & near crashes
  - 20 sec prior, 10 sec post
- Baseline driving



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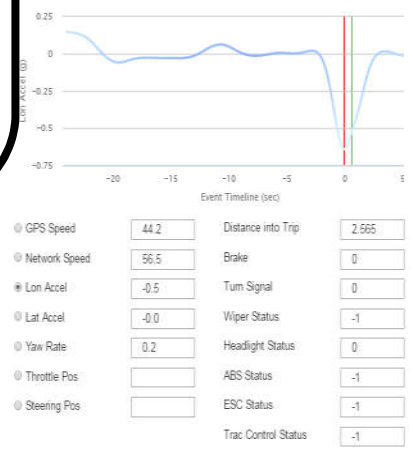
Cumulative SHRP2 Data:

- Over 5 million trips
- 49.7 million miles
- 2 petabytes (PB) of data
- 3958 years of driving



SHRP2 Database

Vehicles

- Vehicle types (car, truck, van, etc.)
- Vehicle ages and condition
- Amount of data collected per vehicle
- Quantities of vehicles installed
- Vehicle technologies and equipment

View…

Trips

- Summary measures describing trips
- Trip length, duration, start time, stop time
- Min, max, mean for speed, acceleration
- Trip summary record table
- Trip density maps

View…

Drivers

- Numbers of participating drivers
- Amount of data collected per driver
- Driver demographics and driving history
- Driver physical and psychological state
- Driver participation experience

View…

Events

- Crashes, near crash, and baseline event records
- Events by type and severity
- Event viewer

View…

Advantages of SHRP2

- Reliably capture crashes and driving exposure
  - Inclusive of all crashes, near crashes
  - Accurate number of miles driven
  - Balanced-baseline samples
- Driver demographics & behavior
  - Background surveys, in-board cameras, secondary tasks
- Vehicle dynamics
  - Acceleration, velocity, radar data
- Environment
  - Weather, road type/conditions, time

Data available at Event & Trip level

Project Goal

- To compute crash rates for novice teen and experienced adult drivers using SHRP2
  - Initial focus on rear-end striking crashes
    - Most common crash scenario for teens (McDonald 2014)
- SHRP2 InDepth: All crashes, near crashes, and baseline driving events for:
  - Novice Teens 16-19 yrs (n=549)
  - Experienced Adults 35-54 yrs (n=591)

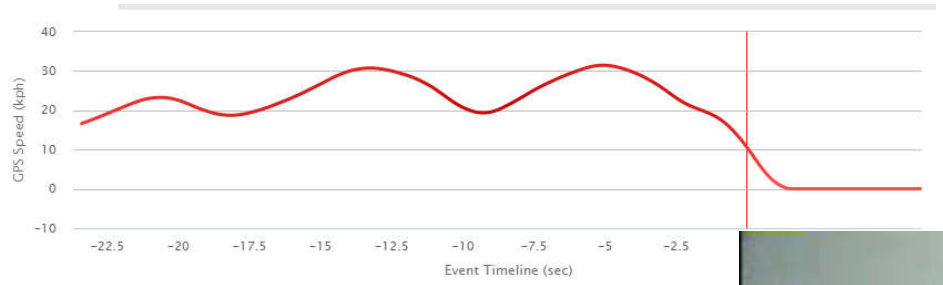
Exposure and Crashes

				All Crashes		Rear-Ends	
Group	**Age**	**N**	**Miles**	**Crashes**	**Rate**	**Crashes**	**Rate**
Teens	16-19	549	4,205,474	87	20.7	39	9.3
Adults	35-54	591	5,651,315	15	2.7	5	0.9
Total / Ratio		1140	9,856,789	102	**7.7**	44	**10.5**

While teens accounted for 43% miles, teens were involved in 85% of crashes.

