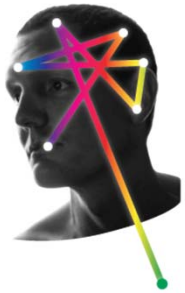
A NOVEL METHOD FOR QUANITIFYING COMFORT IN CHILD PASSENGERS

Julie Brown



NeuRA

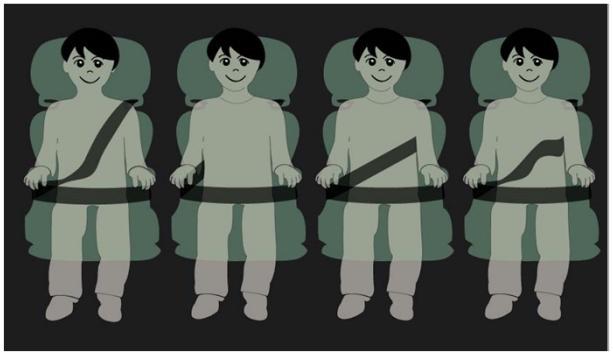
Discover. Conquer. Cure.

INJURY PREVENTION

Background

Types of errors

- Errors in way restraint installed in car
- Errors in way child secured within restraint
  - When parent/adults secure child within the restraint
  - **When child interacts with the restraint during journey**
    - ***May be related to comfort[1-3]***
    - ***Poor restraint fit may cause discomfort → errors in use[4]***



Examples of errors in use of a booster seat introduced by a child during a journey

[1]Klinich KD et al. *38th STAPP Car Crash Conference,* 1994:245–258
[2]Simpson EM, et al. *Pediatrics*. 2002;110(4):729–736
[3]Osvalder A-L, et al. *IRCOBI* 2013.
[4]Bohman K, et al *Proceedings of the 20th International Technical Conference of the Enhanced Safety of Vehicles, Paris*.; 2007

Background

- To date no quantitative study of relationship between comfort and errors in use

But how do we study comfort of children in cars?

Background

Comfort

- Often considered in design of adult car systems
- Many studies in the literature related to;
  - Vehicle seats e.g[1-4]
  - Seat belts e.g[5-6]
- Methods used include surveys, questionnaires and pressures measurements
  - validated methods for studying adult comfort?

[1]Gyi DE & Porter JM *Applied Ergonomics 1999;30(2):99-107*
[2]Kolich M & Tabourn SM *Journal of Occupational Safety and Ergonomics 2002;8(4):483-496*
[3]Kolich M & Tabourn SM *Applied Ergonomics 2004;47(8):841-863*.
[4]Chae S et al *International Conference of Design, User Experience and Usability 2011:368-375*
[5] Balci R et al *Human factors in Automotive Design 201:53-59*
[6] Chen L et al *Human factors in driving, seating and vision 2003;(SP-1772):131-182*

Background

Methods used measure comfort of adults in cars

- Surveys/Questionnaires
  - Automotive Seating Discomfort Questionnaire (ASDQ)[1]
  - Automotive Seating Comfort Survey[2]
  - Body Part Discomfort Chart[3]
- Pressure mapping

Mixed reports in the literature about how well these measures correlate.

[1]Smith et al , *International Journal of Industrial Ergonomics* 2006;36(2):141–149..
[2]Kolich, *SAE Technical Paper*. 1999.
[3]Gyi and Porter *Applied Ergonomics*. 1999;30(2):99–107.

Background

Methods used measure comfort of adults in cars

- Surveys/Questionnaires ⟷ Actual comfort?
  - Automotive Seating Discomfort Questionnaire (ASDQ)[1]
  - Automotive Seating Comfort Survey[2]
  - Body Part Discomfort Chart[3]
- Pressure mapping ⟷ Actual comfort?

[1]Smith et al , *International Journal of Industrial Ergonomics* 2006;36(2):141–149..
[2]Kolich, *SAE Technical Paper*. 1999.
[3]Gyi and Porter *Applied Ergonomics*. 1999;30(2):99–107.

Background

Methods used measure comfort of adults in cars

Sensitive to changes in seating condition ? ⟷ Actual comfort?

- Surveys/Questionnaires
  - Automotive Seating Discomfort Questionnaire (ASDQ)[1]
  - Automotive Seating Comfort Survey[2]
  - Body Part Discomfort Chart[3]
- Pressure mapping

Sensitive to changes in seating condition ? ⟷ Actual comfort?

[1]Smith et al , *International Journal of Industrial Ergonomics* 2006;36(2):141–149..
[2]Kolich, *SAE Technical Paper*. 1999.
[3]Gyi and Porter *Applied Ergonomics*. 1999;30(2):99–107.

Background

Variations in seating condition

- Seating rig to control ‘comfortable’ and ‘uncomfortable’ seating positions
- A well-fitting chair requires both a seat height between 88% and 95% of a student’s popliteal height and a depth of between 80% and 95% of the students’ buttock-popliteal length[1] → COMFORTABLE

[1] Parcells C, et al *Journal of Adolescent Health* 1999;24(4):265-273

Background

Methods used measure comfort of children in cars

- Surveys/Questionnaires used previously for comfort[1-2] (& pain[3-6])
  - *But difficulties obtaining useful self report responses from children from some researchers[1],* [3-6]
- Pressure mapping not previously used
  - But pressure variations an issue in anthropometric mismatch between children & seating conditions[7]
- Video not previously used for comfort
  - But used to study other child behaviour in cars e.g. posture[1-2, 8]

[1]SPettersson I, Osvalder AL *Proceedings of the Nordic Ergonomic Society Conference, Norway 2005* [2] Osvalder AL et al, IRCOBI, Sweden 2013
[3]von Bayer CL et al, *Pain 2007;127(1-2):140-150* [4]Bieri D et al, *Pain 1990;41(2):139-150* [5]Craig KD *APS Journal 1992; 1(3):153-162*
[6]Hicks CL et al *Pain 2001;93(2):173* [7]Parcells C, et al *Journal of Adolescent Health* 1999;24(4):265-273 [8]Foreman et al, AAAM 2011;55:3-14

