Usability and the Effects of Interruption in C-TOC:

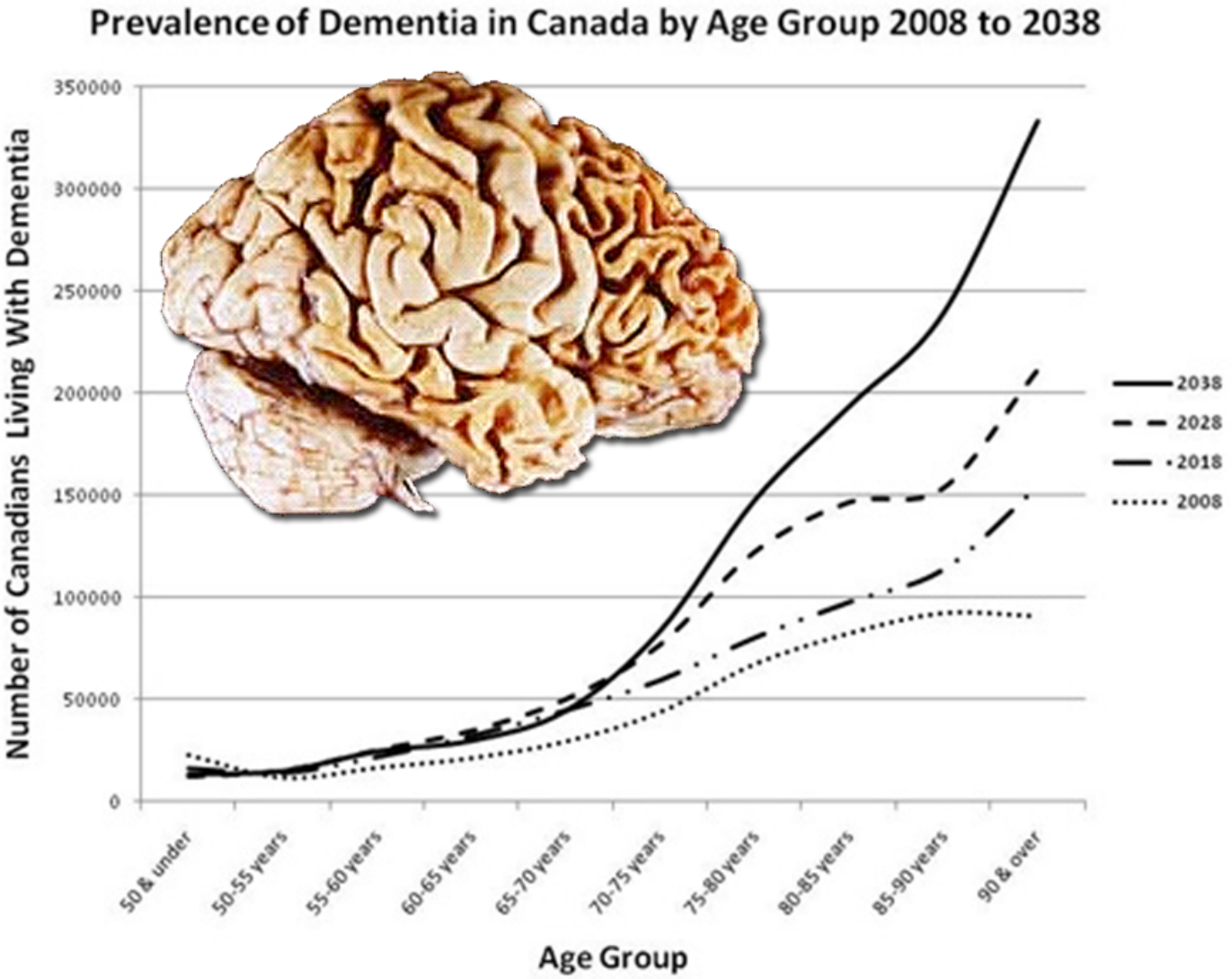
Self-Administered Cognitive Testing on a Computer

Matthew Michael Brehmer

The Imager Laboratory for Graphics, Visualization, and HCT
Department of Computer Science
University of British Columbia

Motivation: an ageing population

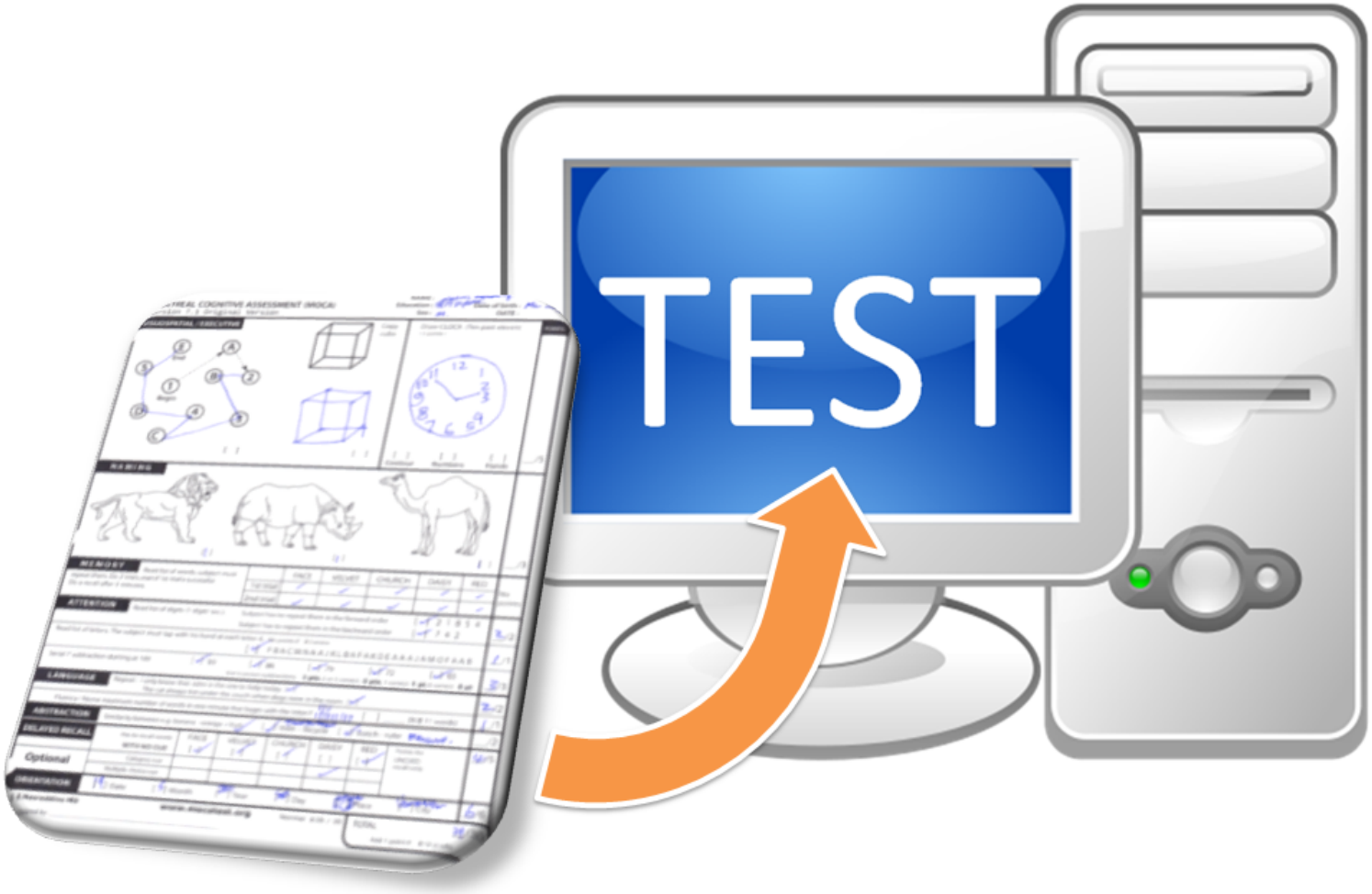
Motivation: increasing awareness of dementia