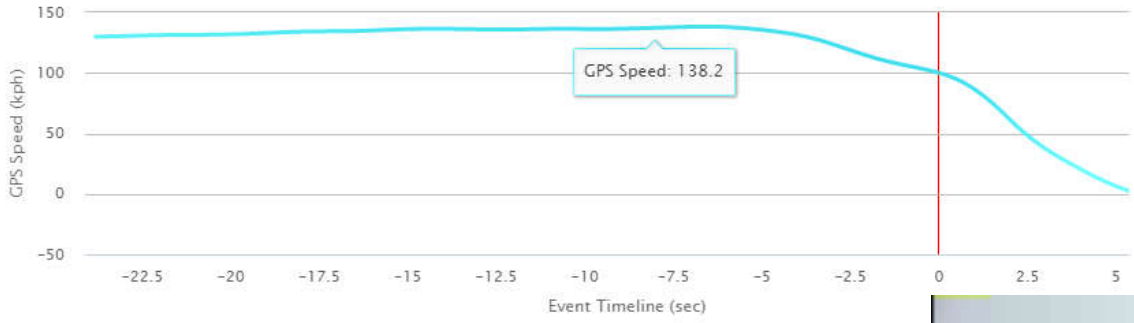
Crash rate ratios higher what was reported in literature.

Exemplar Intersection Event



GPS Speed	0.0	Distance into Trip
Network Speed	1.3	Brake
Lon Accel	0.0	Turn Signal
Lat Accel	-0.0	Wiper Status
Yaw Rate	-2.1	Headlight Status

Exemplar Road Departure



GPS Speed	0.0	Distance into Trip
Network Speed	0.0	Brake
Lon Accel	0.0	Turn Signal
Lat Accel	0.0	Wiper Status
Yaw Rate	-0.2	Headlight Status

Crash Severity
Using SHRP2 Categories

Severity	Teen	Adult	SHRP2 Severity Definition
Severe			Any crash that includes an **airbag deployment**, any **injury** of driver, pedal cyclist, or pedestrian; a vehicle rollover; a **high Delta V**; or that requires **vehicle towing**
Police-Reportable			Includes sufficient property damage that it is police reportable (**minimum of ~$1500 worth of damage**). Also includes crashes that reach an acceleration greater than **+/-1.3 *g***
Minor			Includes **physical contact** with another object but with **minimal damage**

Crash Severity – Rear Ends
Using SHRP2 Categories

Severity	Teen	Adult	SHRP2 Severity Definition
Severe	16*	0	Any crash that includes an **airbag deployment**, any **injury** of driver, pedal cyclist, or pedestrian; a vehicle rollover; a **high Delta V**; or that requires **vehicle towing**
Police-Reportable	14	1	Includes sufficient property damage that it is police reportable (**minimum of ~$1500 worth of damage**). Also includes crashes that reach an acceleration greater than **+/-1.3 *g***
Minor	9	4	Includes **physical contact** with another object but with **minimal damage**