Background

Video observation methods

- Observation of behaviour & facial expression used in pain measurement
  - Particularly when children too young to provide/understand self report measures[1]
- Video method used previously to study comfort in high chairs
  - A count of 'fidgeting and stabilisation' used to measure comfort with and without a footrest[2]

[1]von Bayer CL et al, *Pain 2007;127(1-2):140-150*

[2]Harper et al Ergonomic evaluation of the KinderZeat Child seat in a preschool setting. *Class Project Report 2002:1-18 available at*

Background

- **D**iscomfort **A**voidance **B**ehaviour (DAB) Score
  - ***Inspired by previous work counting fidgeting and stabilisation movements to measure comfort in high chairs***[1]
  - ***Discomfort avoidance behaviours e.g.***
    - stretching of neck
    - stretching of back
    - shifting weight
    - leaning forward/backwards or to either side
    - interacting with the sash belt
    - kicking or moving of the legs.

[1] Harper K, et al. Ergonomic Evaluation of the KinderZeat Child Seat in a Preschool Setting. *Class Project Report*. 2002:1–18.

Aims and Objectives

1. To examine reliability & sensitivity of potential measures of comfort in children aged 4-8 years
    - Survey/questionnaires
    - Pressure mapping
    - DAB method
2. To examine relationship between comfort measured using DAB method and errors in use of booster seats.

Methods

Part 1: Examined reliability and sensitivity of comfort measures (14 children)

- age mean=5.4 years, height mean=116.1cm, weight mean =20.4kg,

Part 2: Examined the association between DAB and observed errors (Jan 2015-Oct 2016, 15 children)

- age mean=5.6 years, height mean=119cm, weight mean =21.9kg,

Participants

- Parents/guardians & their children aged 4-8 years
- Parents were >18, Australian residents, routinely transported their child in a car

Both studies approved by UNSW Human Research Committee

Methods –Part 1: Reliability & Sensitivity

Comfort measures compared across 4 seating conditions;

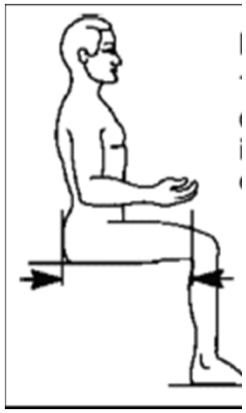
1. Fit – comfortable baseline
2. Fit +footrest – comfortable enhanced
3. Seatbelt high – uncomfortable
4. Long cushion - uncomfortable

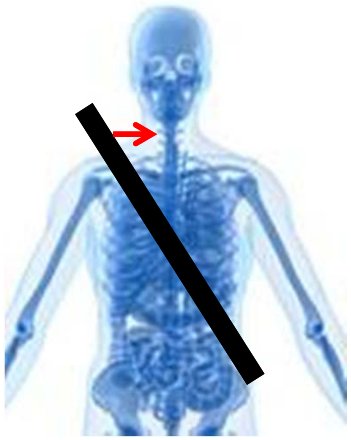
Methods –Part 1: Reliability & Sensitivity

Seating conditions

1. Fit – comfortable baseline

2. Fit +footrest – comfortable enhanced



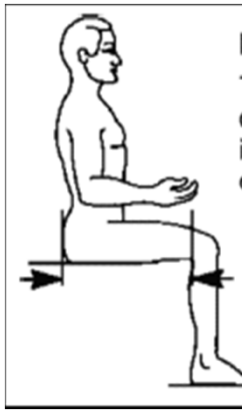


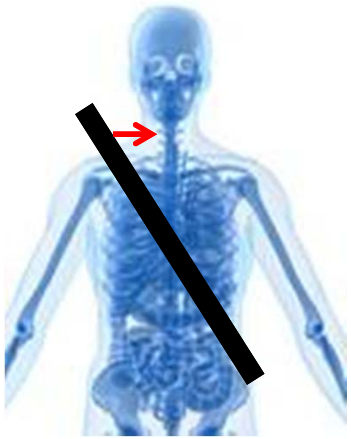
Methods –Part 1: Reliability & Sensitivity

Seating conditions

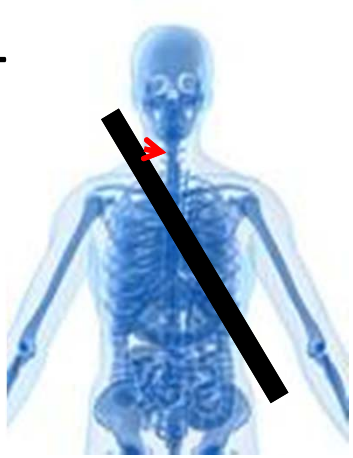
1. Fit – comfortable baseline

2. Fit +footrest – comfortable enhanced





3. Seatbelt high – uncomfortable



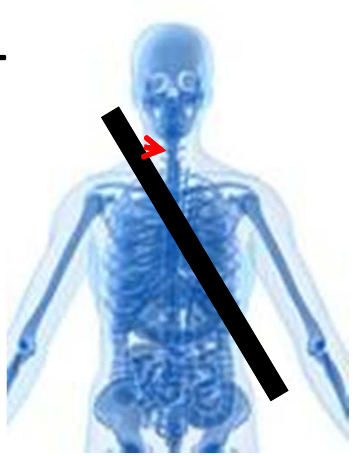
Methods –Part 1: Reliability & Sensitivity

