

*The 3rd International Conference on Driver Distraction
and Inattention (DDI 2013)
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Individual Differences in Driving-Related Multitasking

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Vocalage 

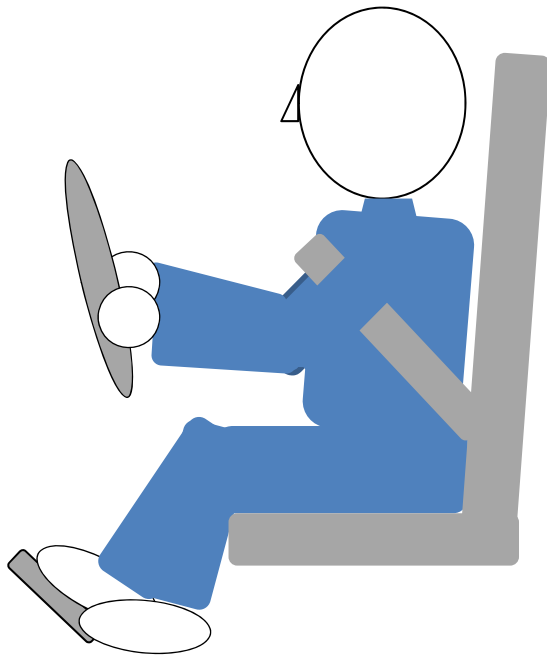
Background & Our Questions

- Drivers task are getting to be complicated due to information technology.

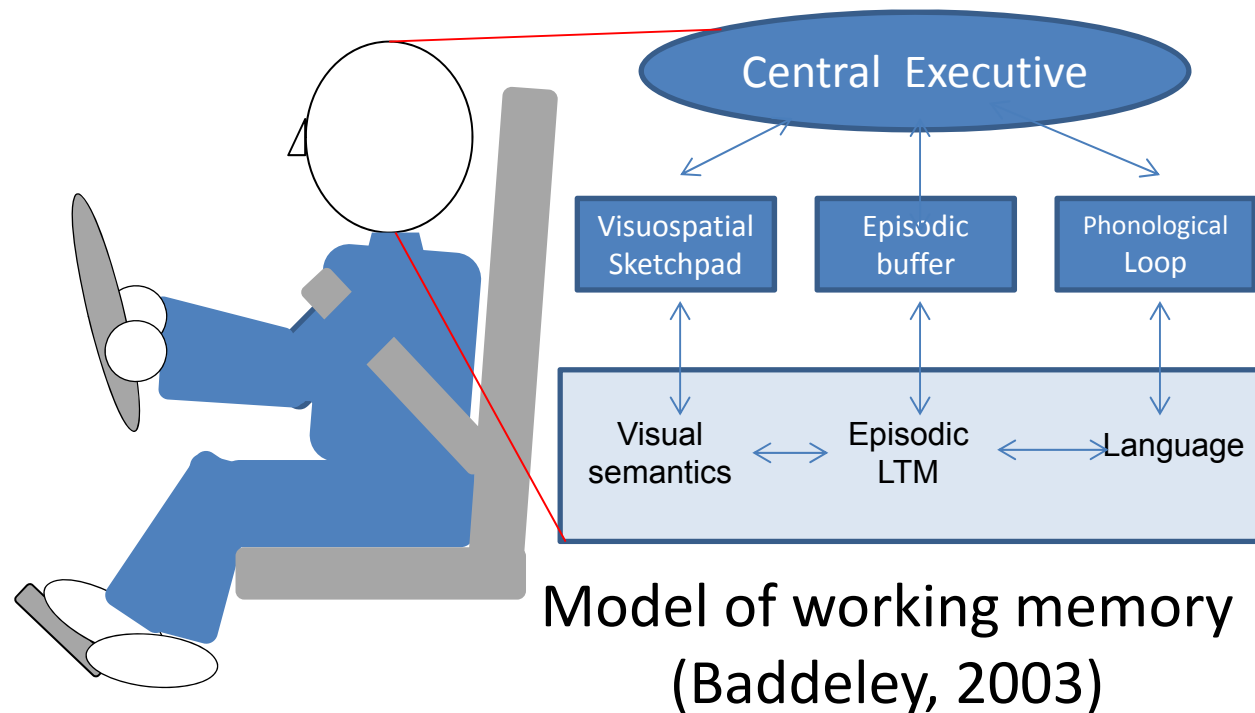


- What skill is required for modern (and future) driving?
- How can we profile cognitive activity of “driving” ?

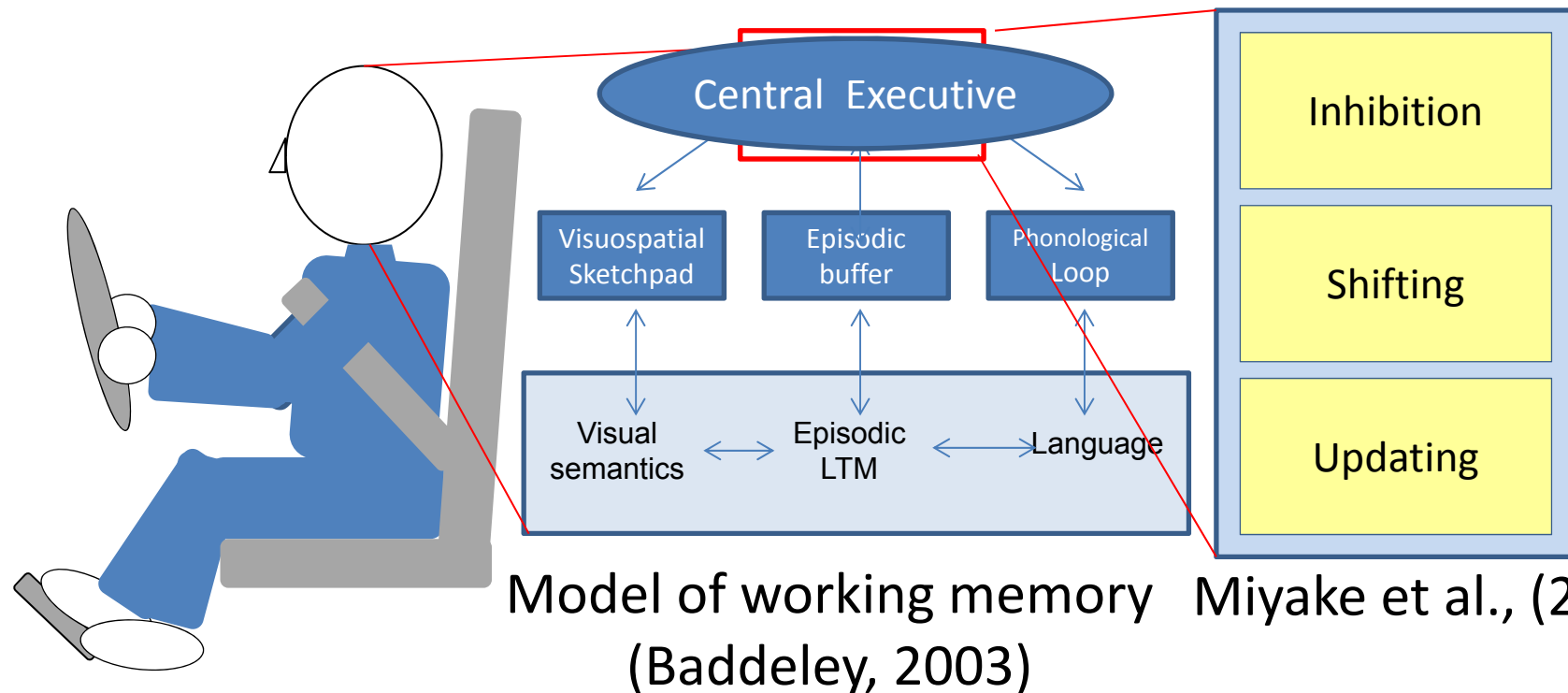
Working Memory and Executive Function (EF)