*6 teen Severe rear-ends had airbag deployment

- 14 total airbag deployments in SHRP2

Crash Severity

Most Severe Adult Crash

- No airbag deployment
- Minor fender bender

Crash Severity

Exemplar Severe Teen Crash

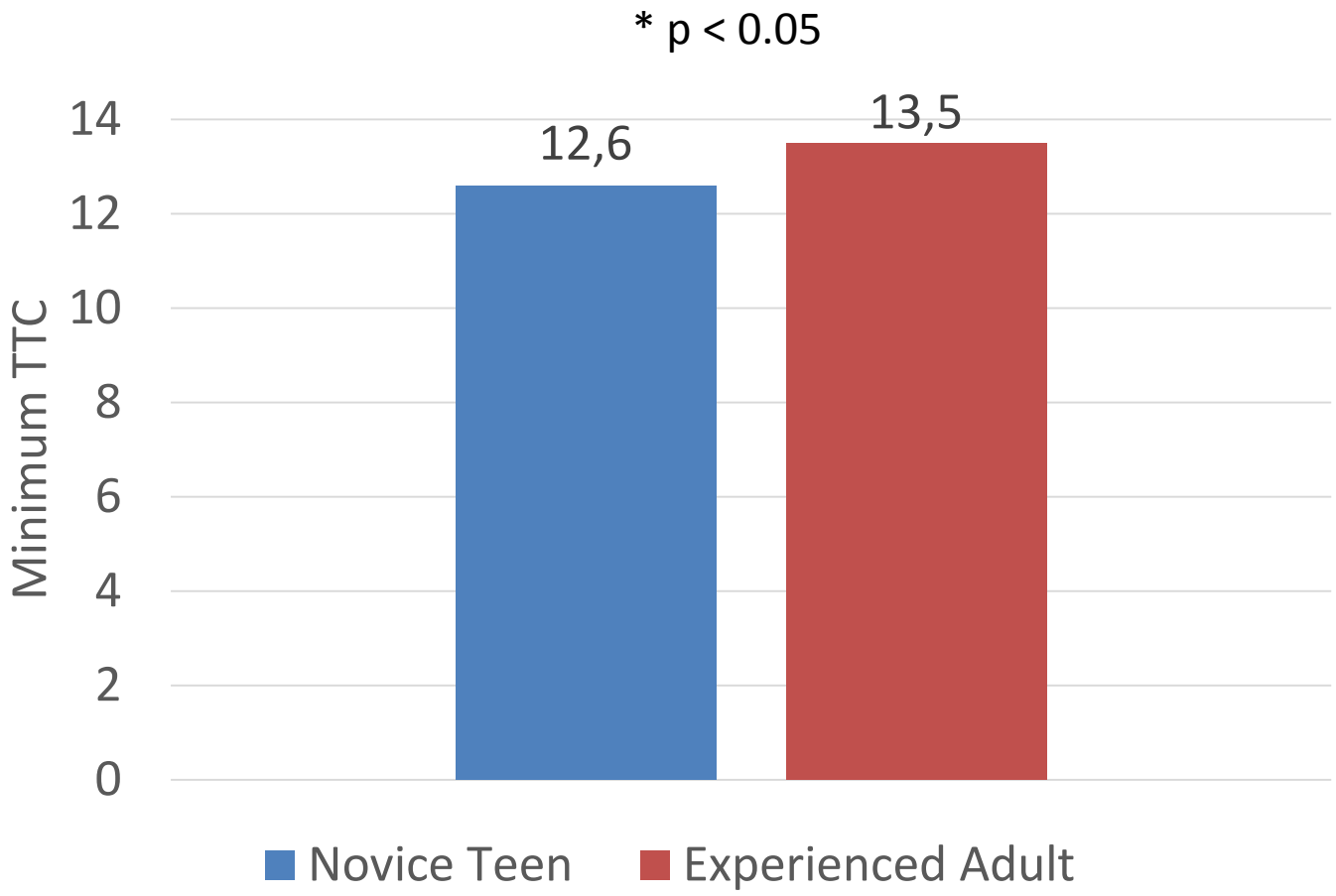
- Airbag deployment
- Highway speed impact with stationary vehicle

Baseline Driving

Group	Drivers	Miles Driven	Trips	Baseline Samples
Novice Teen	549	4,205,474	763,257	2,670
Experienced Adult	591	5,651,315	892,956	3,550

- Car-following:
  - Presence of lead vehicle with Time Headway < 4 sec
  - Velocity greater than 25 km/h
  - 20 second epochs

Baseline Results
Minimum TTC



Baseline Results
Wiedemann Model

- Helps visual car following by relating following **distance** (ΔX) and **velocity** (ΔV)

