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# HOW DO CHILD OCCUPANTS 'REALLY' BEHAVE DURING REAL-WORLD, EVERYDAY DRIVING TRIPS?

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GROUP OF EIGHT AUSTRALIA

# Background

Child Restraint Systems (CRS) provide specialised protection to child occupants in event of motor vehicle crash.

CRS largely optimised through laboratory-based test programs using crash test dummies or anthropomorphic test devices (ATDs) intended to mimic human child occupants.

Current testing programs evaluate CRS performance with ATDs placed in 'ideal or optimal' (upright) positions.

# Background

However, most child occupants do NOT behave like static ATDs.

Recently, naturalistic driving studies (NDS) conducted to study child occupants' positions / behaviours during driving trips (e.g., Stutts et al. 2005; van Rooij et al. 2005; Andersson et al. 2010; Charlton et al. 2010; Forman et al. 2011; Jakobsson et al. 2011; Koppel et al. 2011; Osvalder et al. 2013).

NDS defined as a study *'… undertaken to provide insight into driver & occupant behaviour during everyday trips by recording details of driver, occupants, vehicle & surroundings through unobtrusive data gathering equipment & without experimental control.'*

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# Background

NDS collects more detailed & objective data on a wide range of driver, occupant, vehicle, road, traffic & environmental factors.

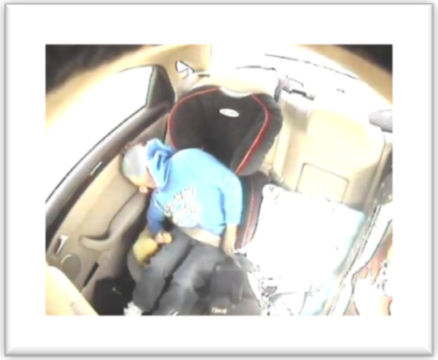


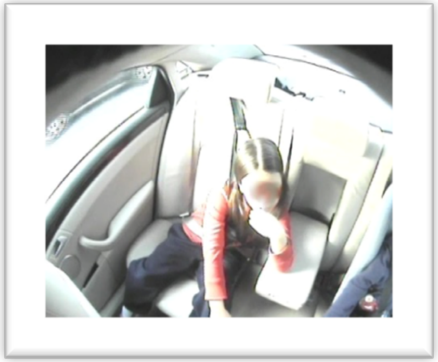
Objective data from NDS can be used to validate findings from other behavioural science techniques such as self-reported studies of driver behaviour & simulation studies:

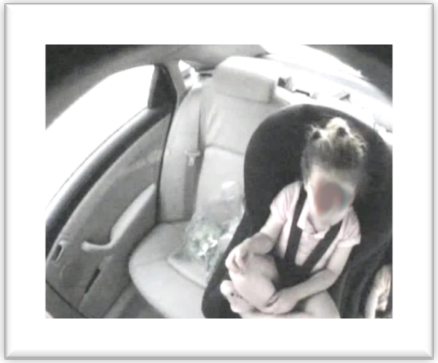
- Drivers do not always do what they say they do (e.g., Myers et al. 2011), &
- Not all findings from simulators are replicated in real traffic, & vice-versa (e.g., Olson et al. 2009).

# Background

Previous NDS shown most child occupants do NOT behave like static ATDs (Stutts et al. 2003; van Rooij et al. 2005; Andersson et al. 2010; Charlton et al. 2010; Forman et al. 2011; Jakobsson et al. 2011; Koppel et al. 2011; Osvalder et al. 2013).







Given child occupants NOT always sitting 'optimal' positions, does this affect specialised protection CRS in event of motor vehicle crash?

Previous NDS with child occupants limited by:

- Small sample sizes;
- Small number of trips (e.g., 1 long trip; 2 short trips etc.);
- Limited details re: child occupants (e.g., ages, gender, CRS type etc.);
- Limited details re: driver (e.g., parent?) & their driving behaviour / performance (e.g., distracted), &
- Presence of observer / photographer (potentially influences child occupants' position & / or behaviour).

# Background

3 year collaboration between researchers from **MUARC** (Charlton, Koppel, Cross, Kuo), **Human Factors North** (Rudin-Brown), **CHoP** (Arbogast, Loeb), **UMTRI** (Eby), **Autoliv** (Bohman) & **Chalmers University** (Stockman, Svensson, Jakobsson).

Aim = observe & quantify child occupant positions / behaviour during everyday driving trips, & to investigate implications of positions / behaviour on injury risk in event of motor vehicle crash, as well as implications of positions / behaviour on distraction & driving performance.

Comprises 3 major components, using complementary approaches:

1. Online survey of parents' knowledge & attitudes related to child occupant safety;
2. NDS focussing on child occupant positions / behaviour, as well as distraction & driving performance, &
3. Sled testing program to explore injury implications of child occupant positions / behaviours.

Findings used to optimise CRS design & testing programs, & develop targeted safety education strategies to prevent child occupant death & injuries that may be related to child occupant positions / behaviour.

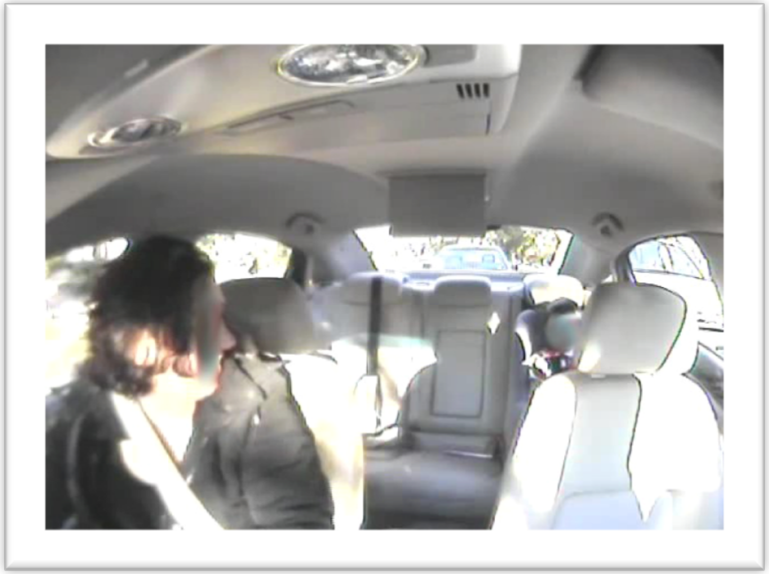
# Method

**Participants**

Recruited Ps who completed online survey & interested in future research (Cross et al, 2017).