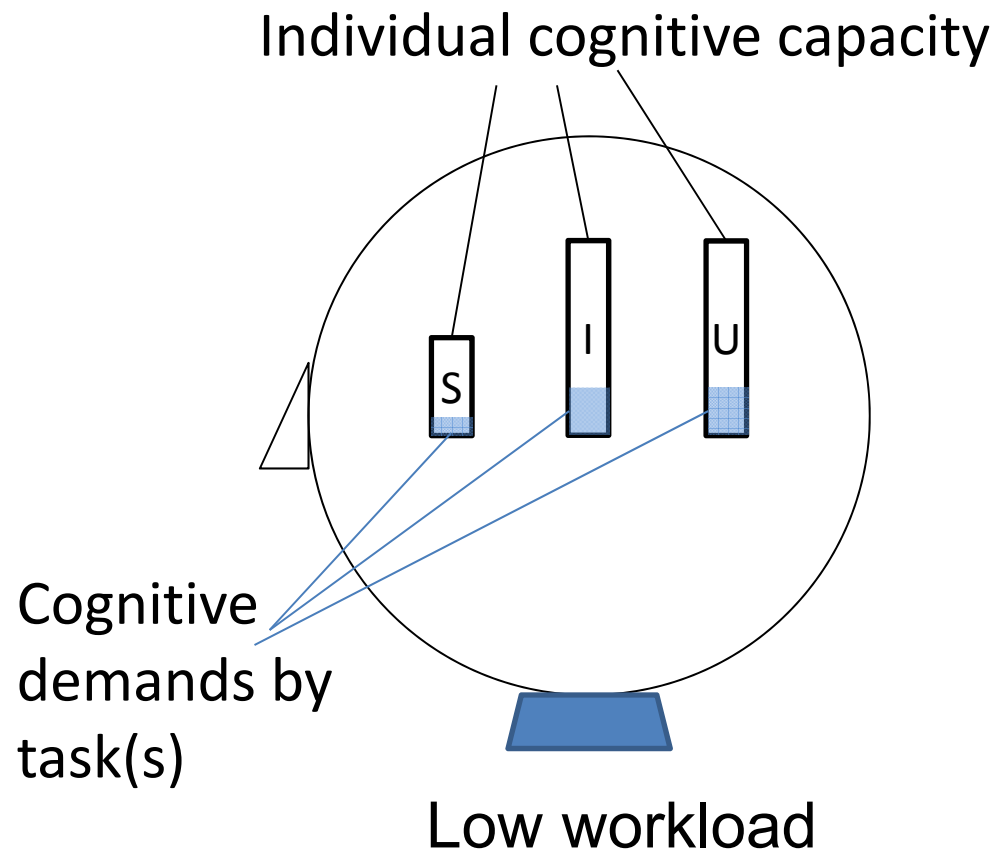
Working Memory and Executive Function (EF)



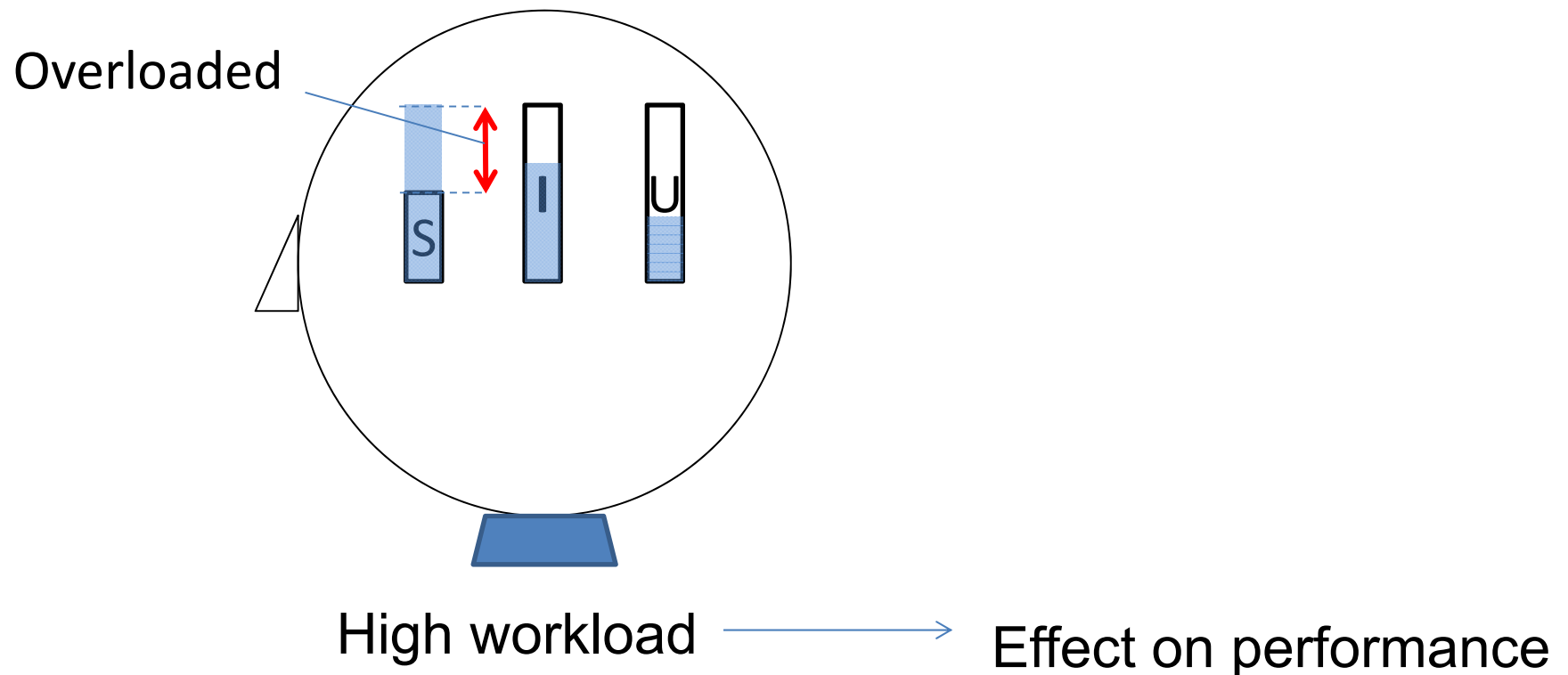
Working Memory and Executive Function (EF)