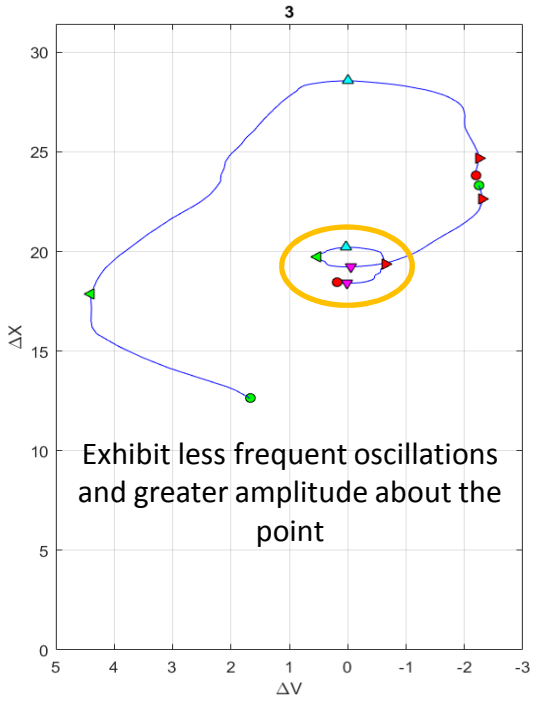


Exhibit less frequent oscillations and greater amplitude about the point

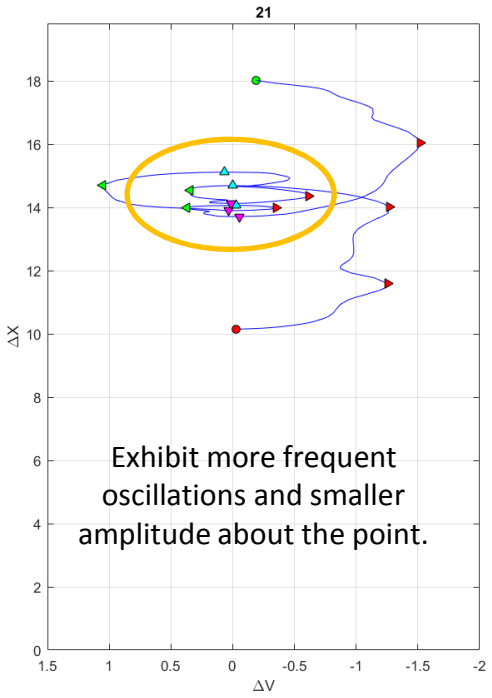
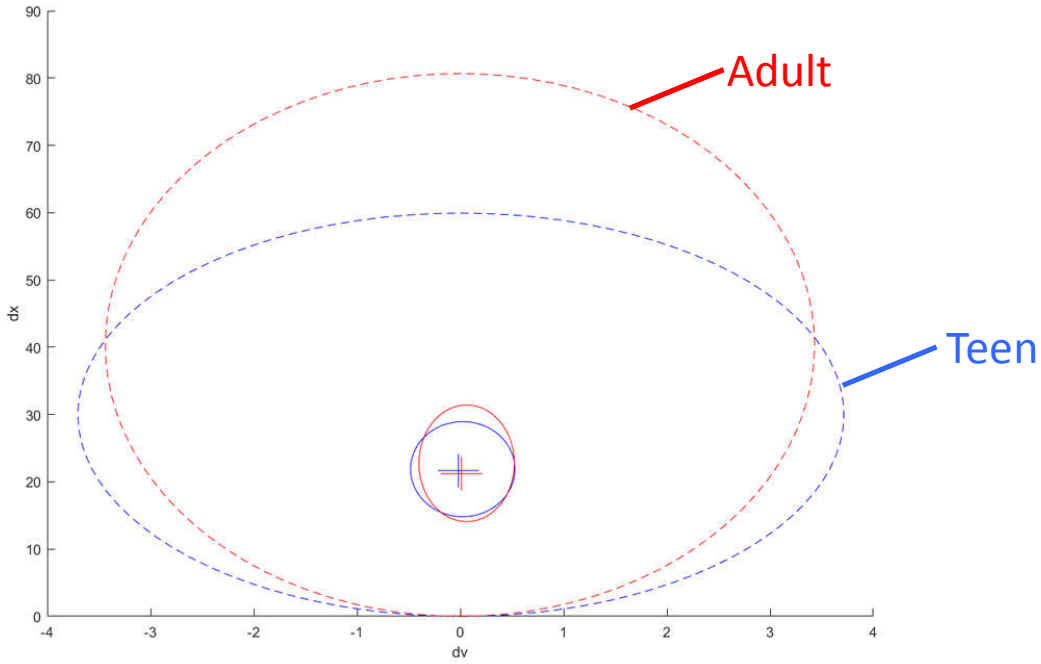


Exhibit more frequent oscillations and smaller amplitude about the point.