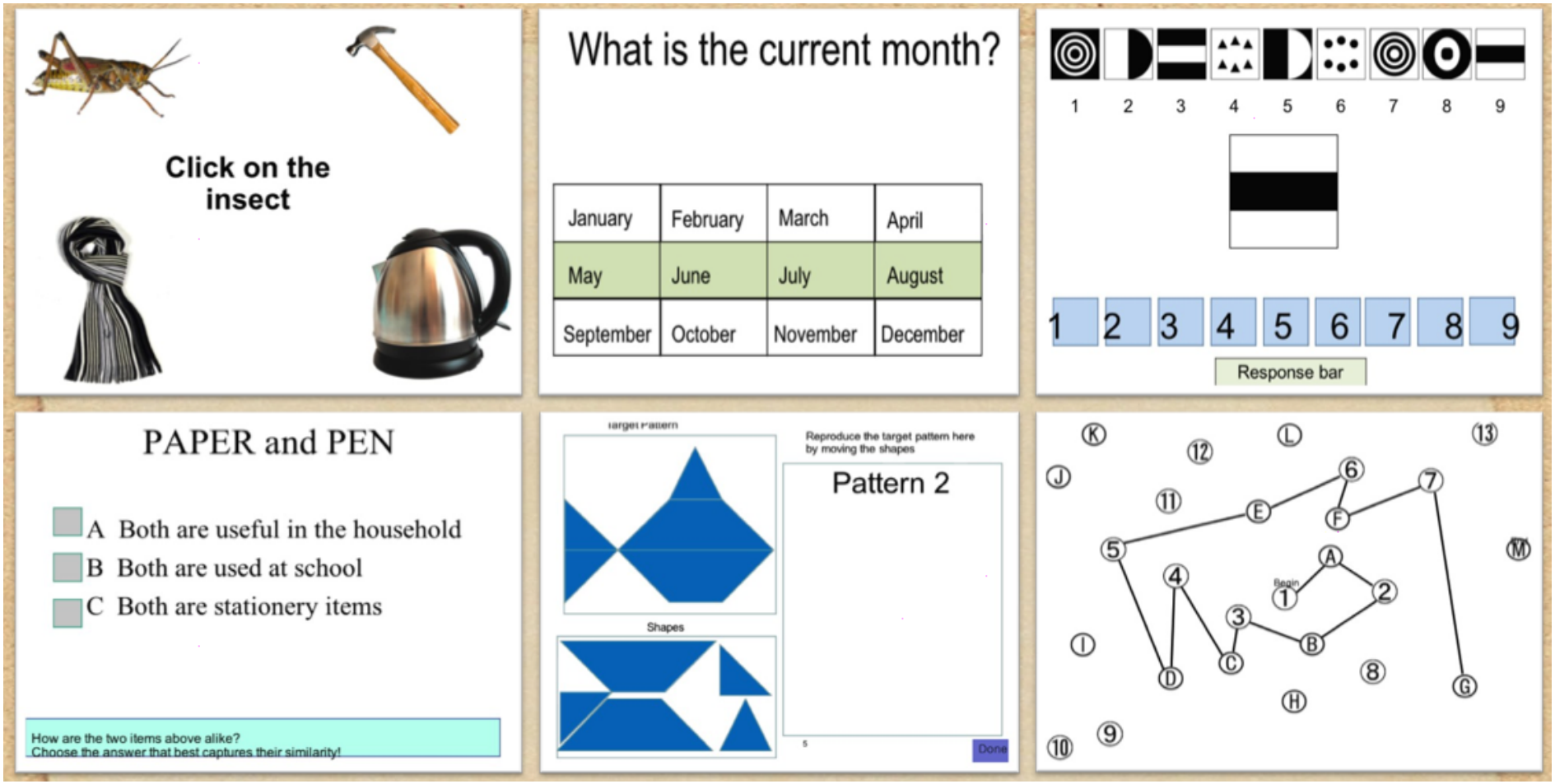
Motivation: long wait times for cognitive assessment

Cognitive assessment tests administered by a clinician

Goal: self-administered computerized cognitive testing



C-TOC: Cognitive Testing On a Computer



C-TOC: Research questions

Does *C-TOC* produce valid results?