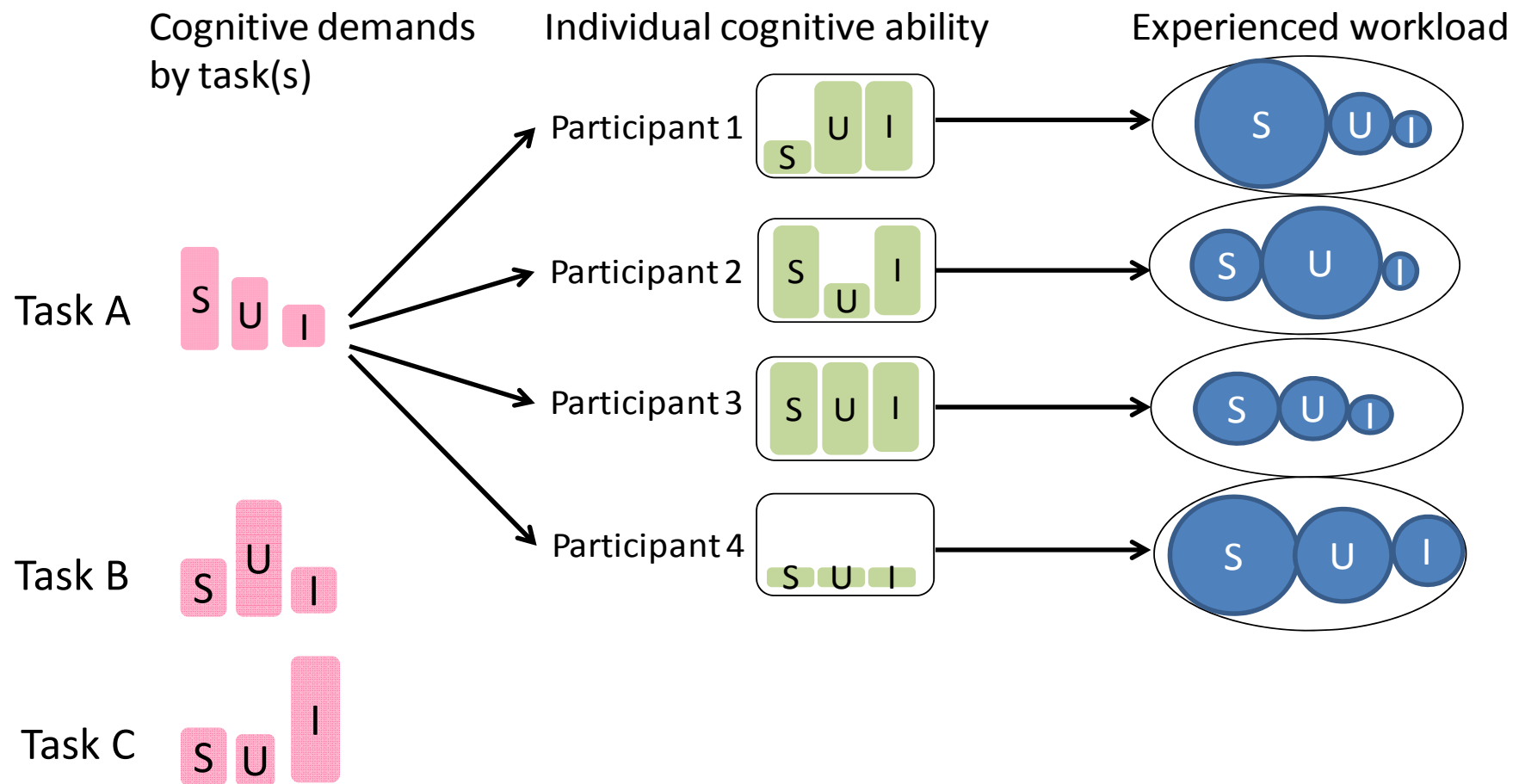
Our View on Executive Function and Cognitive Workload (1)



Our View on Executive Function and Cognitive Workload (2)



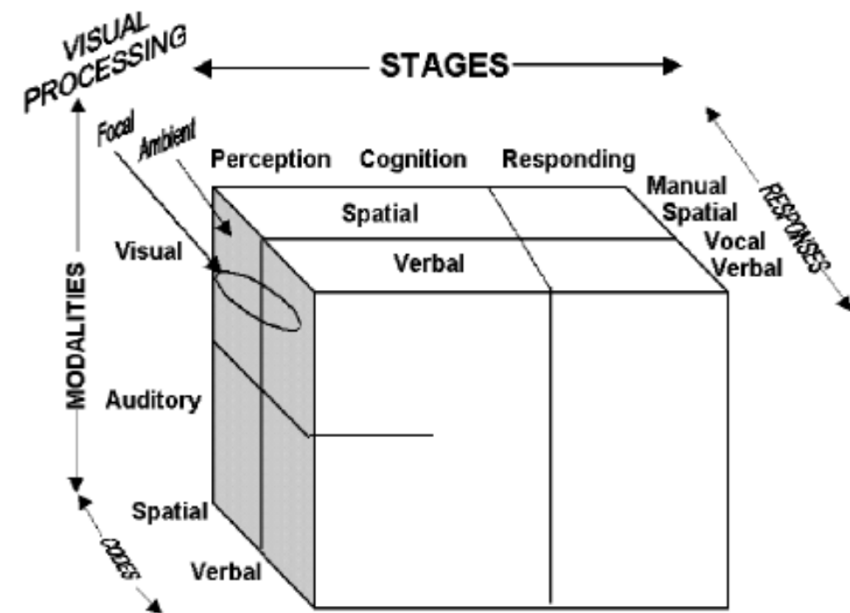
Individual differences in cognitive ability and experienced workload



Related Theory of Workload

- Multiple resource theory (Wickens, 1984, 2008 etc.)
 - Assumes several cognitive resources that can be tapped simultaneously.
 - Multiple information can be processed in parallel if the task requires different resources.

-> auditory secondary task is less distracting than visual secondary task for visual primary task.



(Wickens C. D., 2008)

Time Dependency of Information Presentation

- Audio is an inherently "streaming" (time-dependent) medium.
- Which is more distracting: short visual distraction or long audio distraction?

Destination setting. You have six options. To input a new address, press one, to find destination based on points of interest, press two, to find based on previous destination, press three, to search from a contact list, press four, to search from intersection, press five, to go back to the main menu, press six...