Baseline Results
Car-Following Behavior



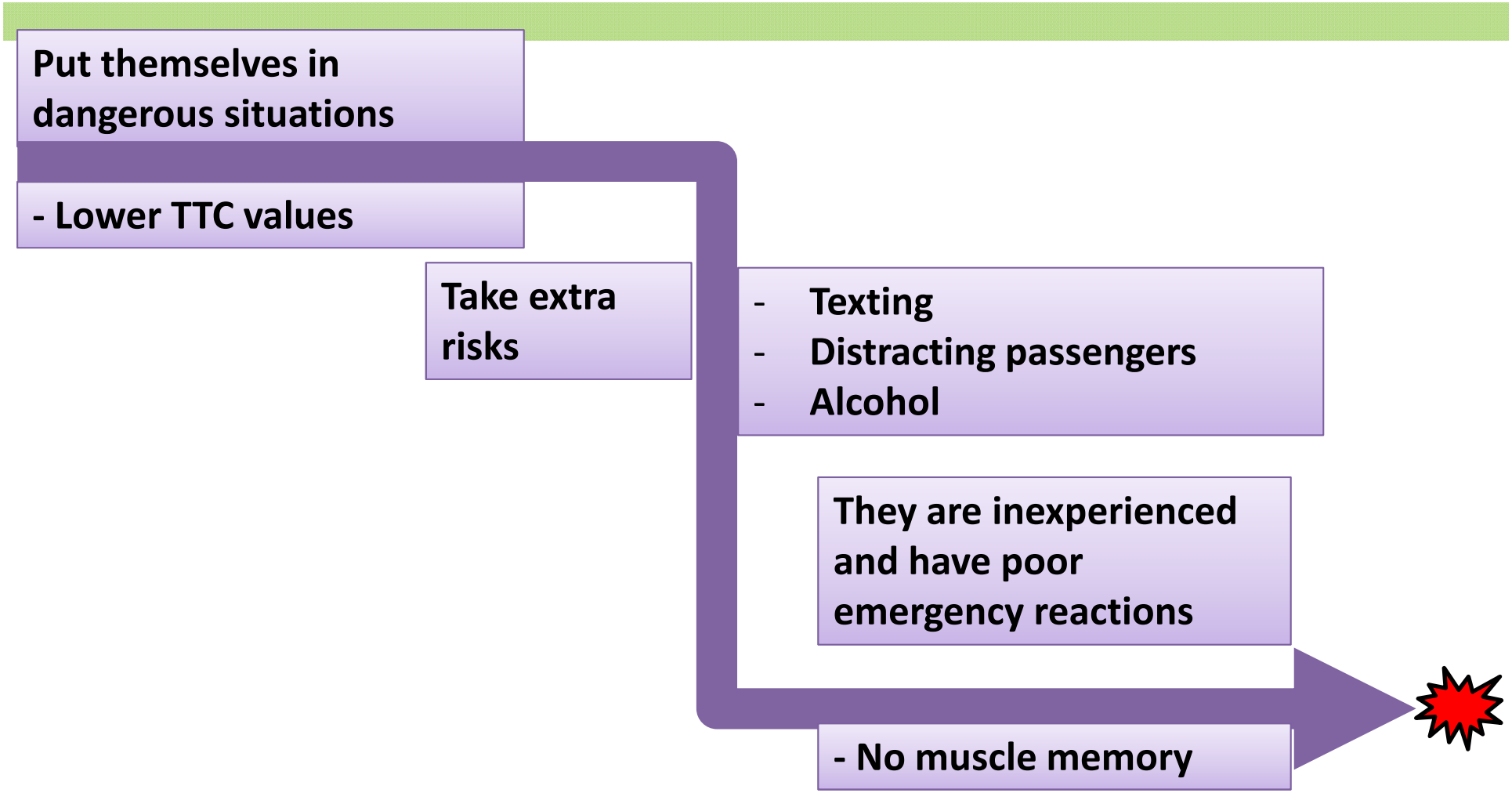
- Teens exhibit increased variation in velocity
- Teens follow closer to lead vehicle