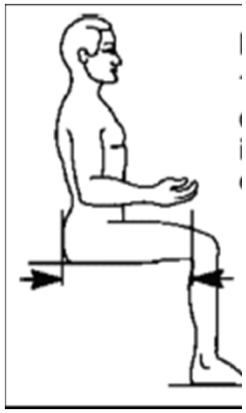
Seating conditions

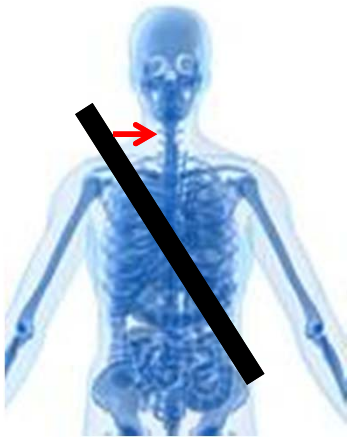
1. Fit – comfortable baseline

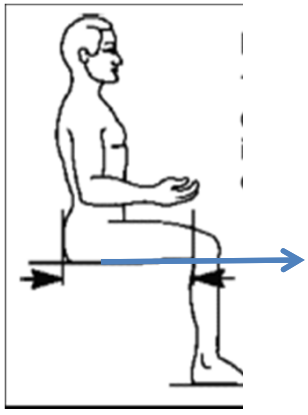
2. Fit +footrest – comfortable enhanced

3. Seatbelt high – uncomfortable









Cushion
10cm > BPL

4. Long cushion - uncomfortable

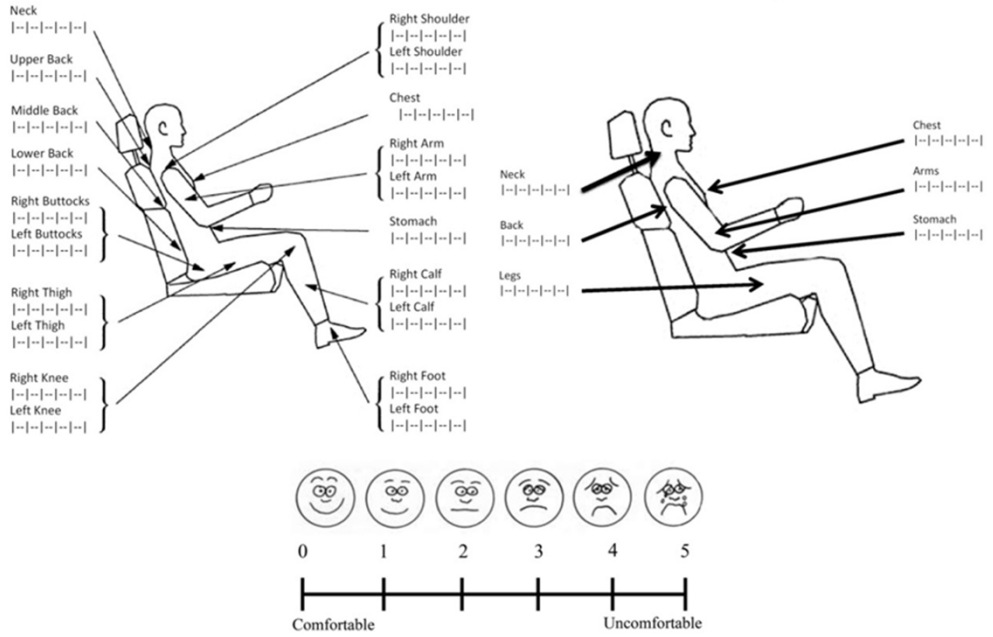
Methods –Part 1: Reliability & Sensitivity

Procedure

- Measured stature, weight & buttock-to-popliteal length
- Children correctly restrained in each seating position (10mins)
- Survey administered by research at end of 10mins while child still seated
- 10 min break between trials
- Seating positions randomly ordered
- Child watch TV program of their choice
- Watched 15 inch screen just below eye height, an arms length in front of child

Methods –Part 1: Reliability & Sensitivity - Surveys

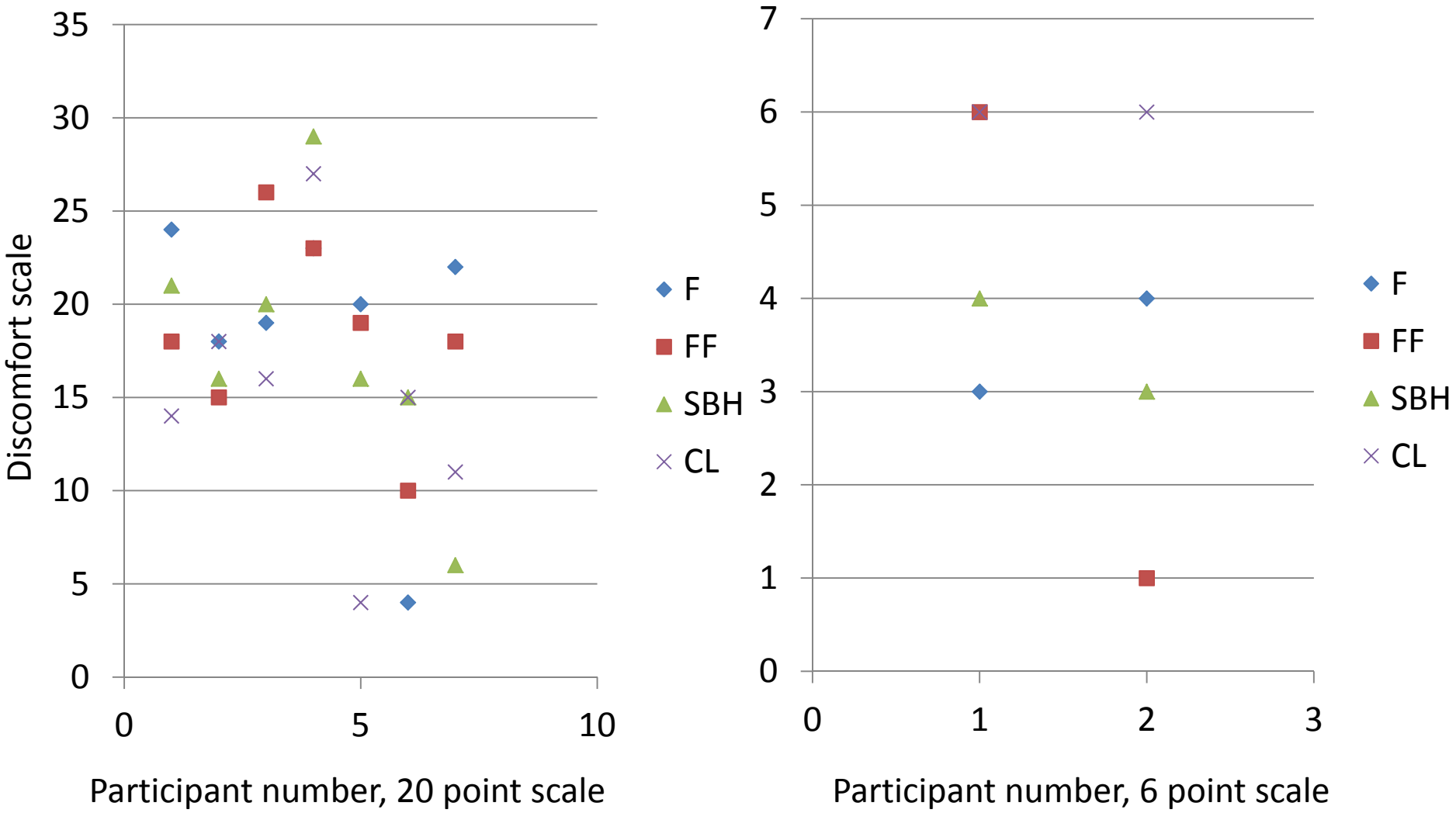
- 2 different tools
  - 20 point comfort/discomfort scale[1] (10 children)
  - 6 point comfort/discomfort scale (4 children)
- Both used a modified FACES pain scale[2-3]