Ps eligible if:

- Aged ≥ 25 years;
- Held full VIC driver's licence;
- Lived within 50km of MUARC, &
- Regularly drove child occupant aged 1–8 years restrained in forward-facing CRS / booster seat.



# Method

2 study vehicles: 2006 Holden Statesman & 2007 Holden Calais.

- Both vehicles = luxury-model sedans with automatic transmission.

Each vehicle equipped with 8 pinhole cameras providing perspectives:

- Forward roadway; Backward roadway; Driver's ¼ profile; Driver's lap / centre console; Side view of rear occupants from left / right; Angled view of rear occupants from forward-left / forward-right.


Each vehicle equipped with omnidirectional microphones embedded in central ceiling panel.

# Method

Mobileye® vision systems also installed.

- System = roadway-facing, monocular device which use computer vision to detect & potentially warn drivers of lane deviations, headway distance, & oncoming pedestrians.
- Warning feature switched off; System logged lane deviation & headway data.

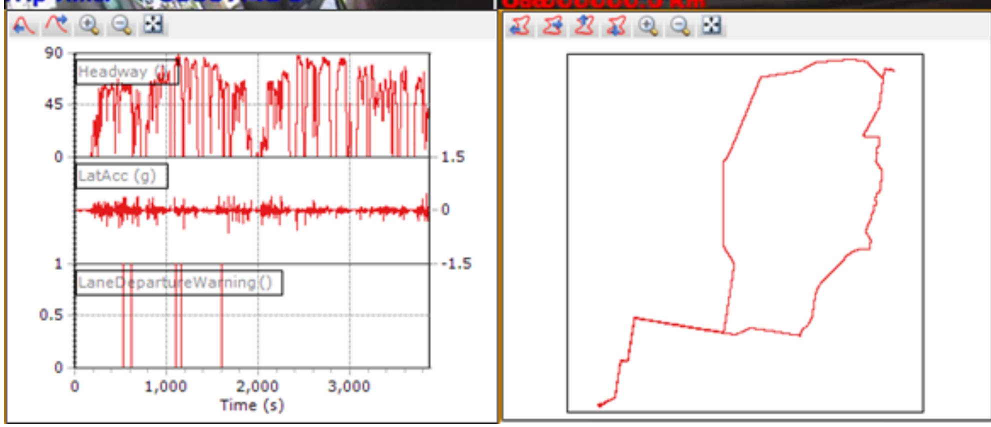
Statesman also equipped with Microsoft Kinect™ sensor.

- Kinect = Microsoft's motion sensor add-on for Xbox 360 gaming console.
- Sensor logged 3D child occupant data to determine position within CRS / booster seat relative to vehicle's hard surfaces.

All recording devices controlled by 2 data acquisition systems (Racelogic VBOX®) located in vehicle boot.

- VBOX® systems collected vehicle data from CAN bus & GPS.
- All data written to SD cards.

# Example of Video & Vbox data


Video data synchronised with vehicle data

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# Method

All data acquisition devices configured to ‘power on’ at vehicle ignition.

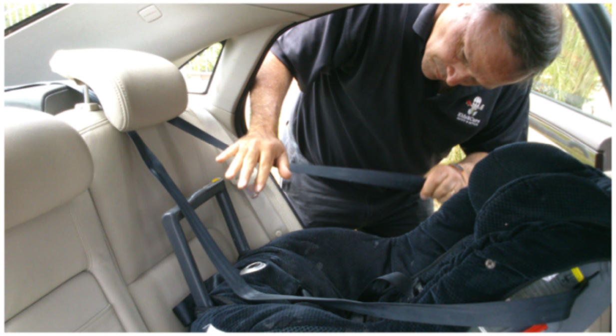
To comply with ethics, stickers prominently displayed in vehicles notifying drivers & passengers that video & audio being recorded.


Additionally, physical button installed that could switch off recording systems & delete trip data if activated by Ps.

# Procedure

Ps provided with vehicle for 2 weeks.

At vehicle handover, professional CRS fitter ensured that Ps' CRS / booster seats were appropriate & correctly installed.



After 1 week, vehicle check-up scheduled.

- Primary purpose = ensure data acquisition devices were functioning correctly.

After 2 weeks, vehicle pickup scheduled.

- Professional CRS fitter installed Ps' CRS / booster seats into Ps' own vehicle.
- Ps given opportunity to identify any trips to be deleted.

# Analysis

42 families (n=81 child occupants) completed n=1,651 driving trips (~690 hrs of video footage):

- Trips = vehicle moved ≥ 200m & vehicle contained ≥ 1 child occupant.

¼ driving trips randomly selected for analysis (n=414, ~102 hours).

- Each trip coded at 9 proportional intervals or epochs (5%, 17%, 25%, 30%, 50%, 53%, 75%, 89%, 95%).

Each epoch (n=3,726) viewed for 5 sec & relevant data extracted manually:

**Trip variables:** Identification of driver; presence / absence of FSP; number of child occupants; other trip details including: duration; day / night; weather; traffic conditions / volume; etc.

**Child-related variables:** Age & gender of child occupants; type of CRS / booster seat used; seating position in vehicle etc.; child occupants' head position (e.g., optimal / shifted); child occupants' CRS / booster seat restraint use (e.g., correct / incorrect); child occupants' behaviour / affect (e.g., passive / active); duration & nature of child occupants' primary activities (e.g., conversation, playing, sleeping etc.).

**Driver-related variables:** Driver demographics (e.g., age & gender); driver's secondary activities (e.g., engagement in potentially distracting activities/secondary behaviours); duration & nature of secondary activities(e.g., mobile phone, child-related, etc.).