Teen Driving Simulator Results

- CHOP simulator study
  - 60 teens, 20 adults
  - Sudden car scenario
- 10% of teens exhibited "pedal confusion"
  - Accelerated
  - Missed brake pedal
  - Hit both pedals

Loeb et al (2015). Emergency braking in adults versus novice teen drivers: response to simulated sudden driving events. Transportation Research Record: Journal of the Transportation Research Board, (2516), 8-14.

Why Do Teens Crash?
The Perfect Storm



Example: Speed, Snow, and Cell Phones

Final Narrative: Subject is traveling on a snow covered undivided two-way road. Subject begins to look down at a cell phone while traveling at an unsafe speed for the conditions (around 40 mph). Subject vehicle begins to drift to the right toward the edge of the road where there is more snow. Subject steers left to correct the vehicle but over steers because of the snowy conditions. Subject vehicle begins to head toward the opposite lane. Another vehicle (V2) approaches in the opposite direction. Subject must steer hard to the right to avoid a collision with V2. Then, subject must steer back to the left after coming close to leaving the roadway on the right again. Subject finally regains control and begins to manipulate her cell phone again

Active Safety Technology Compensate for Skill Deficits

- ADAS can potentially compensate for skill deficits
  - Limited research on suitability of ADAS for teen drivers
    - Population with greatest potential to benefit from ADAS
- ADAS are only effective if teens and parents are:
  1) Willing to purchase and use ADAS in their vehicles
  2) Receptive to how ADAS presents warnings or autonomously corrects for driver misbehavior

Goals

- Understand perceived need and perceptions among teen drivers and their parents.
  - Identify end-users' gaps in understanding
  - Identify attitudes and norms of teen drivers regarding these new technologies
  - To determine technological preferences and potential acceptance of ADAS among teens

Methodology

- Focus Groups (guided discussions)
  - 3 x Teen Drivers (16-19 years) groups
    - Varying demographics and driving experience
  - 2 x Parents of Teen Drivers groups
- Identify predominant themes and range of opinions

Methodology
Focus Groups

- Participant intake survey (~5 min)
  - Demographics, vehicle information
  - Self assessment of driving skill, risk-taking
- Initial presentation on ADAS (~15min)
  - Exemplar videos of ADAS
- Guided discussion (~70 min)
  - Questions about ADAS and behavioral impacts

- Initial Presentation on ADAS: Most common ADAS forms in the US
  - Purpose of each system
  - Exemplar video of ADAS

Warning Systems	
• **Back-Up Alert** • **Blind Spot Warning** • **Cross-Traffic Alert** • **Curve Speed Warning** • **Forward Collision Warning**	• Lane Change/Merge • Lane Departure Warning • Pedestrian Warning • Speed Limit Warning
Automated Safety Systems	
• **Electronic Braking** • **Lane Keeping Assist** • **Pedestrian Braking**	• Pre-Collision Braking • Reverse Collision Stop • Speed Limiting

Guided discussion topics

- General perceptions of ADAS
- Pros/cons of ADAS
- Trust: reliability of technology; driver confidence
- Learning to drive: should teens learn on ADAS-equipped vehicles?
- Driving behavior: would driving an ADAS-equipped vehicle impact behavior?
- Data Concerns: cybersecurity and privacy
- Liability Concerns: who bears fault in a crash
- Optimal warning methods for teens
- Preferences across ADAS options: Drowsy driver alert; Blind Spot Monitoring; Lane keeping assist; Forward Collision Warning; Speed Modification; Automatic Braking
- Ability to modify/deactivate system