[1]Gyi and Porter 1999
[2]Wong and Baker 1988
[3]Borgers et al, 2000, 2004

Subject		1	2	3	4	5	6	7	8	9	10	11	12	13	14
20-point score	F	24	18	19	23	0	0	20	4	22	0	-	-	-	-
	FF	18	15	26	23	1	0	19	10	18	2	-	-	-	-
	SBH	21	16	20	29	0	0	16	15	6	2	-	-	-	-
	CL	14	18	16	27	8	0	4	15	11	4	-	-	-	-
	NSF	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6-point score	F	-	-	-	-	-	-	-	-	-	-	3	0	0	4
	FF	-	-	-	-	-	-	-	-	-	-	6	0	0	1
	SBH	-	-	-	-	-	-	-	-	-	-	4	0	0	3
	CL	-	-	-	-	-	-	-	-	-	-	6	0	0	6
	NSF	-	-	-	-	-	-	-	-	-	-	0	0	0	2

Results –Part 1: Reliability & Sensitivity - Surveys

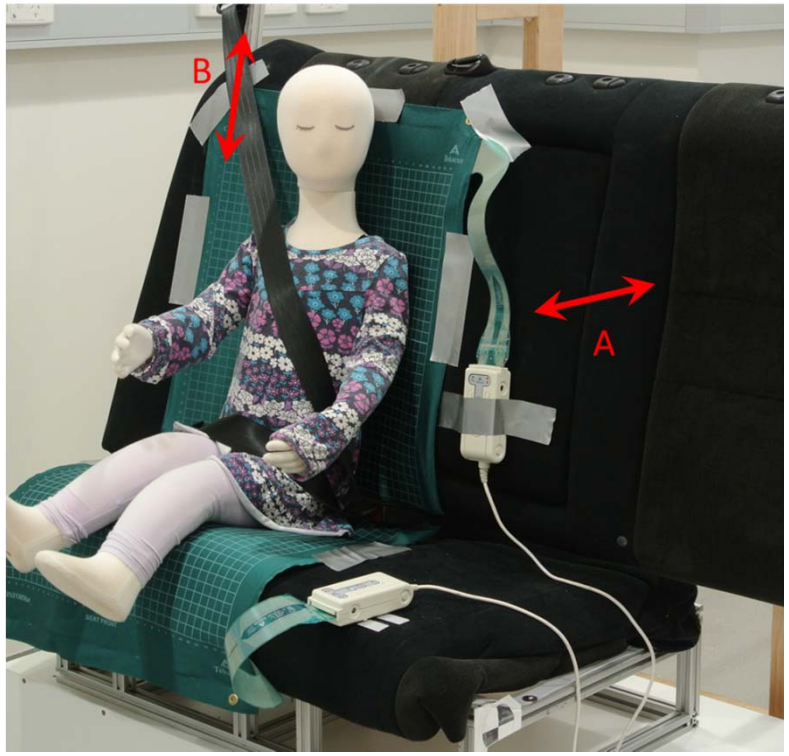


Results –Part 1: Reliability & Sensitivity - Surveys

- Neither sensitive to changes in seating condition
- Mean differences between conditions very small
- No statistically significant difference

Methods –Part 1: Reliability & Sensitivity – Pressure mapping

- Tekscan system (5330 CONFORMat)
- Measured for full 10 min duration
- One mat on seat back & one mat on seat cushion
- Measured
  - Change in centre of force (ΔCOF)
  - Peak pressure (PP)
  - Average contact area (μCA)



Results –Part 1: Reliability & Sensitivity – Pressure mapping

- Some measures were sensitive to some changes in seating condition
- A number of technical difficulties using mats
  - Consistent mat placement for changing cushion length
  - Difficult optimising sensitivity

Condition	ΔCOF	μCA	PP
Fit + Footrest	0.03	0.01	0.77
Fit - Seatbelt High	0.28	0.10	0.67
Fit - Cushion Long	0.66	0.00	0.81