Research Questions

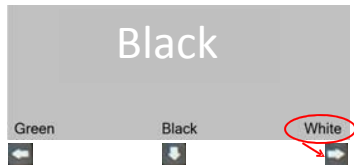
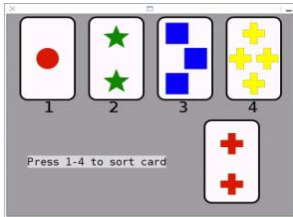
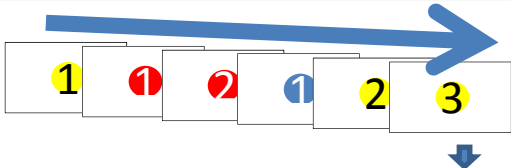
- How do Individual differences affect primary (driving-related) task performance?
- How does presentation style of the secondary task affect primary task performance?
- Do these factors interact?

Experiment

Measuring Individual Differences:

EF test

- Selected 3 cognitive test based on Miyake et al. (2000)
- $N=44$ (30M, 14F, 18-34y, $M=25y$, $SD=4.5y$) -> selected 22 people for main experiment

Inhibition: Stroop test	Shifting: WCST	Updating: Color monitoring
		

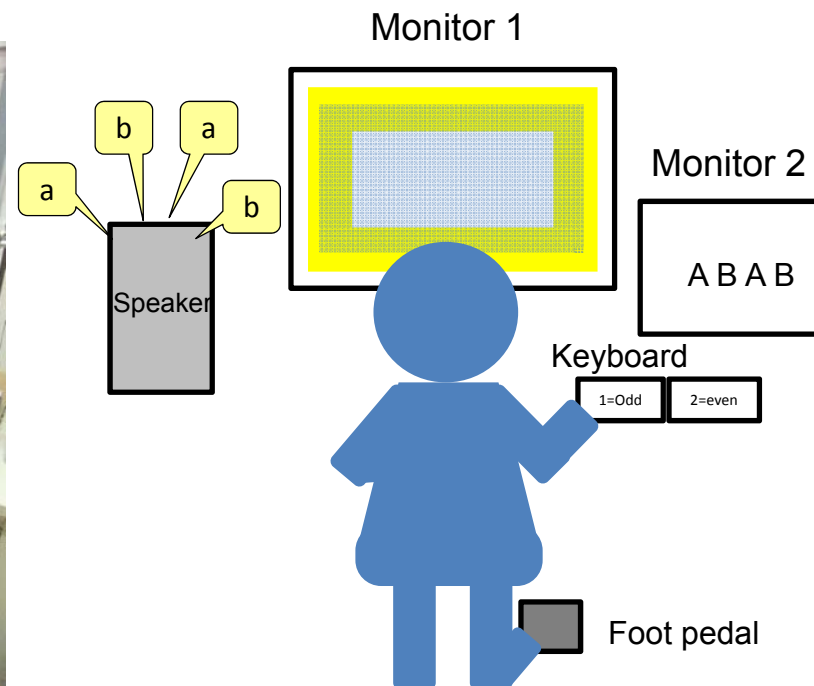
Main Experiment

- 22 participants (12M&10F, 18-33y, $M=25y$, $SD=4.6y$).
- Within-participant design

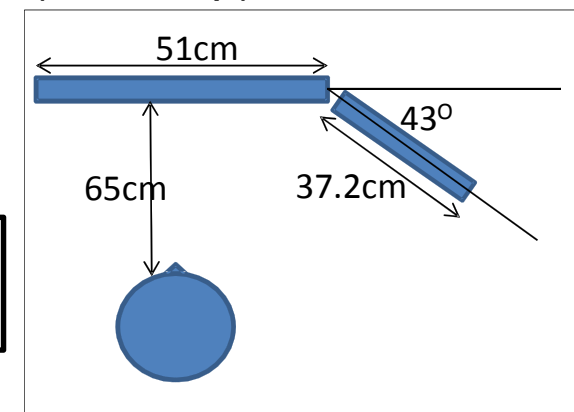
Cameras for eye tracking system



Foot pedal

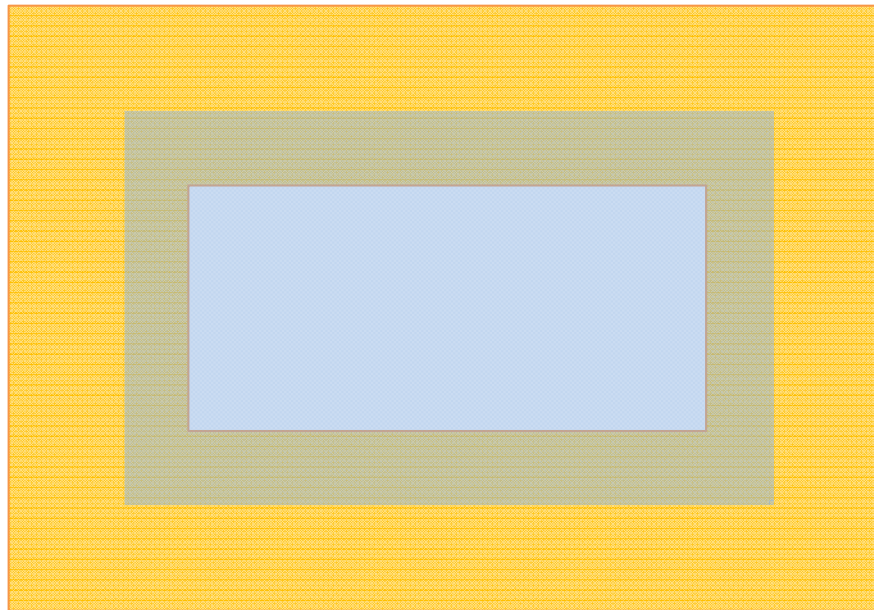


(From top)

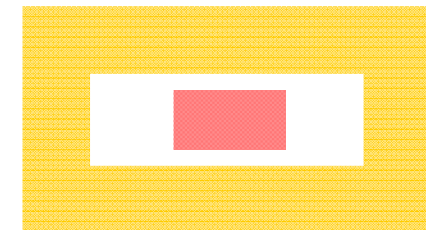
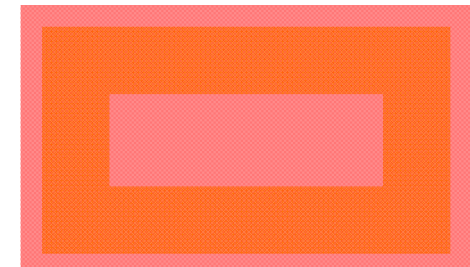


(Primary) 1D Pedal Tracking Task

- abstracted car following task



- Tap the foot pedal → The target rectangle expanded.
- Release the foot pedal → The target rectangle shrank.



When the target rectangle becomes too large/small, it turned to red




(Secondary) List Monitoring Task

- Count vowels in a list of letters -> answer if the number is odd or even by pressing a key (1=odd, 2=even).