Is *C-TOC* usable by older adults?

Will *C-TOC* work outside the clinic?

C-TOC: Research questions

Does *C-TOC* produce valid results?

Is *C-TOC* usable by older adults?

Will *C-TOC* work outside the clinic?

Will *C-TOC* work at home?

Interruptions and distractions in the home

Motivation

- An understanding of how older adults are disrupted by interruptions

Motivation

- An understanding of how older adults are disrupted by interruptions
- The effects of interruption on C-TOC test performance

Motivation

- An understanding of how older adults are disrupted by interruptions
- The effects of interruption on C-TOC test performance
- Detection and mitigation of interruptions to preserve test validity

The Cost of Interruption (COI)[1]

- DVs: task completion time, task resumption time, accuracy,
- Predicting the cost of interruption

[1] http://interruptions.net

The Cost of Interruption (COI)[1]

- DVs: task completion time, task resumption time, accuracy,
- Predicting the cost of interruption
  - Interruption demand (Gillie 89, Monk 08, Oulasvirta 06)

[1] http://interruptions.net

The Cost of Interruption (COI)[1]

- DVs: task completion time, task resumption time, accuracy,
- Predicting the cost of interruption
  - Interruption demand (Gillie 89, Monk 08, Oulasvirta 06)
  - Primary task demand (Bailey 00, Salvucci 10, Speier 03)

[1] http://interruptions.net

The Cost of Interruption (COI)[1]

- DVs: task completion time, task resumption time, accuracy,
- Predicting the cost of interruption
  - Interruption demand (Gillie 89, Monk 08, Oulasvirta 06)
  - Primary task demand (Bailey 00, Salvucci 10, Speier 03)
  - Primary task structure (Cutrell 01, Iqbal 06)

[1] http://interruptions.net

The Cost of Interruption (COI)[1]

- DVs: task completion time, task resumption time, accuracy,
- Predicting the cost of interruption
  - Interruption demand (Gillie 89, Monk 08, Oulasvirta 06)
  - Primary task demand (Bailey 00, Salvucci 10, Speier 03)
  - Primary task structure (Cutrell 01, Iqbal 06)
  - Similarity of primary and interrupting tasks (Bailey 00, Gillie 89)

[1] http://interruptions.net

The Cost of Interruption (COI)[1]

- DVs: task completion time, task resumption time, accuracy,
- Predicting the cost of interruption
  - Interruption demand (Gillie 89, Monk 08, Oulasvirta 06)
  - Primary task demand (Bailey 00, Salvucci 10, Speier 03)
  - Primary task structure (Cutrell 01, Iqbal 06)
  - Similarity of primary and interrupting tasks (Bailey 00, Gillie 89)
  - Duration of interrupting tasks (Bailey 00, Gillie 89, Monk 08, Oulasvirta 06)

[1] http://interruptions.net

The Cost of Interruption (COI)[1]

- DVs: task completion time, task resumption time, accuracy,
- Predicting the cost of interruption
  - Interruption demand (Gillie 89, Monk 08, Oulasvirta 06)
  - Primary task demand (Bailey 00, Salvucci 10, Speier 03)
  - Primary task structure (Cutrell 01, Iqbal 06)
  - Similarity of primary and interrupting tasks (Bailey 00, Gillie 89)
  - Duration of interrupting tasks (Bailey 00, Gillie 89, Monk 08, Oulasvirta 06)
  - Frequency of interruptions (Zijlstra 99)

[1] http://interruptions.net

The Cost of Interruption (COI)[1]

- DVs: task completion time, task resumption time, accuracy,
- Predicting the cost of interruption
  - Interruption demand (Gillie 89, Monk 08, Oulasvirta 06)
  - Primary task demand (Bailey 00, Salvucci 10, Speier 03)
  - Primary task structure (Cutrell 01, Iqbal 06)
  - Similarity of primary and interrupting tasks (Bailey 00, Gillie 89)
  - Duration of interrupting tasks (Bailey 00, Gillie 89, Monk 08, Oulasvirta 06)
  - Frequency of interruptions (Zijlstra 99)
  - Warning of imminent an interruption (Altmann 04, Hodgetts 06, Trafton 03)

[1] http://interruptions.net

The Cost of Interruption (COI)[1]

- DVs: task completion time, task resumption time, accuracy,
- Predicting the cost of interruption
  - Interruption demand (Gillie 89, Monk 08, Oulasvirta 06)
  - Primary task demand (Bailey 00, Salvucci 10, Speier 03)
  - Primary task structure (Cutrell 01, Iqbal 06)
  - Similarity of primary and interrupting tasks (Bailey 00, Gillie 89)
  - Duration of interrupting tasks (Bailey 00, Gillie 89, Monk 08, Oulasvirta 06)
  - Frequency of interruptions (Zijlstra 99)
  - Warning of imminent an interruption (Altmann 04, Hodgetts 06, Trafton 03)
  - Contextual factors