**Vehicle variables:** Vehicle kinematics (e.g., speed, acceleration, braking, lateral position, etc.) & GPS.

# Results: (n=42 families; n=81 child occupants)

| Main driver / family characteristics | | |
|---|---|---|
| **Main driver age** | 30-39 years | 60% (25) |
| | 40-49 years | 34% (14) |
| | 50+ years | 1% (1) |
| | Unknown | 5% (2) |
| **Main driver gender** | Female | 69% (29) |
| | Male | 31% (13) |
| **Main driver education level** | University | 81% (34) |
| | TAFE/Technical | 12% (5) |
| | High school | 7% (3) |
| **Number of children per family** | 1 child | 26% (11) |
| | 2 children | 60% (25) |
| | 3 children | 12% (5) |
| | 4 children | 2% (1) |

# Results: (n=42 families; n=81 child occupants)

| Child occupant characteristics | | |
|---|---|---|
| **Age** | 0-1 years | 3% (3) |
| | 1-3 years | 42% (34) |
| | 4-7 years | 41% (33) |
| | 7+ years | 14% (11) |
| **Gender** | Female | 47% (38) |
| | Male | 53% (43) |
| **CRS used** | Seatbelt | 6% (5) |
| | Booster seat | 29% (23) |
| | FFCRS | 61% (49) |
| | RFCRS | 4% (3) |
| **Seating position in vehicle** | Right (Behind driver) | 48% (39) |
| | Centre | 9% (7) |
| | Left | 43% (35) |

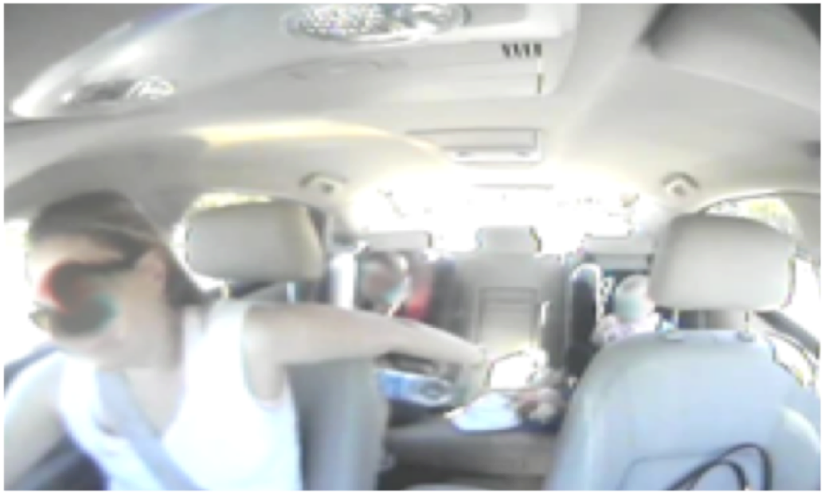
# Results

Most driving trips (n=1,651) undertaken:

- < 20 minutes (80%);
- During the day (06:00-18:00, 93%);
- During the week (70%);
- With 2 rear seated occupants (47%);
- With female drivers (67%) &
- With front seat passenger (28%).

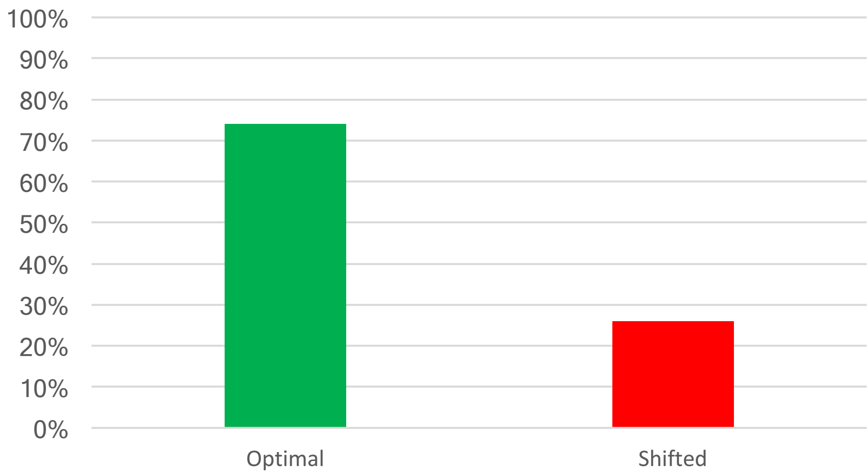
Most driving trips (n=414) undertaken:

- < 20 minutes (79%);
- During the day (06:00-18:00, 95%);
- During the week (72%);
- With 2 rear seated occupants (55%);
- With female drivers (64%) &
- With front seat passenger (32%).