- We controlled;


- Distractors
 - Only A or B
 - A, I, U, C, F, and M
- List length
 - 4
 - 12
- Presentation types and modality
 - Sequential
 - Audio
 - Visual
 - Simultaneous

Presentation style	distractor	modality	list length
sequential	AB	audio	4
			12
		visual	4
			12
	AUICFM	audio	4
			12
		visual	4
			12
simultaneous	AB	visual	4
			12
	AUICFM	visual	4
			12






Example of secondary task (4AB_sim)

A B B A



Example of secondary task (4AB_simultaneous)

A B B A



Example of secondary task (4AUICFM_sequential)

F



M



I



C

Variables

- Independent variables
 - Cognitive test scores
 - Inhibition: Correct RT
 - Updating: Accuracy of Color monitoring task
 - Shifting: Number of perseverative errors
 - Secondary task condition
 - List length
 - Distractor
 - Presentation style
- Dependent variables
 - Pedal tracking task performance
 - Accuracy
 - SD of the target size
 - N of conditions in which participants went out of bounds
 - Secondary task performance
 - Accuracy
 - Eyegaze
 - Mean Dwelling time on M1
 - Max dwelling time on M2

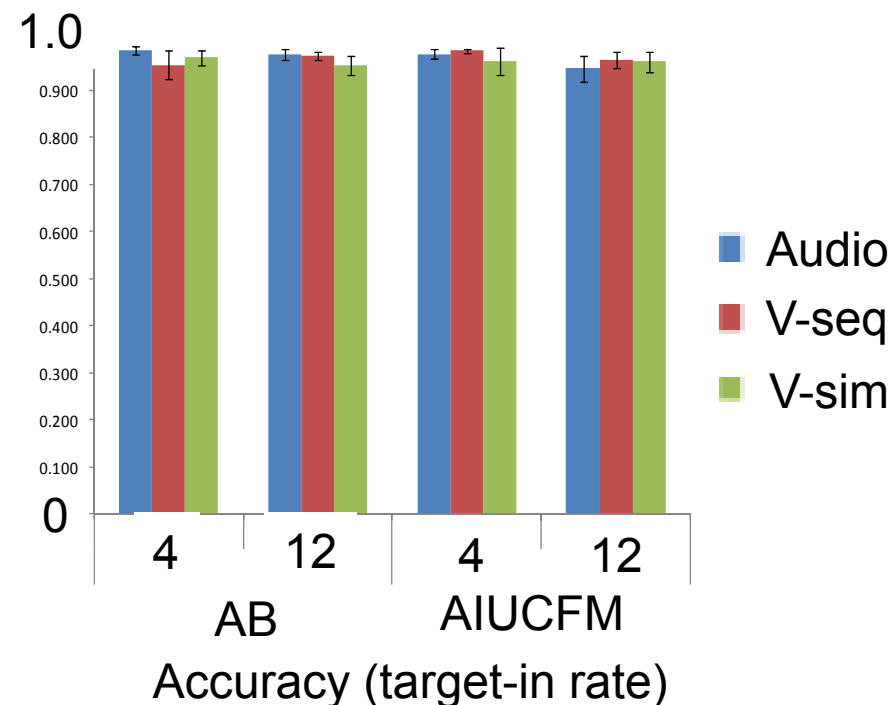


Results

Results: Primary Task Performance

Accuracy of pedal tracking

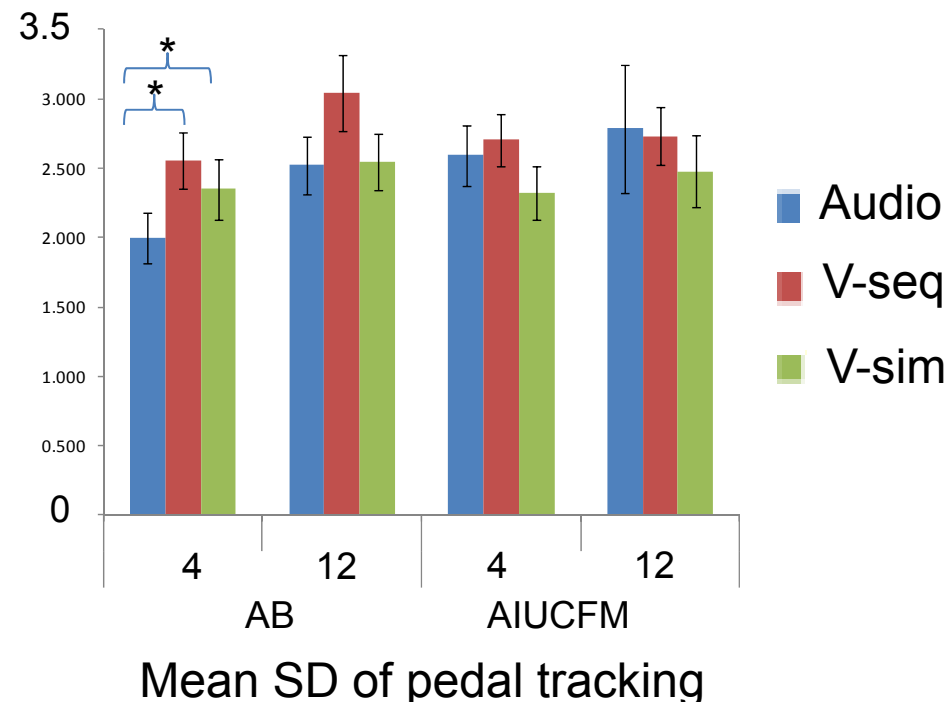
- Found high accuracy (the time proportion that the target rectangle stayed inside the yellow frame) in all conditions
-> Ceiling effect