Teen Results

- Teens are savvy, opinionated consumers
- Teens are skeptical of technology
  - Know it can fail
  - Overconfidence in driving ability v "machine"
- Teens prefer to learn on non-ADAS cars
  - Skill development
  - Intuition development
- ADAS technology may increase distracted driving

Theme 1: Trust

- Initial skepticism - potential for failure
- ADAS should be considered a supplemental aid

- *"Just because it's helping us doesn't mean it's going to save us…It's not there to drive for us."*

- *"I was thinking about, like what if it doesn't do what it's supposed to do, and it just stops you in the middle of the road, and you're just like - I can't move?"*

- *"I'd rather trust myself than some iffy technology. I'm just saying, if we don't actually know if it works and it's just in the beginning stages, I do trust myself as a driver."*

- *"There's no downside to having it."*

Theme 2:
Technology Preferences – Tailoring ADAS

- Assumed early-stage ADAS would be oversensitive
  - Create stress, overstimulation, and distraction

"But my concern is…would there be a different beep for each of them? And if it's like beep, then you're, 'Wait. Which one? Where am I messing up?'"

- Annoyance was a significant thread in discussion
  - May cause teens to ignore or deactivate ADAS

"I think it's really helpful, but sometimes it just comes up when nothing is a problem. And the noise is kind of frightening, so sometimes I get freaked out for no reason…It's over-sensitive a lot. Sometimes it can stress you out a little bit if it's too loud and too sensitive."

Theme 2:
Technology Preferences – Tailoring ADAS

- Consequently, teens felt strongly that ADAS must be customizable
  - Many felt need for "on/off" option

- Preference for visual, auditory, or haptic
  - Teens preferred visual + haptic
  - Auditory was least popular

Theme 3:
Value of ADAS

- Teens recognized inherent value of ADAS
  - Overall felt ADAS was worth cost of purchase

"Even if it costs more…if it saves your life, it's pretty worth it."

*"Having [ADAS] would limit a lot of tragedies…
I would definitely be less inclined to drive recklessly with these devices in my car."*

"I think this technology is very cool. And it's definitely something that is going to be very prevalent in our lifetimes – in our generation especially…"

"Before I came in here, I didn't even know about all the different things that you could use. Now that I do, I can see that a lot of them could be really useful for me."

Theme 4: Learning to Drive

- ADAS effect on driving skills:
  - Learning to drive on ADAS vs. non-ADAS vehicle
    - Majority of parent and teen participants believed new drivers should learn on a non-ADAS vehicle
    - Several teens said learning to drive on a non-ADAS car would enhance awareness of their surroundings,
      - traffic patterns, geography, directions, and safety
    - Concern that ADAS use will inhibit development of intuition
  - "I feel like learning to drive without the system, you'd have to learn to do a lot of things subconsciously. So with the system in place, you might not have some of those same intuitions of driving."

Theme 5: Effect of Driving Behavior

- ADAS Effect on Driving Behavior
  - Distracted driving may increase with ADAS use
  - "It's like if you've been drinking and then you want to drive home and you're like oh, I probably shouldn't because I've been drinking. But -- it's going to save me, like maybe you will."
  - What else might you do? bicker over the aux cord; put make up on; lay down; do homework; be on my phone; Snapchat; text; eat a hoagie; zone out; listen to music; change the radio; engage with passengers…
  - May improve driving by increasing awareness to avoid triggering ADAS warnings