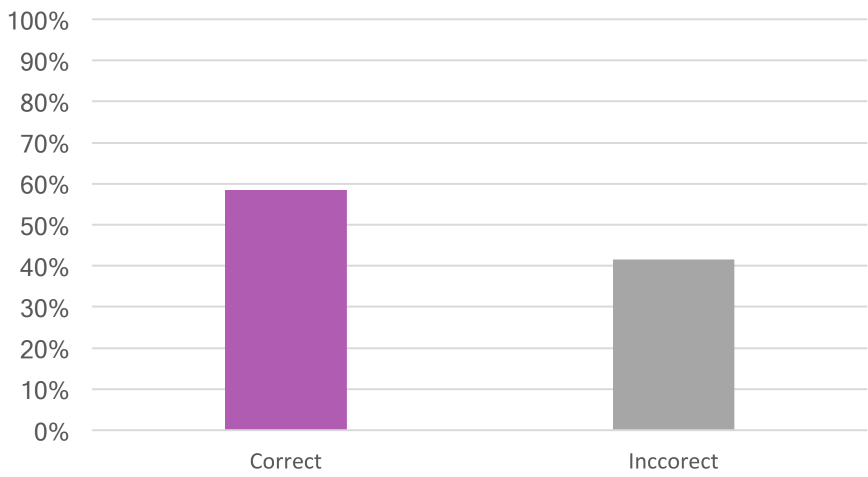


# Results

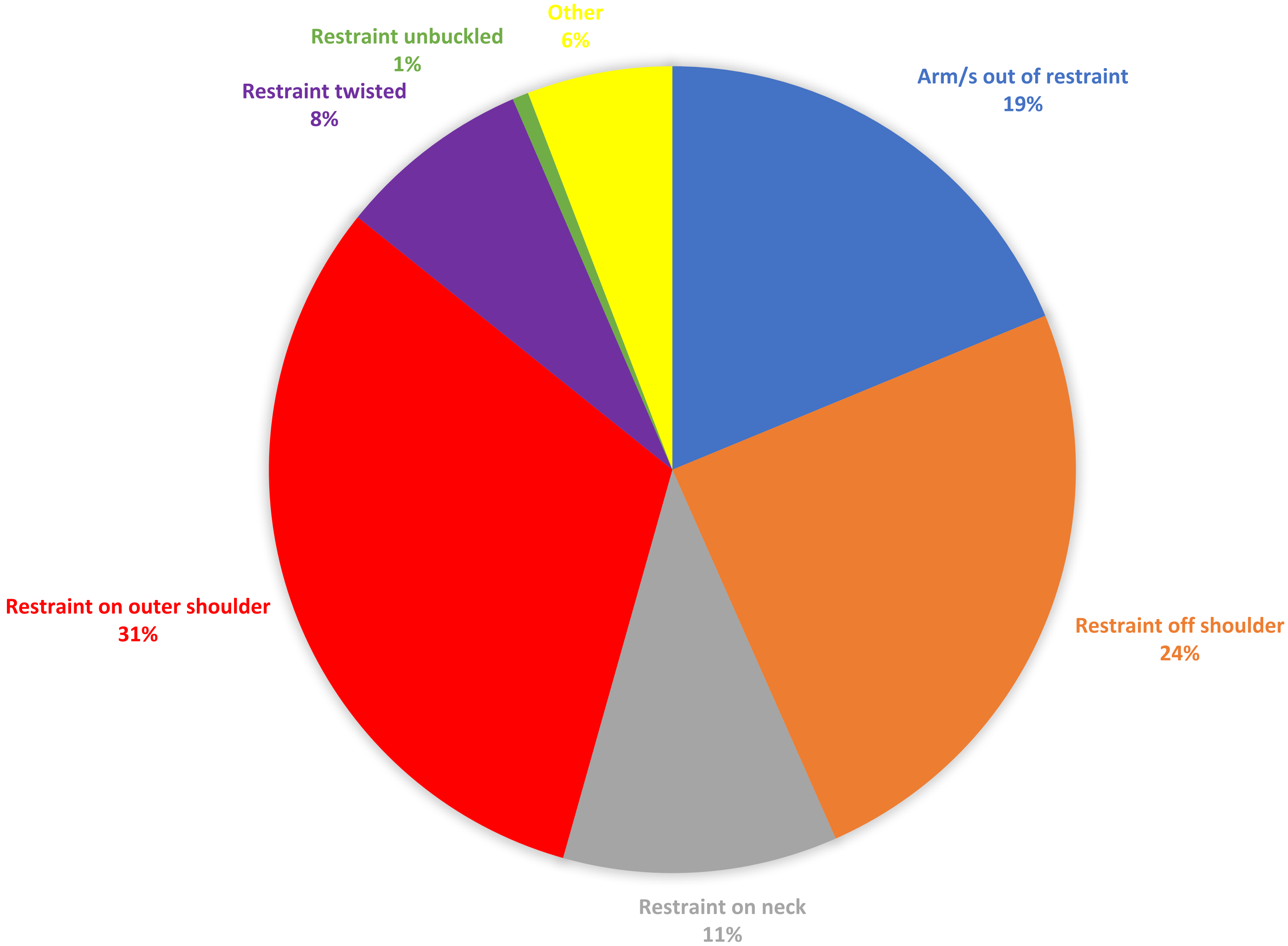
Child occupants' head position most likely to be classified as 'optimal' (79%, i.e., head within protective structure of CRS or booster seat).




Child occupants most likely to be classified as 'correctly' restrained (58%, i.e., not twisted, loosely fit, or unfastened belts / harness).



# Child occupants' incorrect restraint use (shoulder only)

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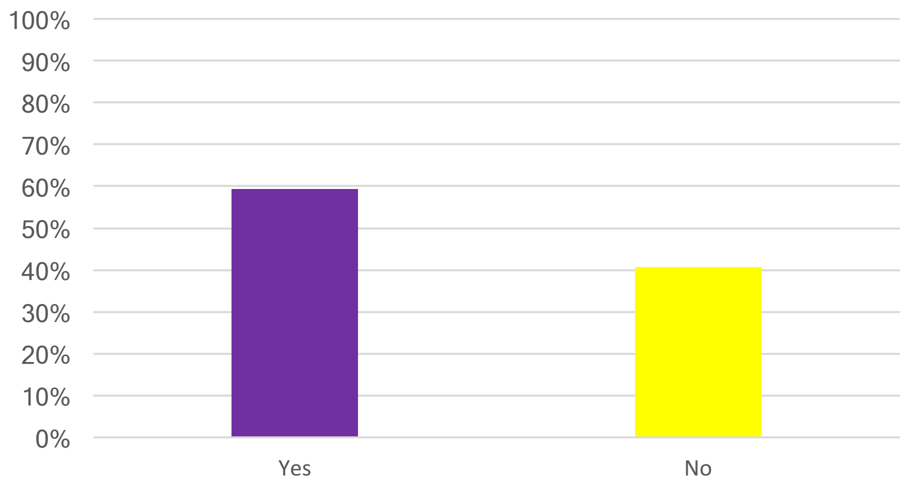
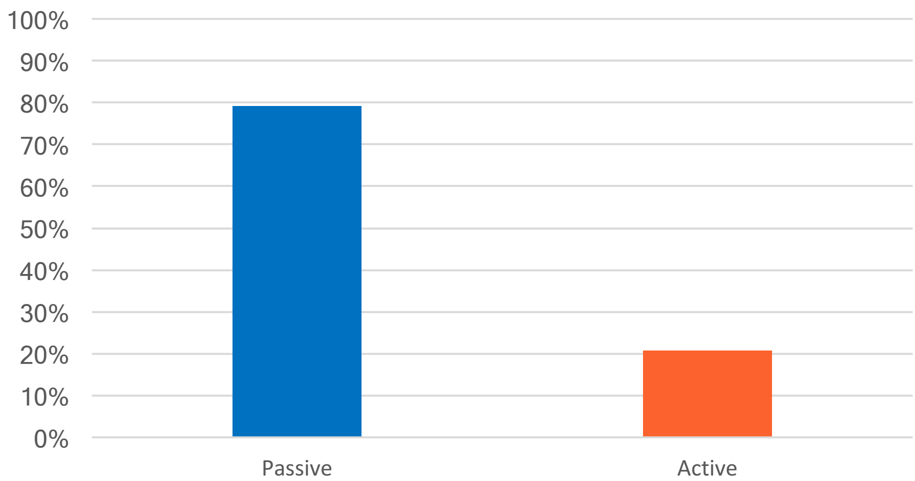
# Results

Child occupants most likely to interacting with other vehicle occupants (59%, i.e., conversation, playing etc.).