Results: Primary Task Performance

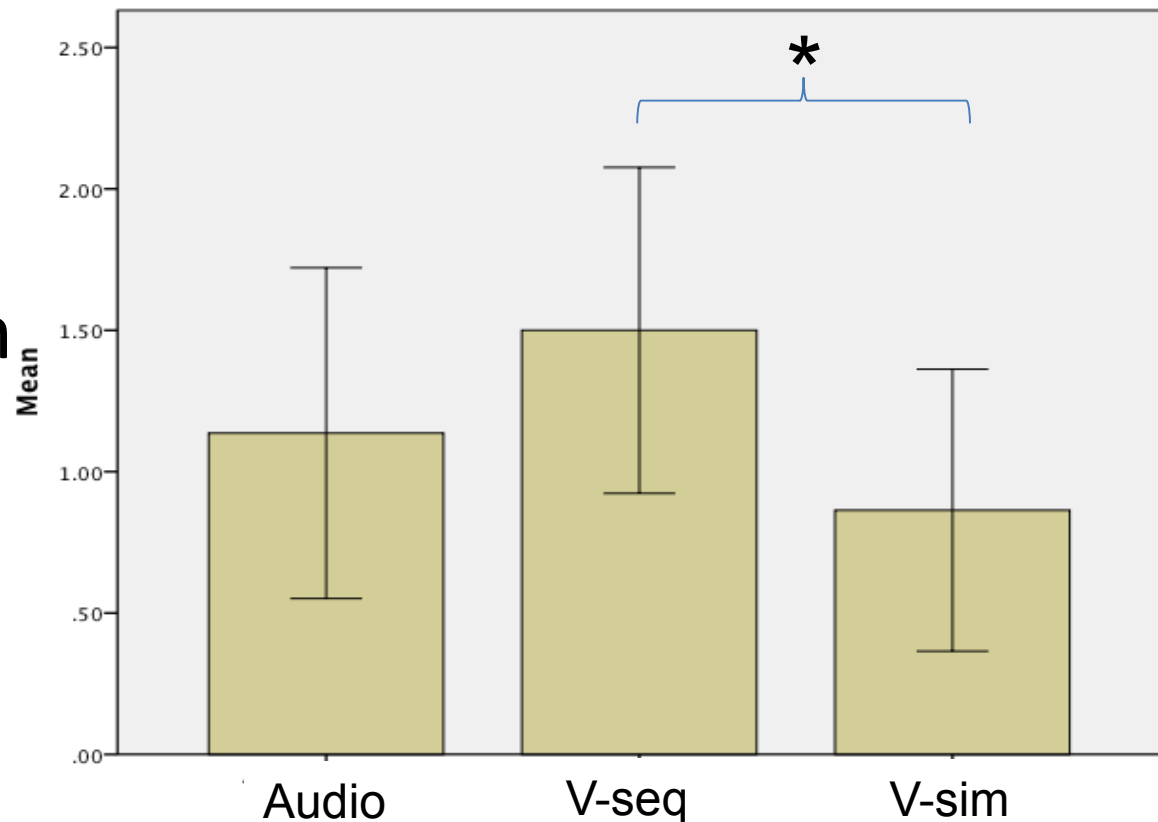
SD of pedal tracking

- SD of pedal tracing: was larger under longer list with smaller distractions.
- Compared the effect of presentation styles within each condition (4AB, 12AB, 4AUICFM, 12AUICFM). SD of Audio presentation was smaller than that of Visual presentation **only in 4AB condition**.



Mean number of participants who went out of bounds by Presentation type

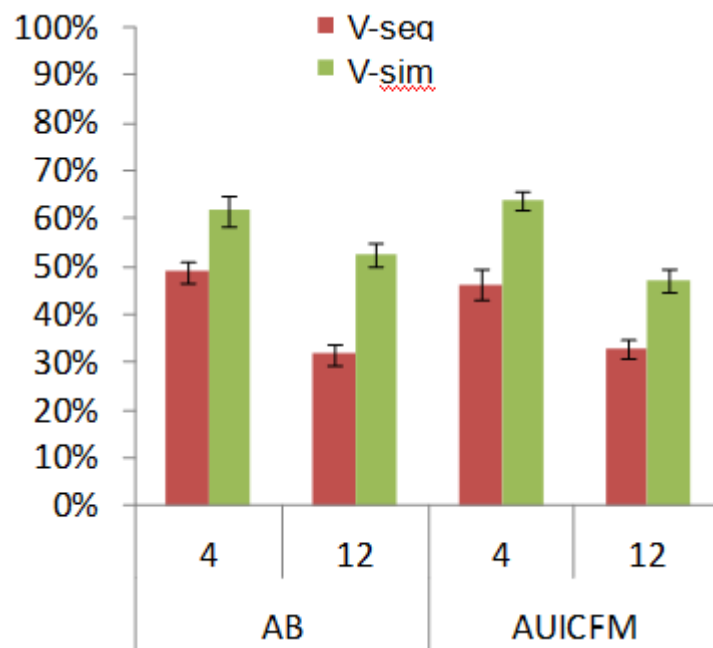
- More participants tended to go out of bounds in V-seq
- Significant difference between V-seq and v-sim



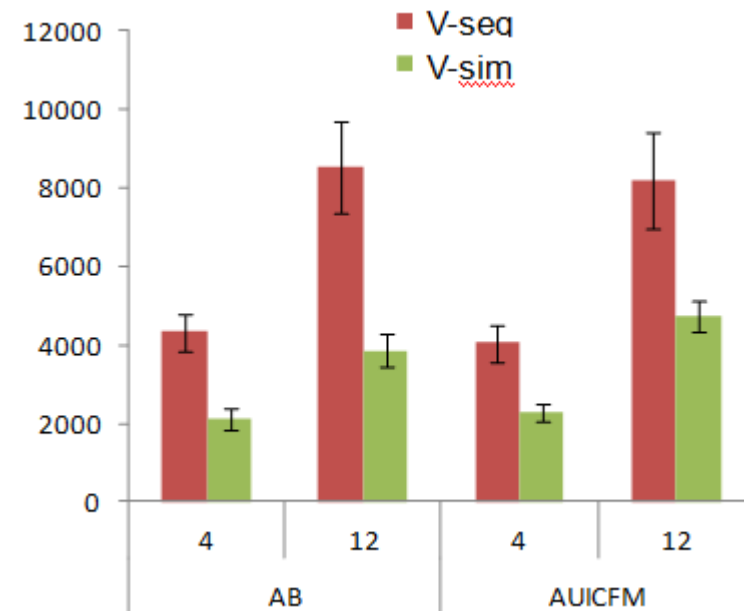
The number of conditions (out of 4) in which participants went out of bounds
(Error bars: 95% CI)

Eye gaze

- V-seq showed ;
 - shorter dwelling time on M1
 - longer maximum dwelling time on M2.



Mean proportion of time spent dwelling on M1.



Mean maximum time spent dwelling on M2.