Significance (paired sample t-test) Seat cushion

Condition	ΔCOF	μCA	PP
Fit + Footrest	0.28	0.97	0.92
Fit - Seatbelt High	0.74	0.78	0.56
Fit - Cushion Long	0.50	0.02	0.40

Significance (paired sample t-test) Seat back

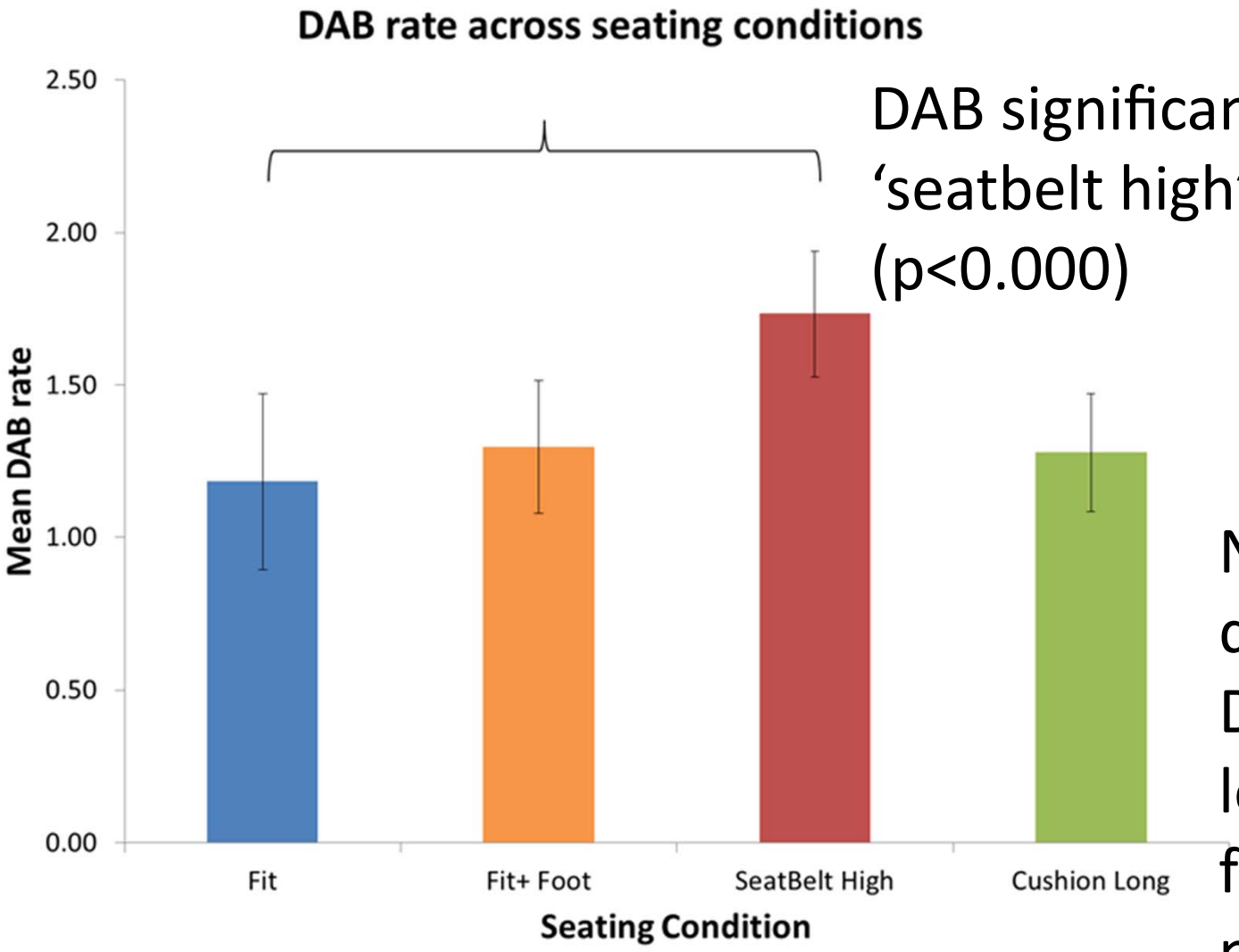
Methods –Part 1: Reliability & Sensitivity -DAB

- Children filmed in each seating position (10mins)
- 10 min break between trials
- Seating positions randomly ordered

- Video viewed and DAB scored
- 9/14 were scored by two people

$$DAB = \frac{\text{Total Discomfort Avoidance Behaviour Instances}}{\text{Video Length (Minutes)}}$$