Child occupants most likely to be classified as behaving 'passively' (79%, i.e., sitting still).

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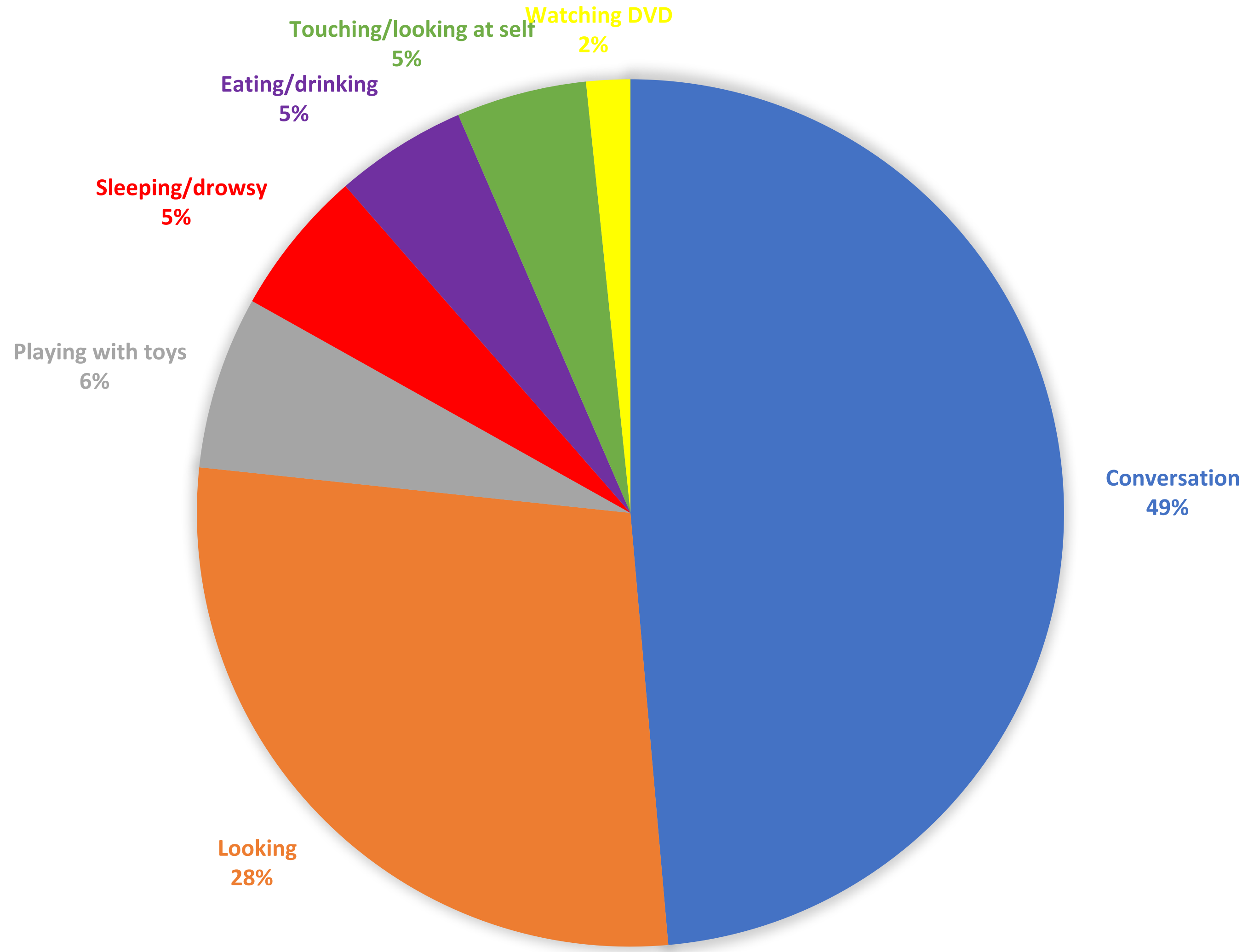
# Child occupants' primary activity