Example of Gaze Switching

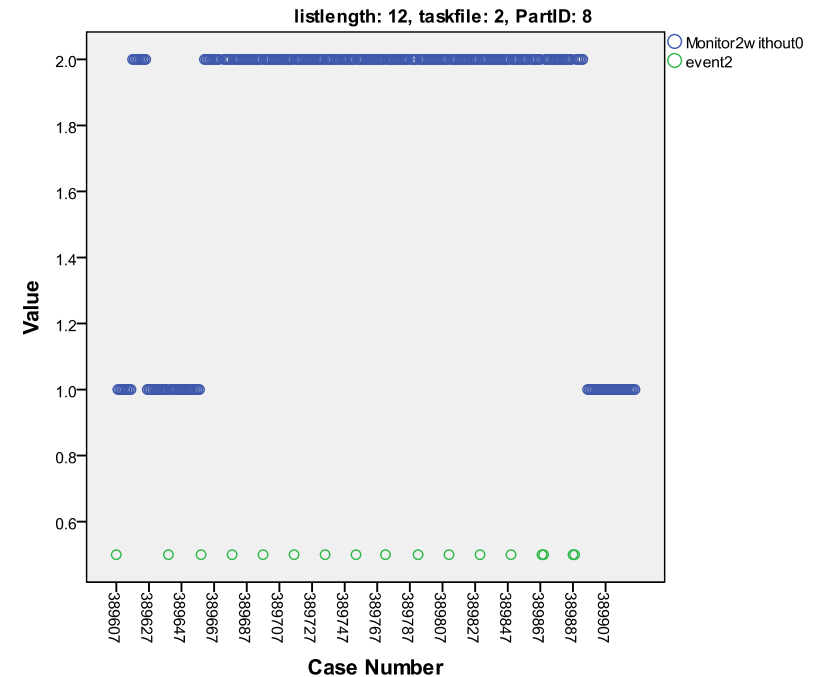
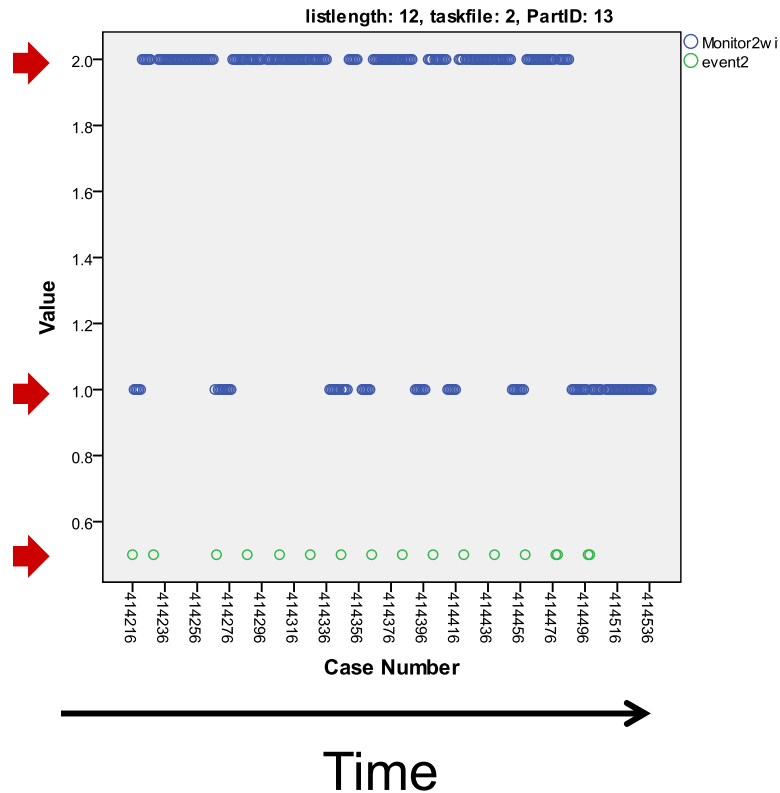
Shifting between M1&M2
(12AB_seq, PartID=13)

Facing M2 watching M1
peripherally
(12AB_seq, PartID=8)

Secondary
display
(M2)

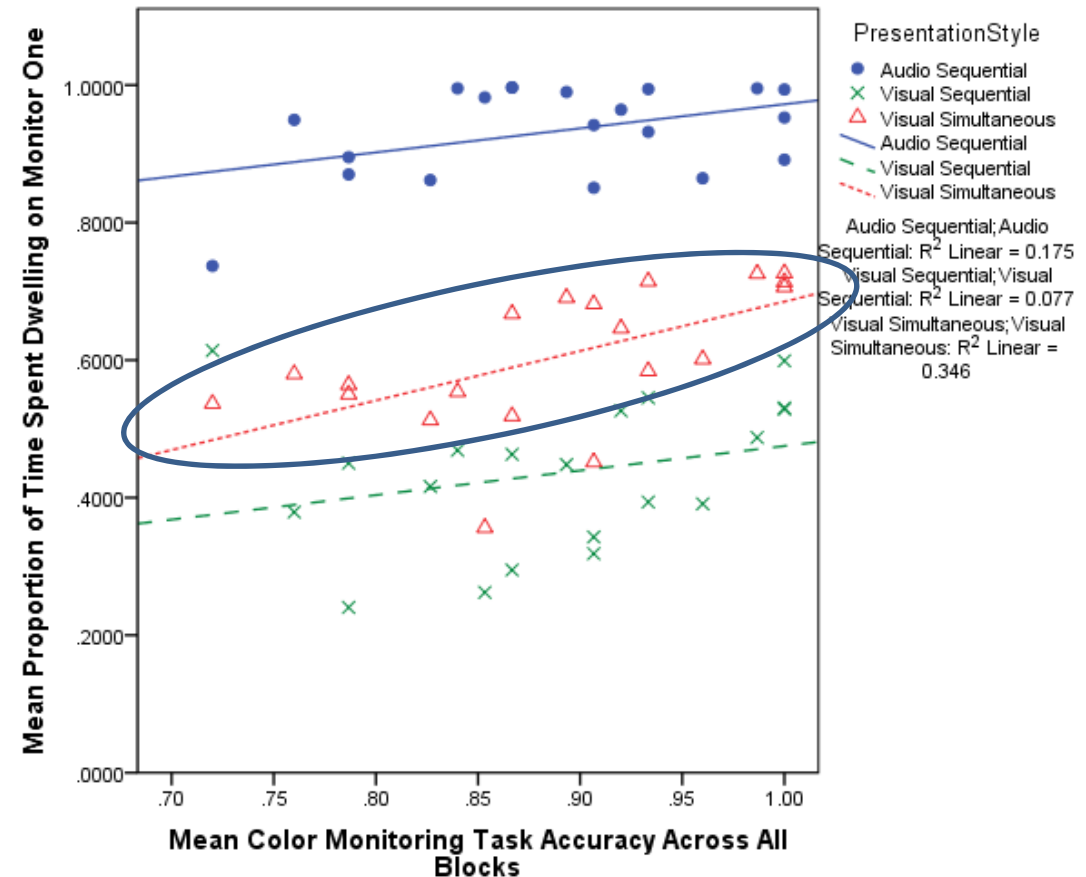
Primary
display
(M1)

Stimulus
presented



Cognitive ability and Eye gaze (1)

- Updating ability x Mean proportion of time spend dwelling on M1 by presentation style
- People with higher Updating ability tended to gaze on M1 for longer time in V-sim.