Results- Part 1: Reliability & Sensitivity

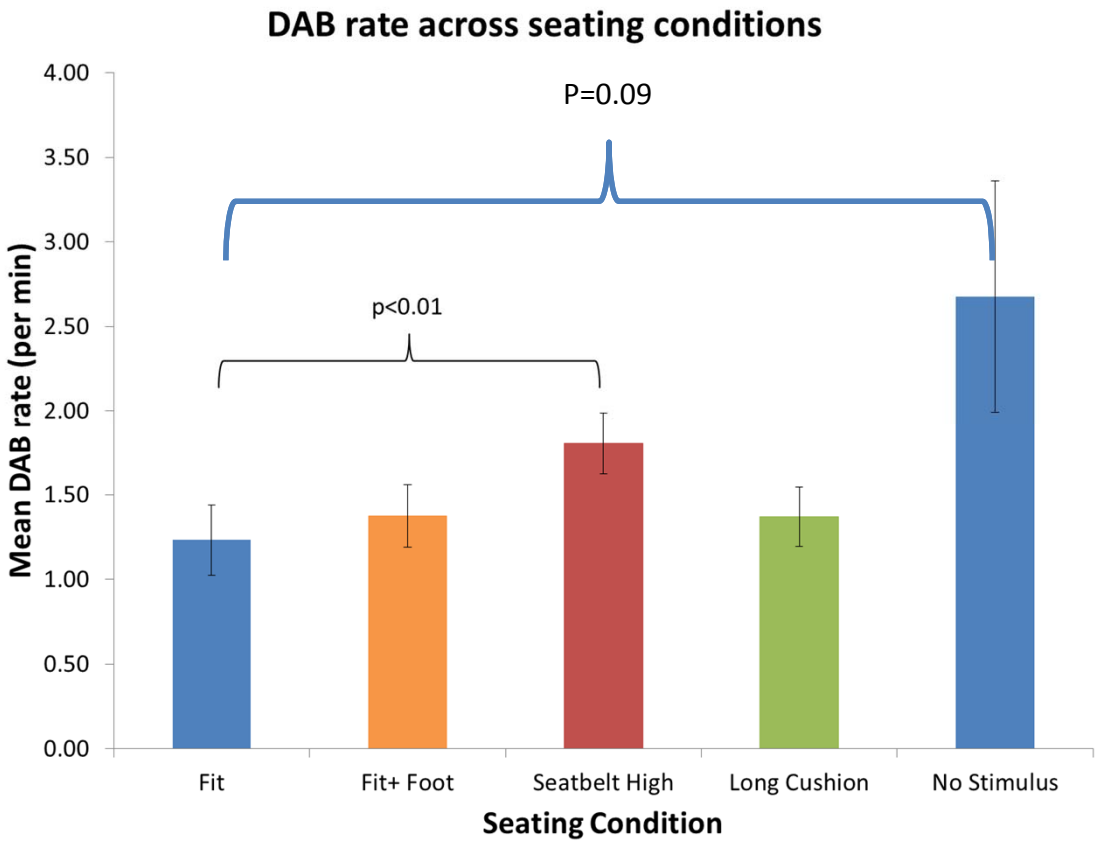


DAB significantly ↑ in 'seatbelt high' position ($p<0.000$)

No significant difference in DAB in 'cushion long', or 'fit + footrest' position

Methods –Part 1: Reliability & Sensitivity - stimulus

- 4 trials undertaken with video stimulus removed
- Fit condition minus the video