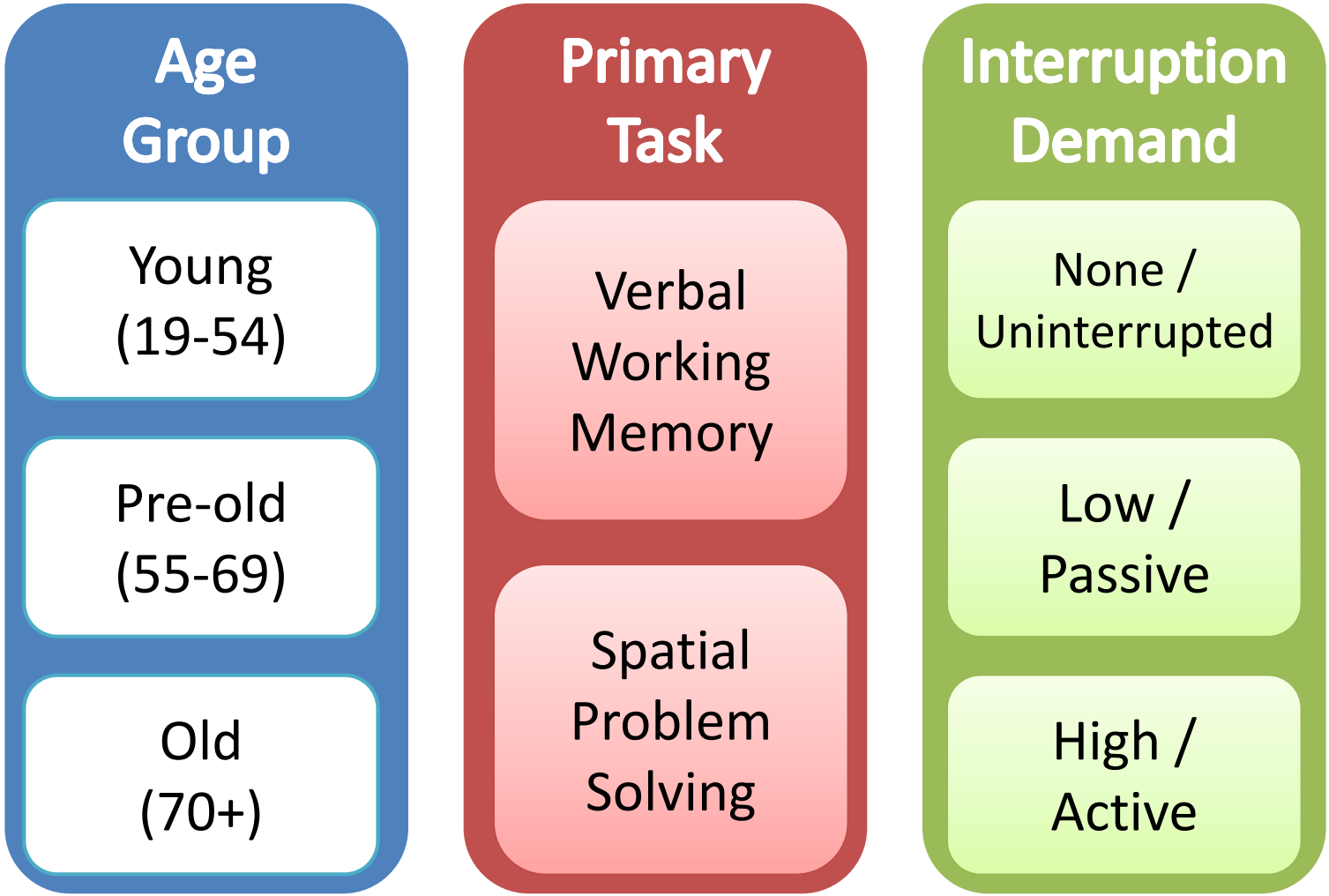
[1] http://interruptions.net

The COI for Older adults

- Normal cognitive ageing: changes in working memory, processing speed, attention, distractibility, task-switching
- Reported COIs for older adults:
  - Working memory (Clapp 10)
  - Ability to remember intentions (Farrimond 06)

Study Design

3 x 3 x 2 mixed design

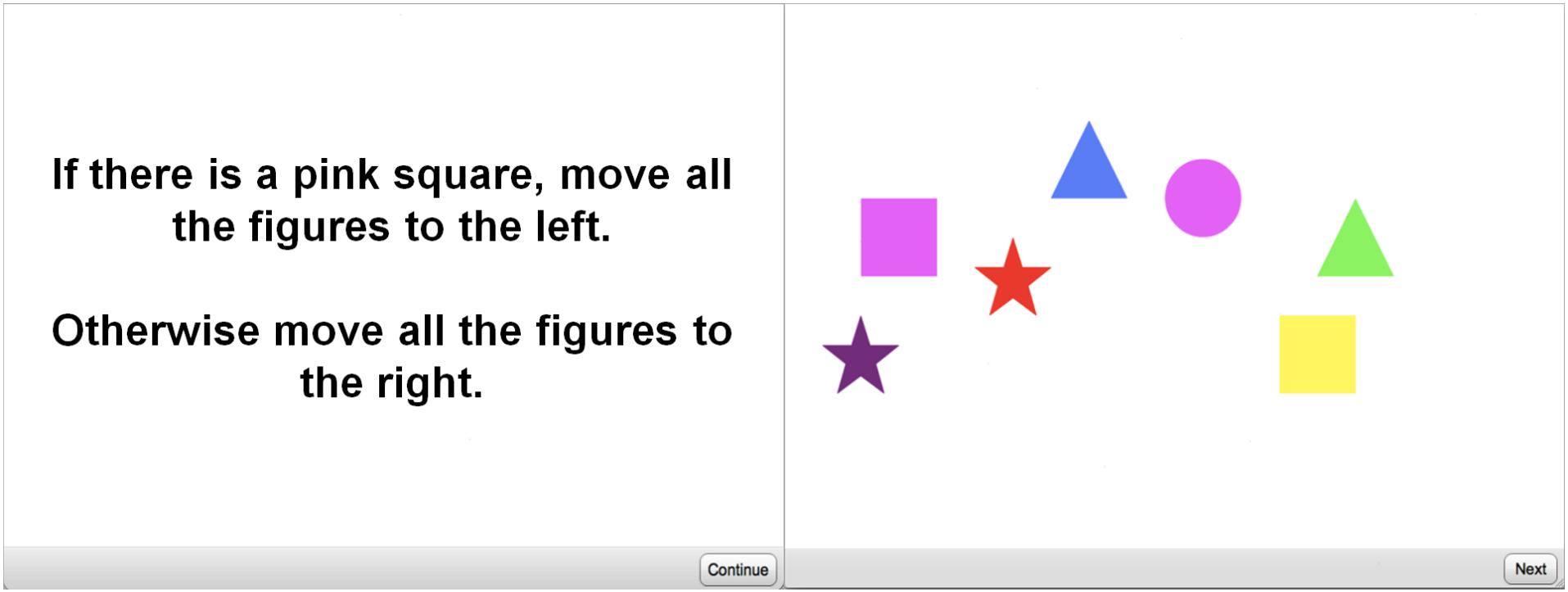


Between Subjects
N = 36 (12 / group)