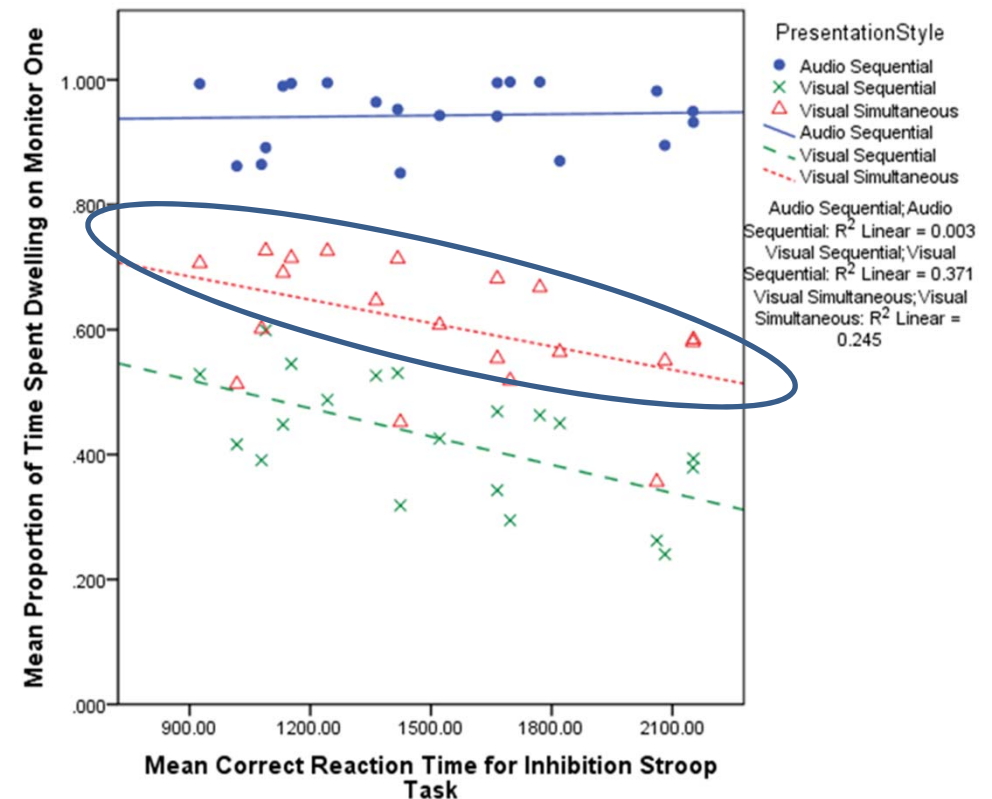


Variable	Audio			Visual Sequential			Visual Simultaneous		
	<i>B</i>	<i>SE B</i>	θ	<i>B</i>	<i>SE B</i>	θ	<i>B</i>	<i>SE B</i>	θ
Updating Accuracy	0.35	0.18	0.42	0.36	0.29	0.28	0.72	0.23	.59**
R^2	0.18 ($p = .067$)			N.S.			0.35**		

Note: * $p < .05$ ** $p < .01$ *** $p < .001$

Cognitive ability and Eye gaze (2)

- Inhibition ability x Mean proportion of time spend dwelling on M1 by presentation style
- People with higher Inhibition ability (i.e., shorter RT in Stroop task) tented to gaze on M1 for longer time in V-sim.

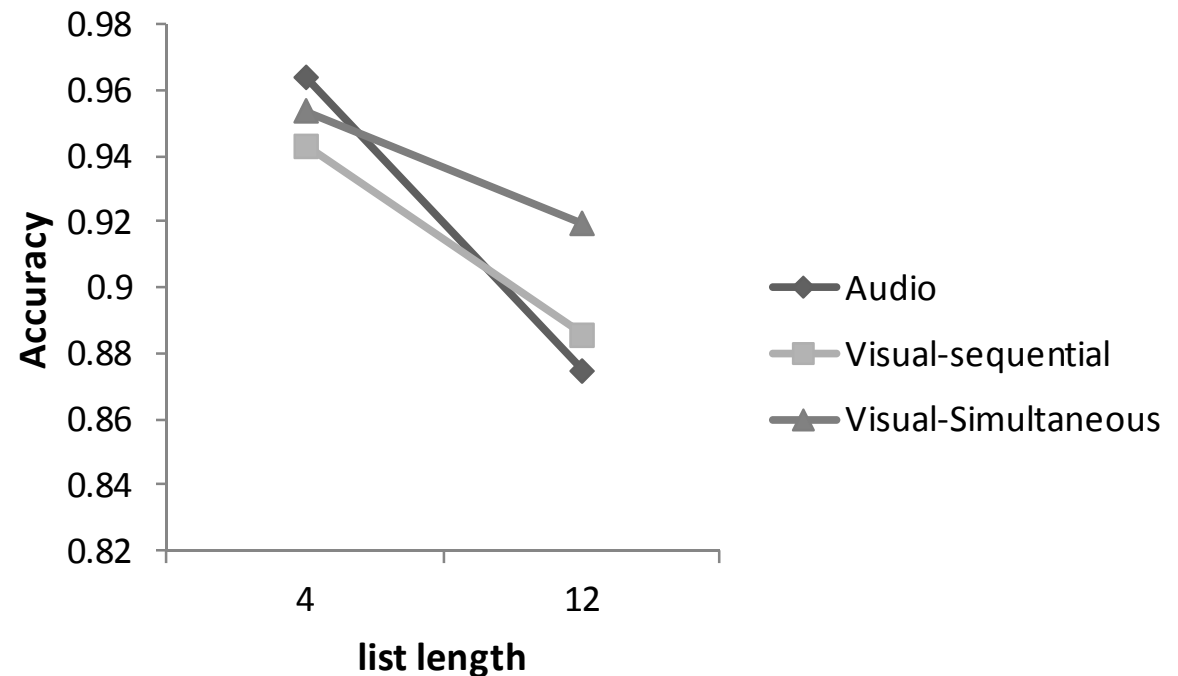


Variable	Audio			Visual Sequential			Visual Simultaneous		
	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β
Updating Accuracy	0.35	0.18	0.42	0.36	0.29	0.28	0.72	0.23	.59**
R^2	0.18 (p = .067)			N.S.			0.35**		

Note: *p < .05 ** p < .01 *** p < .001

Secondary task performance (accuracy) by condition

- In general, longer list induced lower accuracy in the secondary task
- This tendency was strongest in Audio condition



The effect of the interaction between presentation style and list length on Accuracy of the secondary task.

Summary

- Primary task performance was robust.
 - Accident rarely happens.
 - We should consider not only average performance, but also extreme cases and measures based on individual differences.
- Audio presentation had advantage on pedal tracking SD when the list was short and simple, but there was no significant advantage when the list was long and complicated.
- Among 3 presentation style in the experiment, V-seq was the most distracting.
 - Shorter dwelling time on M1 and longer dwelling time on M2 .
 - Reverse priority was likely to be found in V-seq.
- High cognitive ability -> longer dwell time on M1
 - advantage in information processing?

Future topics

- What leads to better attention-shifting in multitasking?
 1. High sensory sensitivity (able to notice information quickly)
 2. High ability in inhibition (doesn't respond to unnecessary information)
 3. Quick recovery from distraction
- In relation of multitasker research by Nass et al.(2012)
 - High multitasker= strong in 1, weak in 2 and 3?

Thank you!



Mark Chignell

David Canella



Moshe Eizenman

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Scope in this presentation and other publications related to this research

- Focusing on the effect of **individual differences** (i.e., The effect of risk tolerance and cognitive ability) on the primary/secondary task performance and eye gaze --- DDI2013
- The effect of **secondary task conditions** on the **primary and secondary** task performance and eye gaze --- HFES2013
- The effect of **secondary task conditions** on the **secondary** task performance, eye gaze and modality selection --- ITS WC 2013