Methods –Part 2: DAB & Errors in use

Booster 1: Low back integrated booster

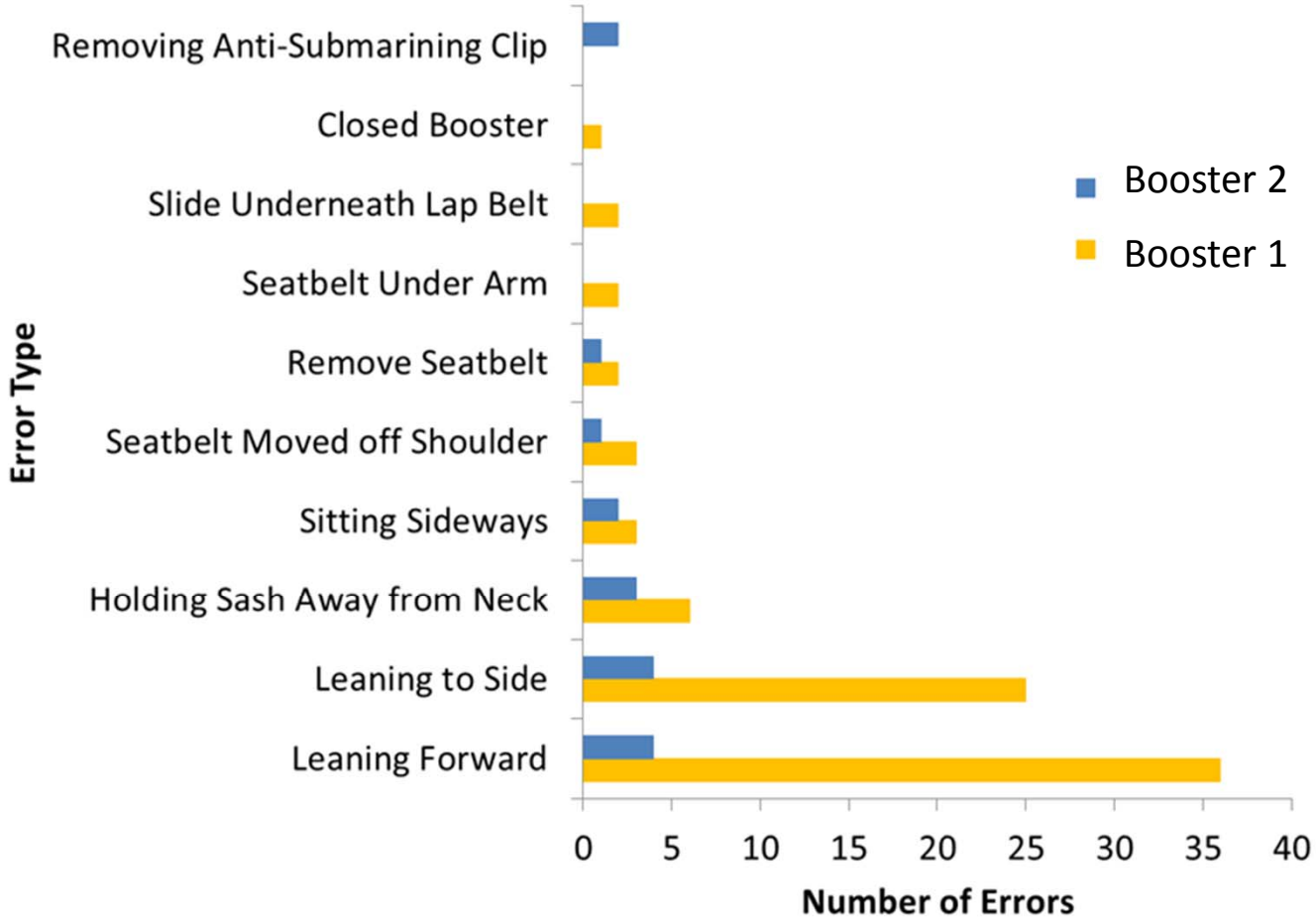
Volvo V50 test buck

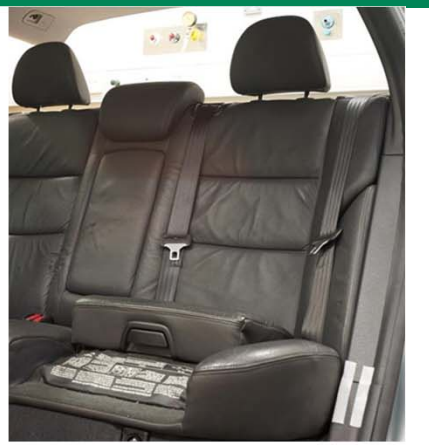
Booster 2: High back add-on booster

Methods –Part 2: DAB & Errors in use

- Child restrained in each booster for 10 mins with 10 min break between
- Child video recorded
- Video viewed and DAB scored
- 5/15 scored by 2nd rater

Results- Part 2:DAB & Errors in use



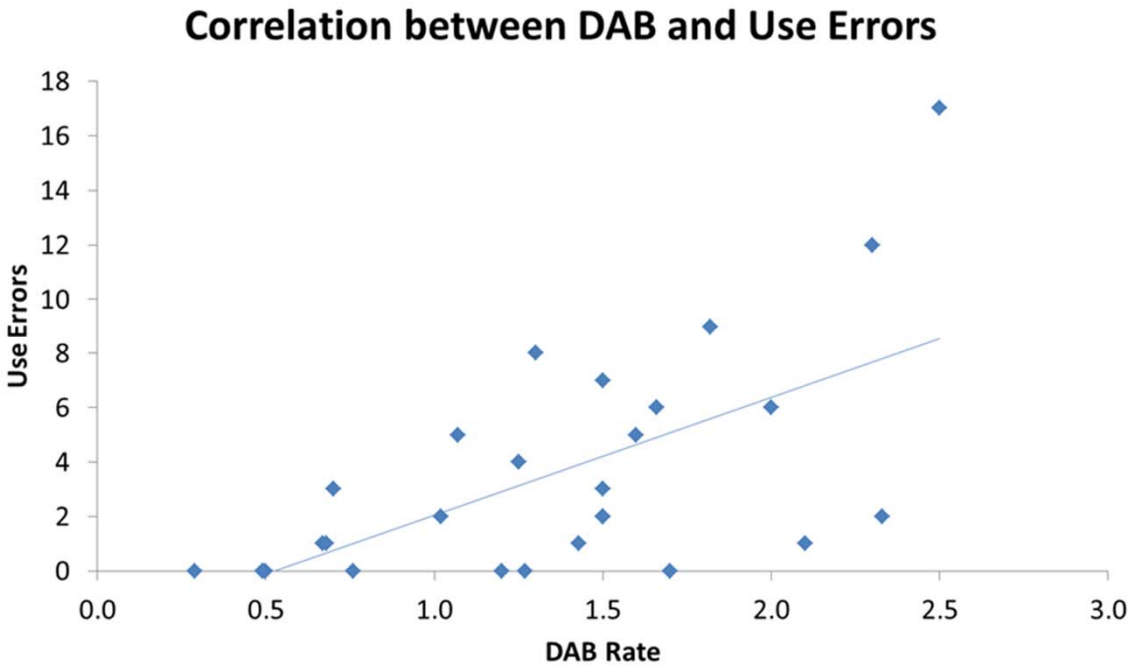


Booster 1

Booster 2

Results- Part 2:DAB & Errors in use

- General estimating equations to conduct linear regression
- Increases in DAB were correlated with increases in child-induced errors
- Significant even when controlling for restraint type, age & height
- ICC remained high



Errors in use =3.89*DAB -2.18, $p<0.0001$

Also significant relationships between errors and;

- Restraint type, p=0.002
- Height, p= 0.045

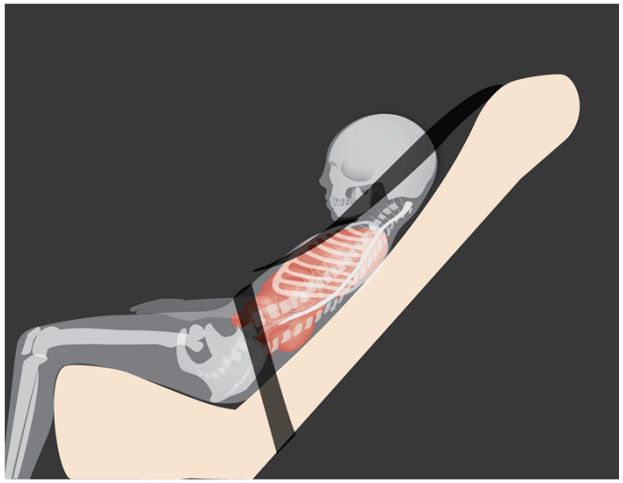
Main findings

- DAB score was sensitive to discomfort induced by changes in shoulder belt position
- DAB score appears reliable between different raters
- As discomfort ↑ (as measured by DAB), number of child-induced errors ↑
- Comfort experienced by children is important for correct use of restraints

Discussion – DAB Score

- Sensitivity trials assumed comfort is maximised by a good ergonomic match based on work by Parcels et al[1]
- Expected DAB ↑ with 'cushion long'
- Limitation of DAB
- Maybe improved by including time out of position and/or some posture score