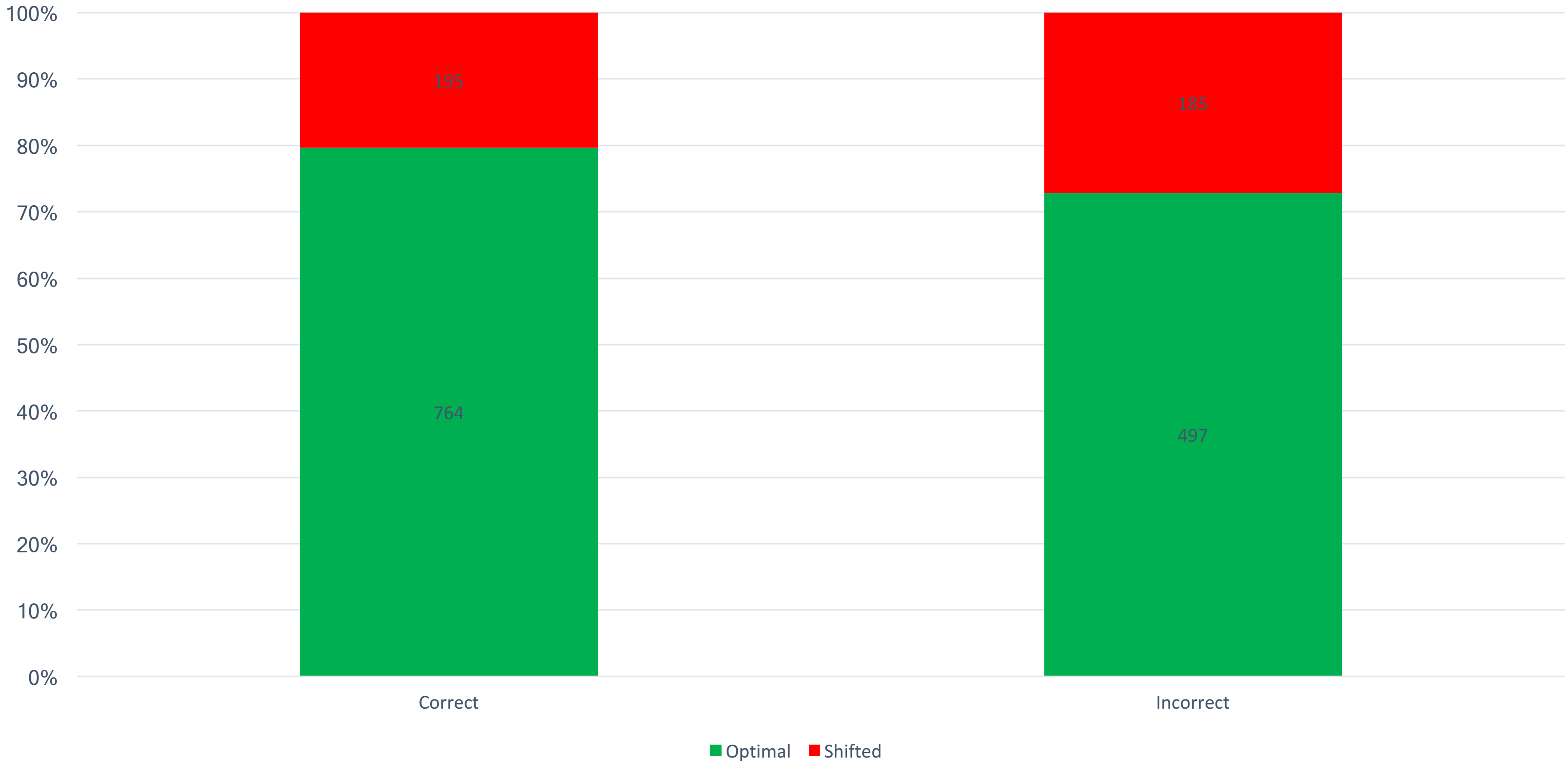


# Child occupants' head position & restraint type


Significant r'ship between child occupants' head position & restraint type, $X^2$ (1, n=1641)=17.28, $p$<0.001;

- 'Optimal' head position significantly more likely if restraint type was FFCRS.

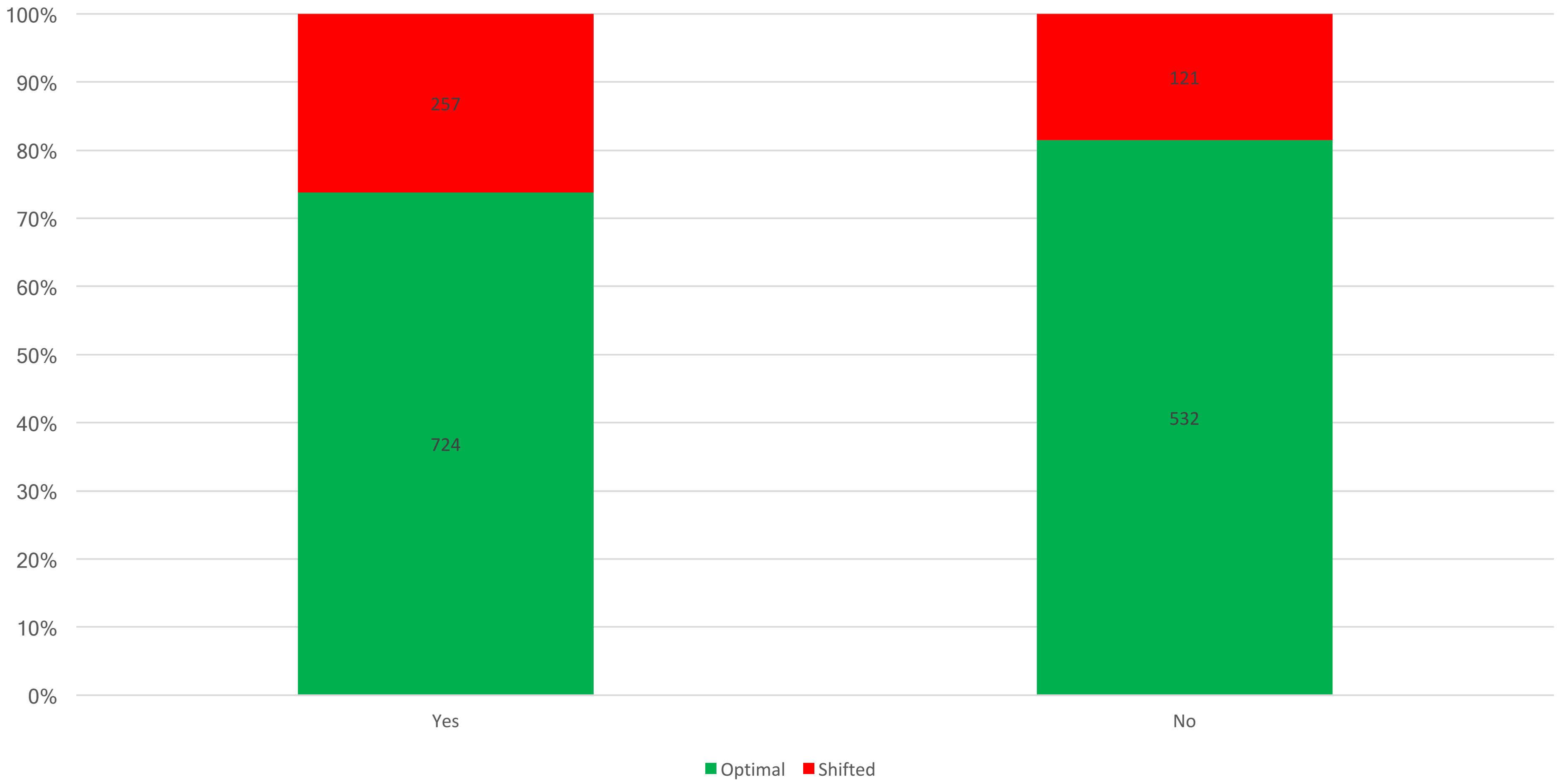
# Child occupants' head position & restraint use




Significant r'ship between child occupants' head position & restraint use, $X^2$ (1, n=1641)=10.33, $p$<0.01;

- 'Optimal' head position significantly more likely if restraint use was 'correct'.