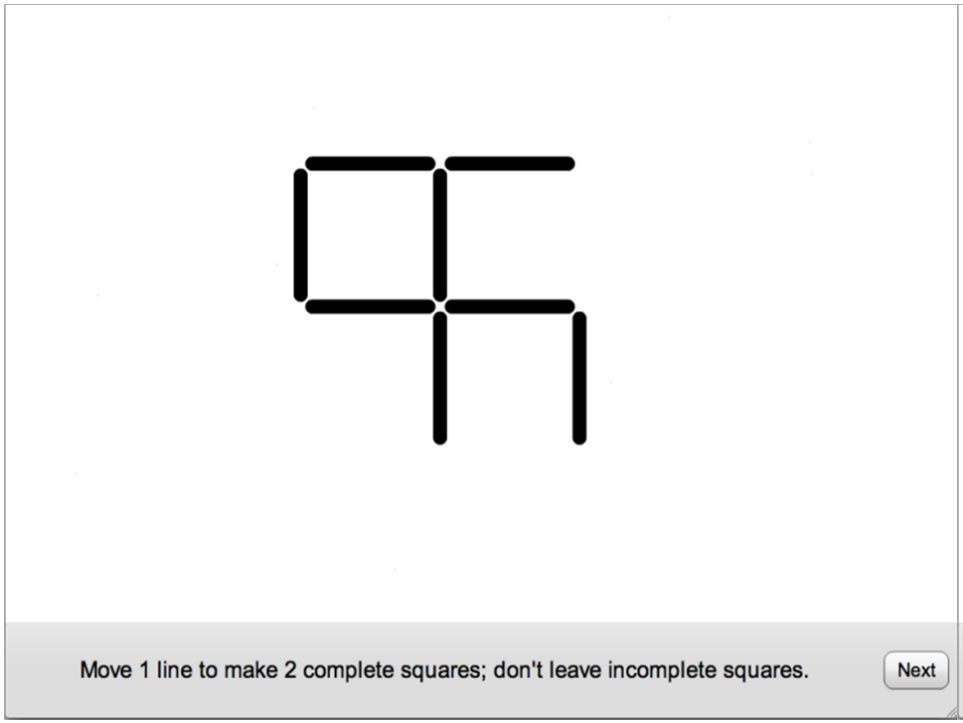
Within subjects,
counter-balanced

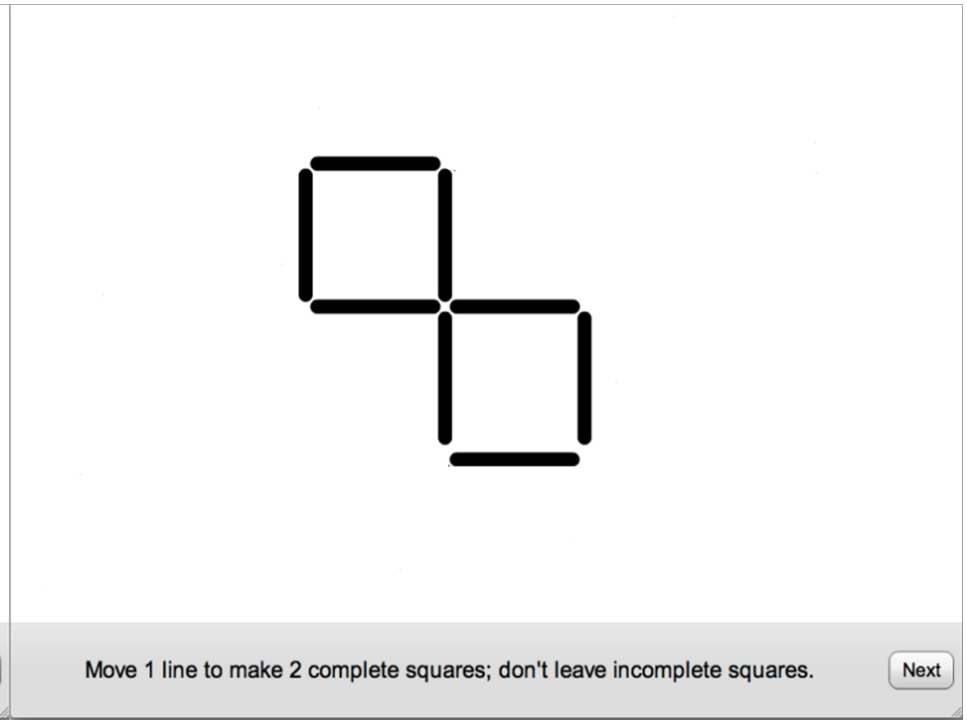
Within subjects,
counter-balanced

Primary Task: VERBAL



Primary Task: SPATIAL

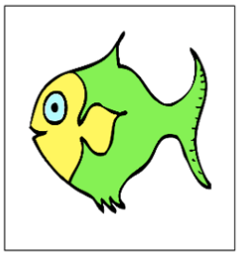




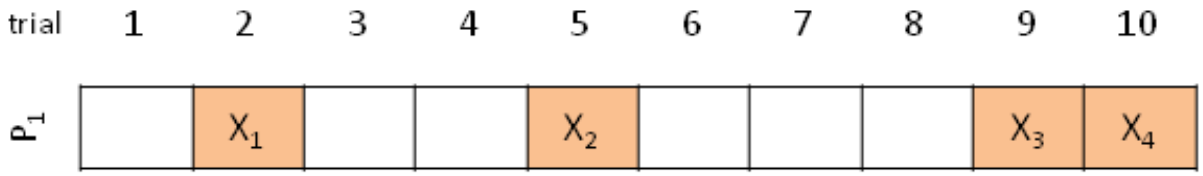
Interrupting Tasks: PASSIVE (left), ACTIVE (right)

WATCH these images.
DO NOT CLICK on them.