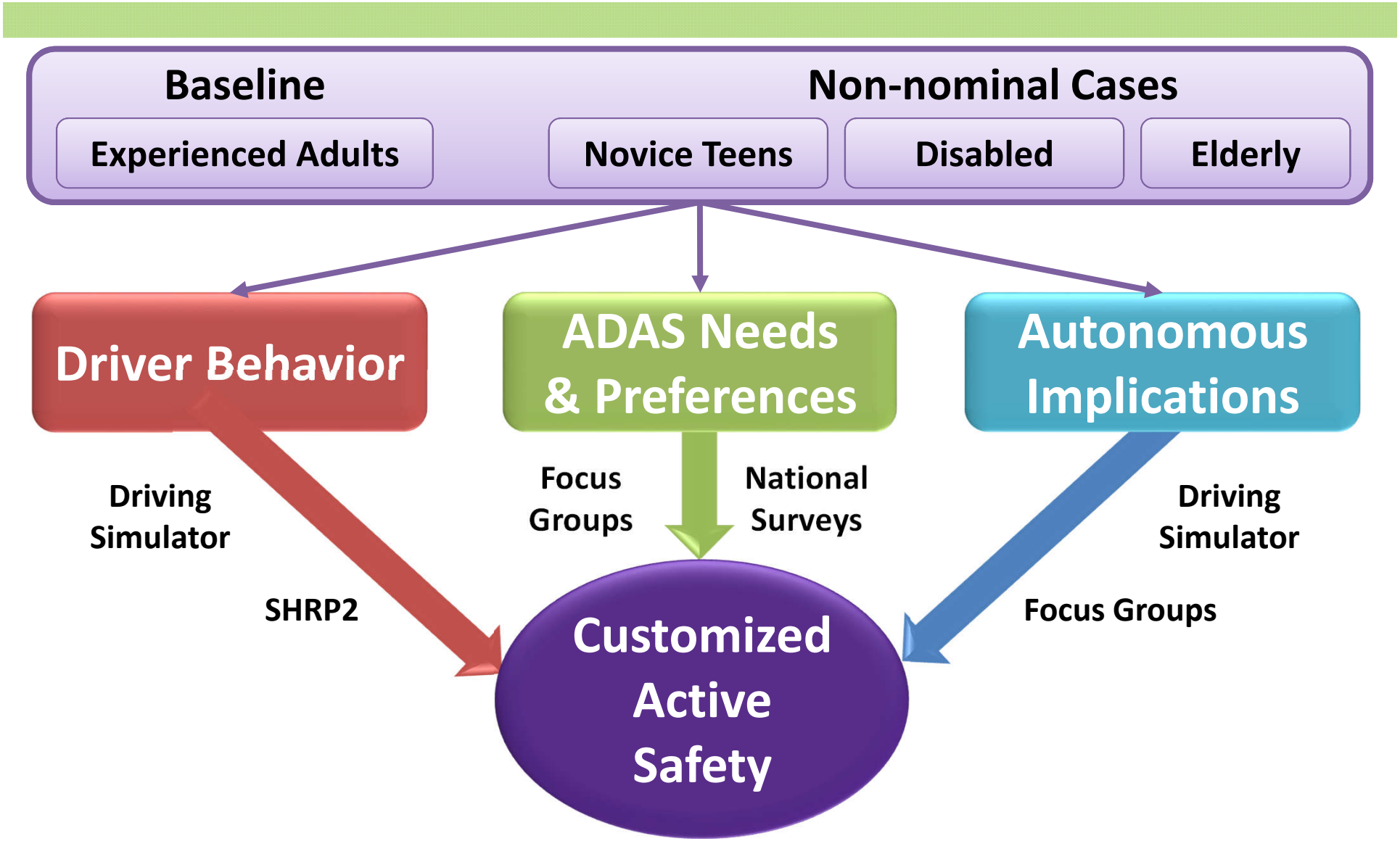
- "It could make you a better driver also because you don't want the thing to be beeping all the time. You'd have to stay in your lane and drive better so if you don't have to worry about it going off, so you stay in the line. It could make you a better driver, pay attention more."

Parent Themes

- Felt ADAS useful support for teen drivers after initial learning phase
- Expressed some skepticism for the technology
- Wanted freedom to customize ADAS to meet their teen's needs
- Optimistic that these technologies might keep their children safer, and more willing to sacrifice control to that end
  - ADAS might foster safer driving since the driver might be more attentive in order to avoid triggering the system

- "Now, every car has a seatbelt. Back then, a lot of cars did not have seatbelts. So maybe 20, 30 years from now, when the majority of cars have this, I think it'll be helpful."

Customized Active Safety



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