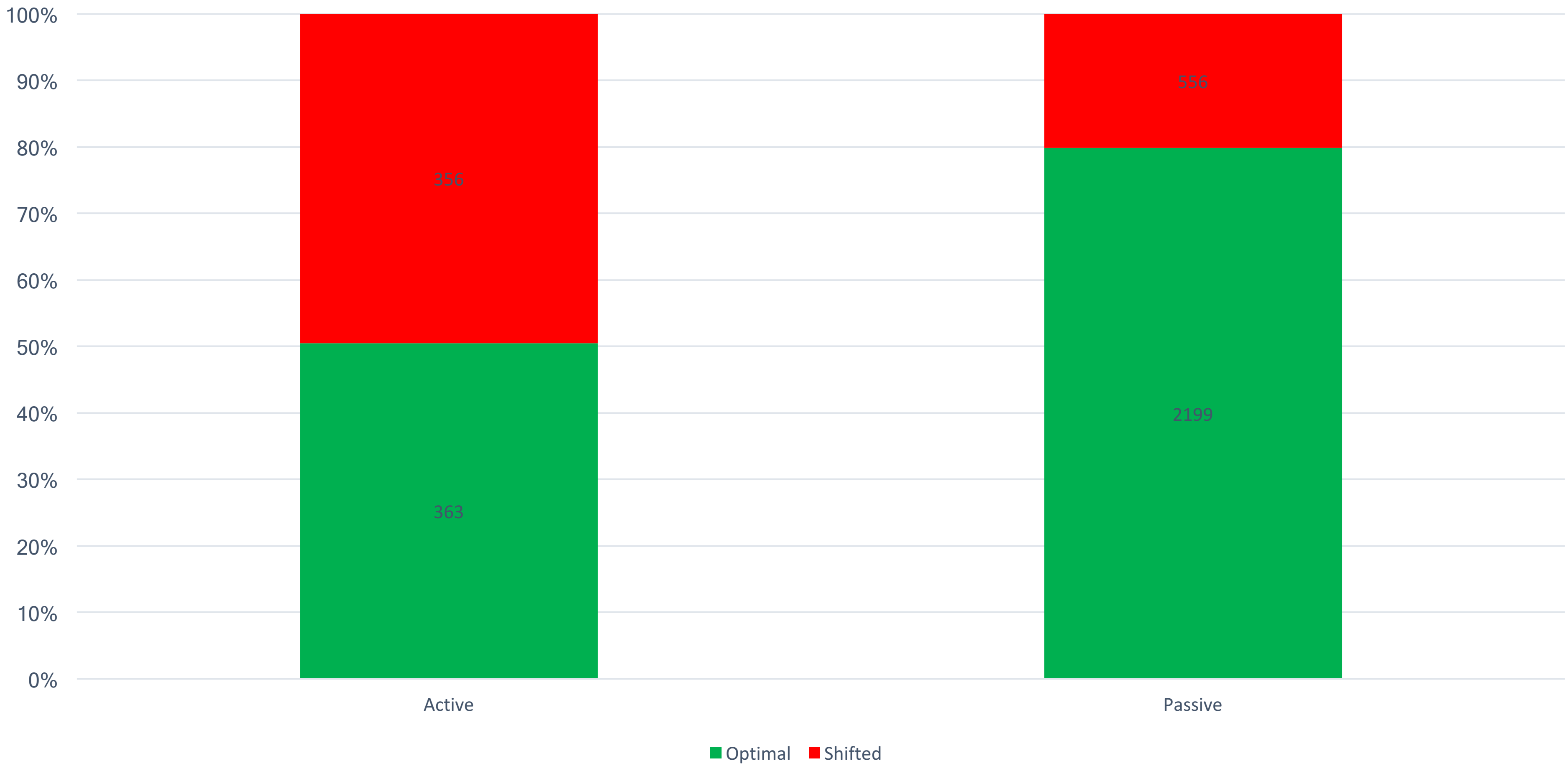
# Child occupants' head position & in-vehicle interaction




Significant r'ship between child occupants' head position & in-vehicle interaction, $X^2$ (1, n=1634)=12.96, *p*<0.001;

- 'Optimal' head position significantly more likely if in-vehicle interactions were NOT present.

# Child occupants' head position & behaviour




Significant r'ship between child occupants' head position & behaviour, $X^2$ (1, n=3474)=253.38, *p*<0.001;

- 'Optimal' head position significantly more likely when behaviour was 'passive'.