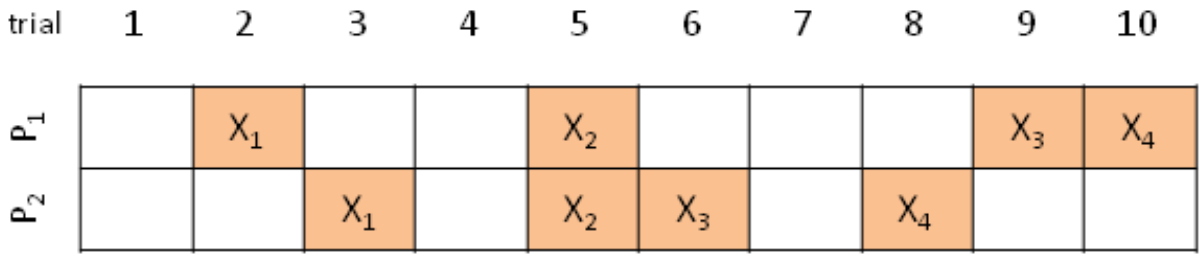
CLICK in the box
when the current image repeats
what you saw 2 images ago.



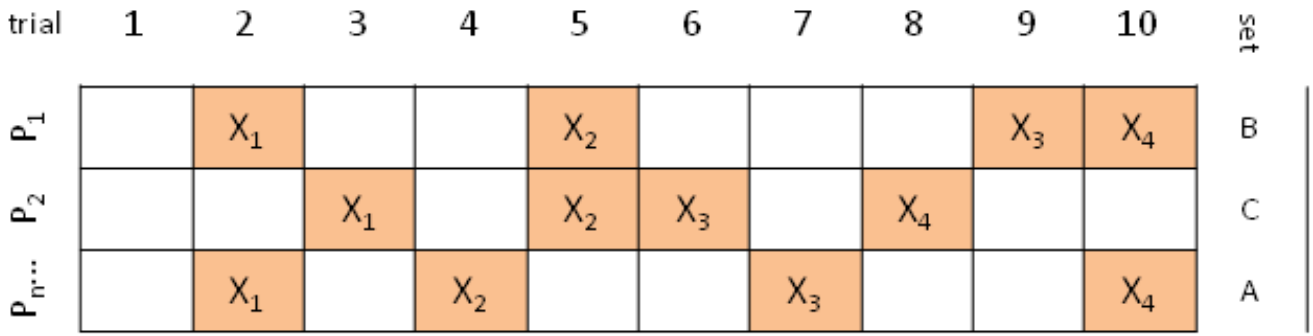
Coordination of Tasks



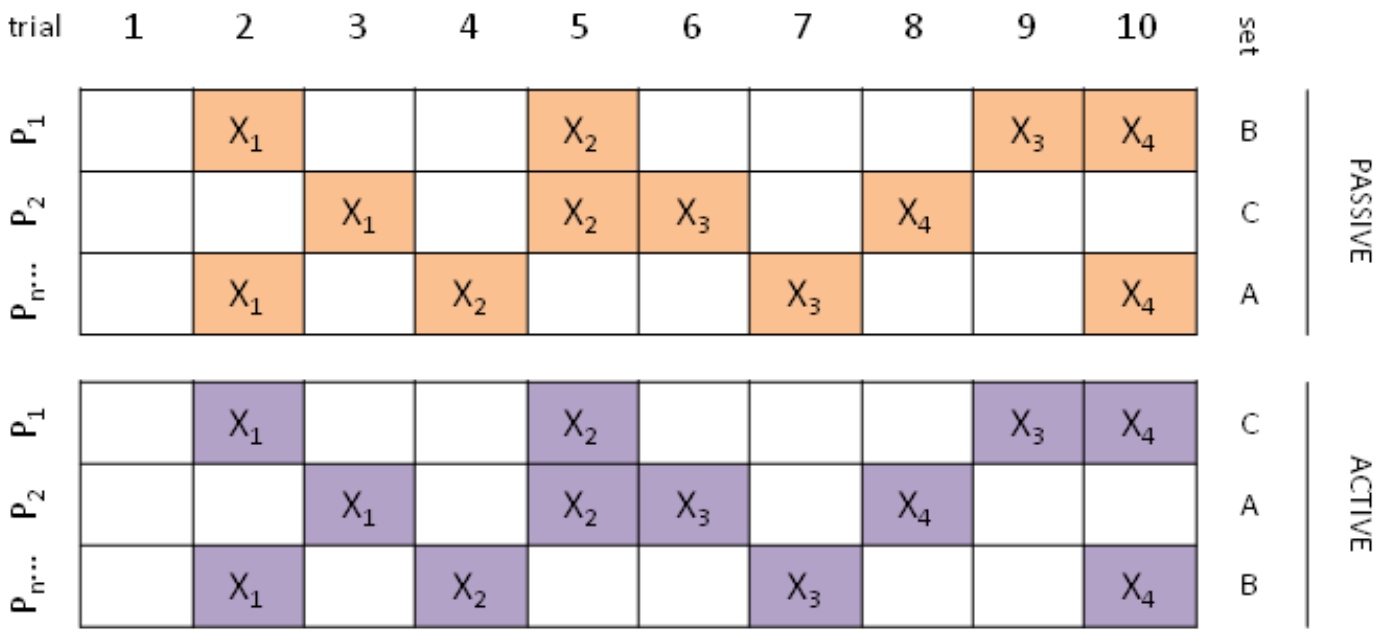
Coordination of Tasks



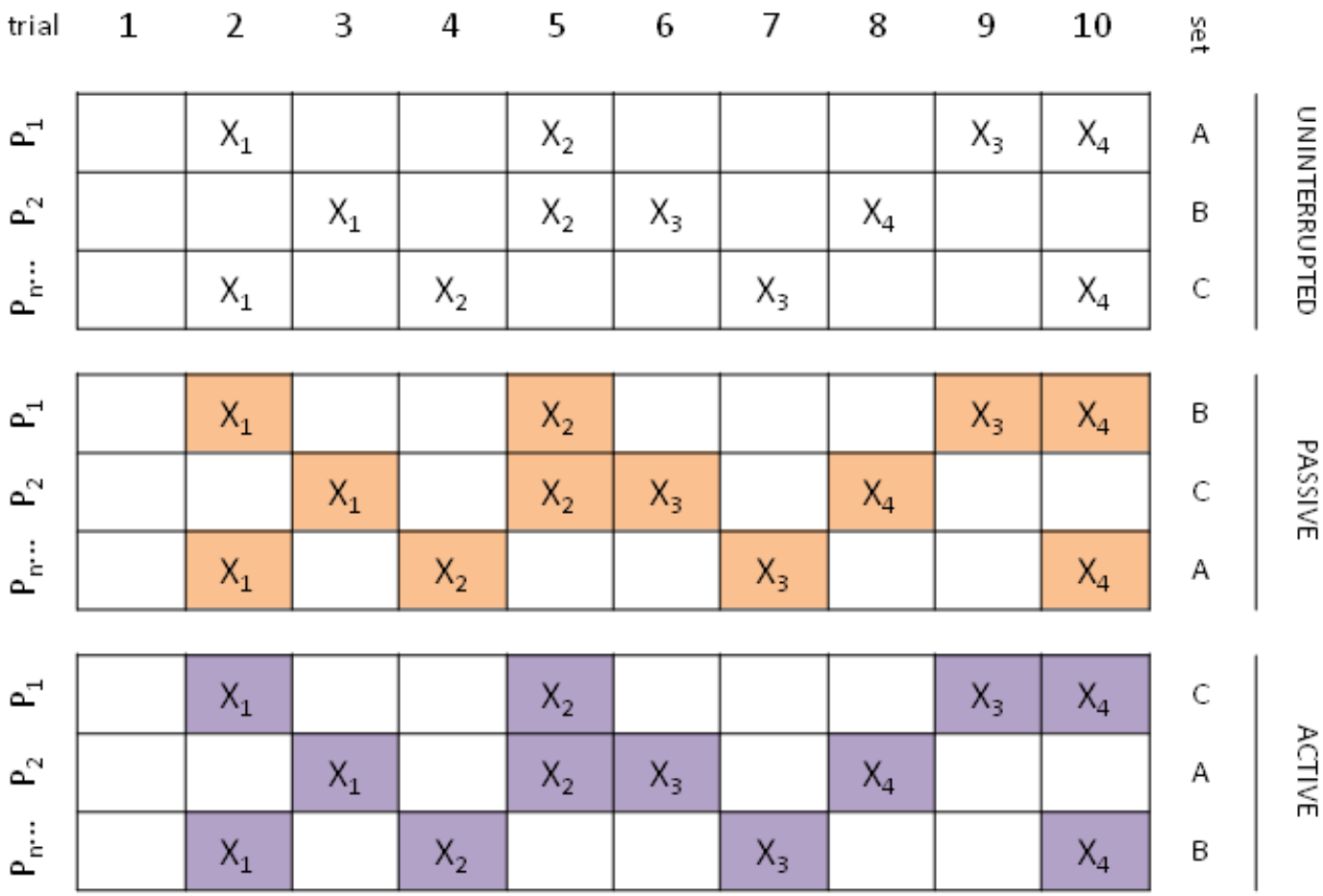
Coordination of Tasks



Coordination of Tasks



Coordination of Tasks



Quantitative & Qualitative Measures

Trial Completion Time
Task Resumption Time
Trial Accuracy

Quantitative & Qualitative Measures