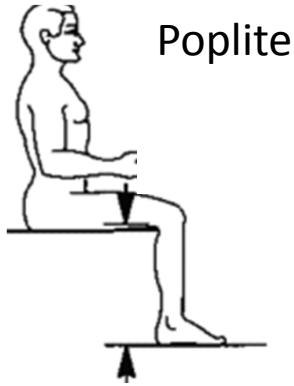
DAB Score=1



[1] Parcells C, et al *Journal of Adolescent Health*. 1999;24(4):265–273

Discussion – DAB Score

- Expected DAB ↓ with ‘footrest’
- “a seat height between 88% and 95% of a student’s popliteal height”[1]
- We allowed child to choose
- Didn’t control well
- But did see a difference in ΔCOF

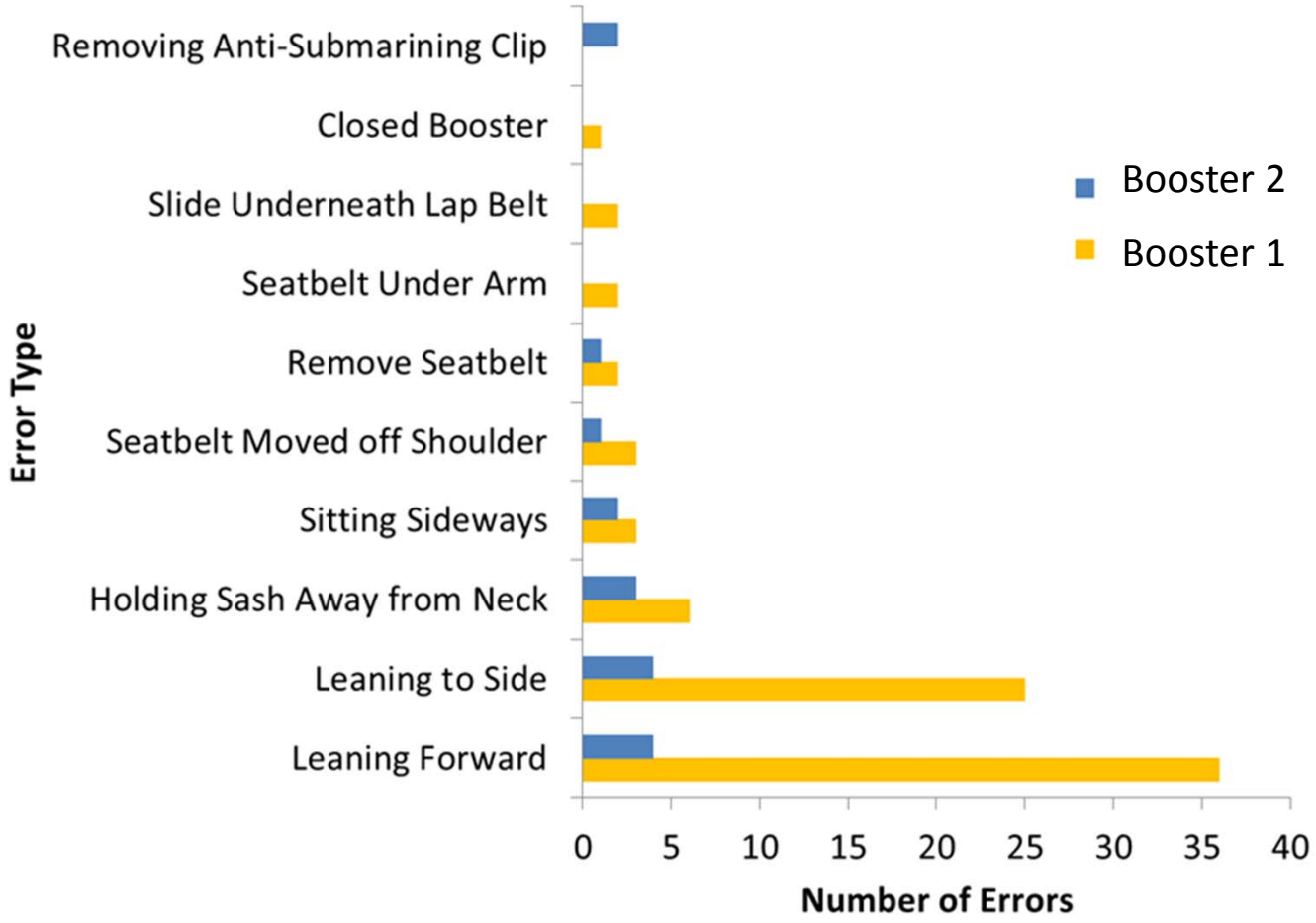


Popliteal height

Condition	ΔCOF
Fit + Footrest	0.03

[1] Parcells C, et al *Journal of Adolescent Health*. 1999;24(4):265–273

Discussion – DAB & Errors in Use



Order was not randomised, all sat for 10mins in Booster 2, then 10 mins in Booster 1

Caution against drawing conclusions about higher propensity for errors in Booster 1

Limitations

- Some extreme motions counted in DAB & as error
- May have artificially strengthened association between DAB & errors

Limitations

- Some extreme motions counted in DAB & as error
- May have artificially strengthened association between DAB & errors

- Work conducted in laboratory environments
- Needs to be repeated in naturalistic study

Limitations

- Some extreme motions counted in DAB & as error
- May have artificially strengthened association between DAB & errors

- Did not account for individual behaviour differences in children
- No problem with repeated measures design
- Using DAB in other study designs may need to account for differences

- Work conducted in laboratory environments
- Needs to be repeated in naturalistic study

Summary

- DAB score is sensitive to changes in comfort
- Further refinement of DAB may be required
- DAB easier to use than other methods
- Comfort appears likely to be important for minimising child induced errors in use
- Further work being conducted to confirm observations in a naturalistic environment

NeuRA

Discover. Conquer. Cure.

INJURY PREVENTION

Acknowledgements

- **Co-authors**
  - **Cameron Fong**, Lynne Bilston, Gunther Paul
- **Funding**
  - NSW Centre for Road Safety
  - CF supported by Australian Government APA Scholarship & NeuRA top-up scholarships
  - JB & LB supported by National Health & Medical Research Council Fellowships

neura.edu.au