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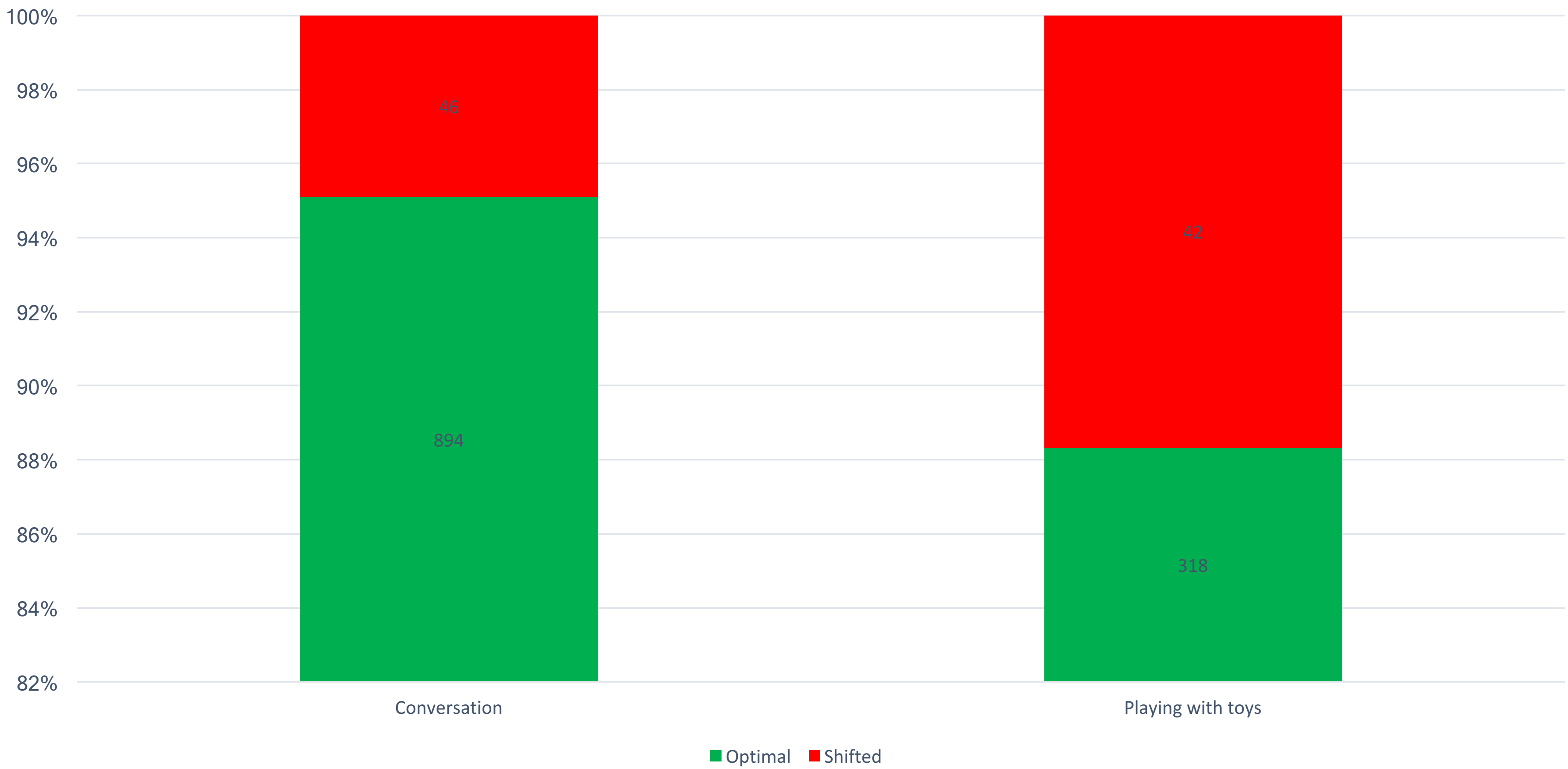
# Child occupants' head position & primary activity




Significant r'ship between child occupants' head position & primary activity, $X^2$ (1, n=1300)=4.13, $p<0.05$;

- 'Optimal' head position significantly more likely during 'conversation' compared with 'playing with toys'.

# Discussion

Aim of current NDS = observe & quantify child occupants' positions / behaviour during real-world, everyday driving trips.

Findings across n=414 driving trips (n=3,726 epochs) revealed that:

- Child occupants' head position most likely to be classified as 'optimal' (79%).
- Child occupants most likely observed to be: 'correctly' restrained (58%), involved in interactions with other vehicle occupants (59%), engaged in conversation (49%), & behaving 'passively' (79%).

'Optimal' head position was significantly related to:

- Restraint type: More likely in FFCRS;
- Restraint use: More likely during 'correct' restraint use;
- In-vehicle interaction: More likely if in-vehicle interactions NOT present, &
- Child occupant behaviour: More likely if child occupants' behaviour was 'passive'.

→ **Need to accommodate some behaviours rather than prevent them.**

# Limitations & Next Steps?

Some limitations are noted.

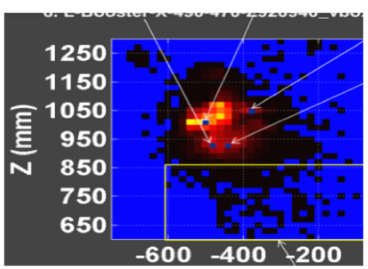
Current findings re: child occupants' head position based subjective classification (i.e., head within protective structure of CRS or BS) across ¼ driving trips (n=414) & 9 short (5sec) epochs.

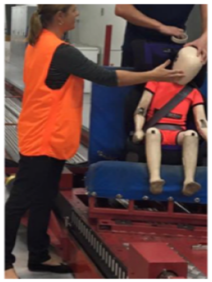
- Use Kinect data (i.e., 3D child occupant position data) to determine more objective data re: head position within CRS / booster seat relative to vehicle's hard surfaces.

Due NDS methodology (i.e., unobtrusive data gathering techniques), high % of missing data due to: body interference (32%), sunlight interference (22%), data image quality (7%), clothing interference (5%), darkness interference (4%), or other multiple reasons (30%).

Next steps = work with international colleagues, as well as industry partners, to determine:

- Injury implications of real-world positions / behaviours in the event of a motor vehicle crash?



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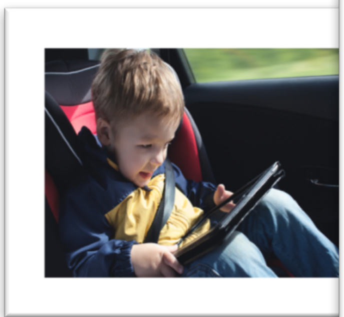

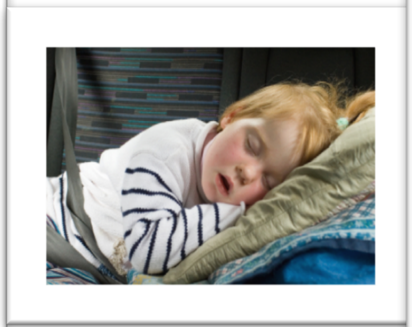
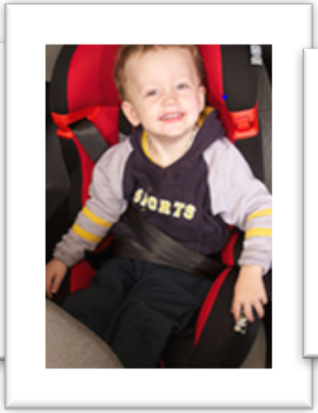
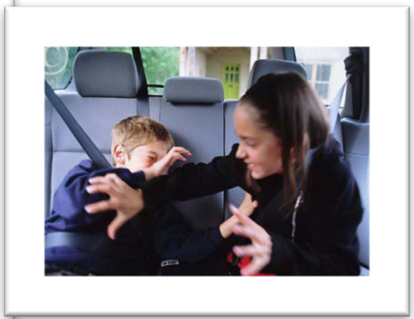

# QUESTIONS?

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