Trial Completion Time
Task Resumption Time
Trial Accuracy
Questionnaires
Structured Interviews

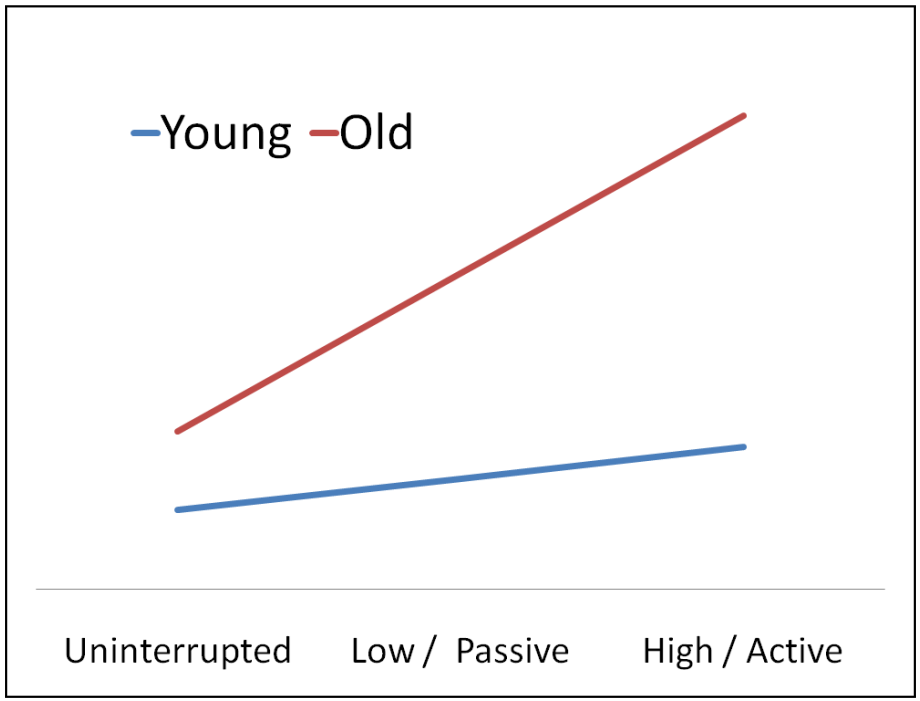
Hypotheses

Hypotheses: Age & Interruption Demand

- 1.1. *Overall,* YOUNG *adults will perform better than older adults.*

Hypotheses: Age & Interruption Demand

- 1.1. *Overall,* YOUNG *adults will perform better than older adults.*
- 1.2. *Older adults will incur a disproportionately larger* COI *when interruption demand increases.*

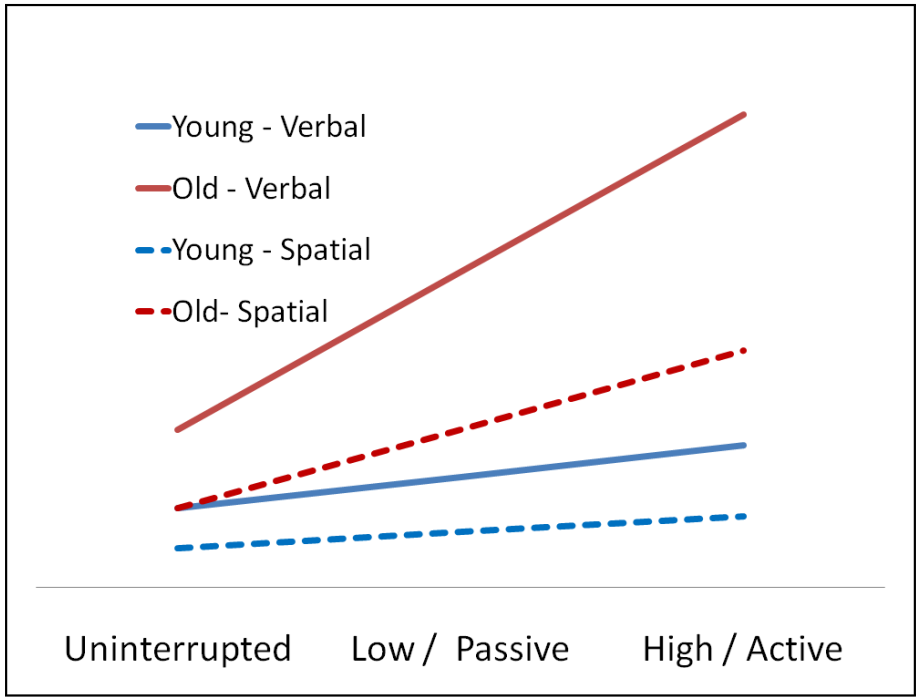


Hypotheses: Age, Task & Interruption Demand

- 2.1. *The* VERBAL *task places a greater load on working memory. Therefore increased interruption demand will incur a disproportionately greater* COI *on the* VERBAL *task than on the* SPATIAL *task.*

Hypotheses: Age, Task & Interruption Demand

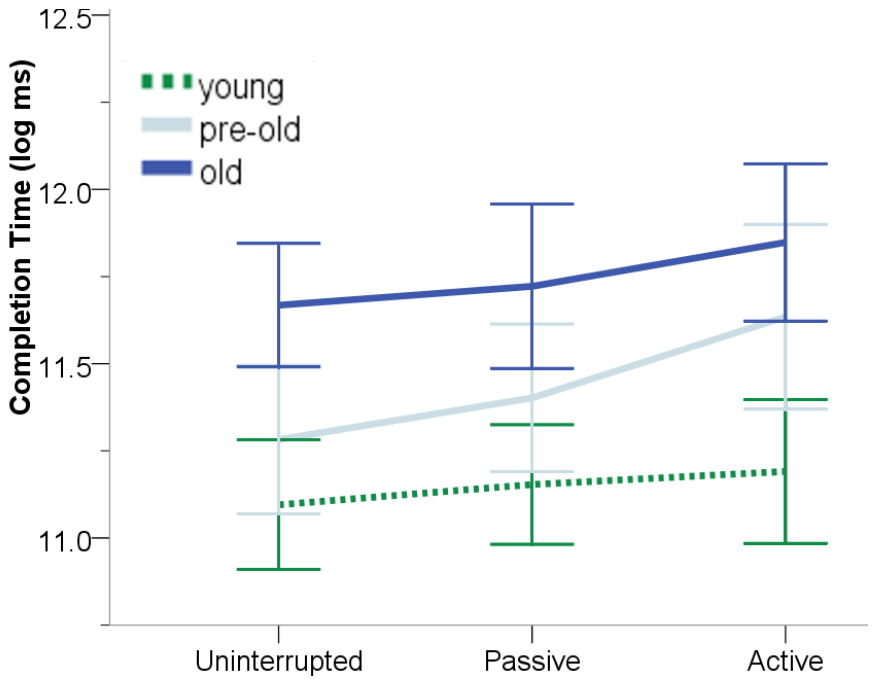
- 2.1. *The* VERBAL *task places a greater load on working memory. Therefore increased interruption demand will incur a disproportionately greater* COI *on the* VERBAL *task than on the* SPATIAL *task.*
- 2.2. *This difference in* COI *will be greater for older adults.*



Results

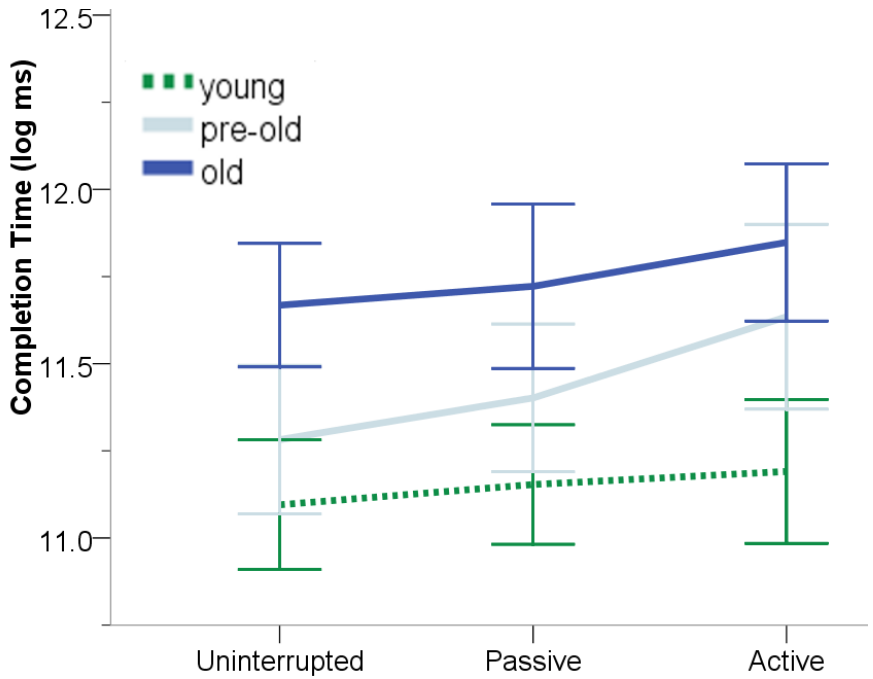
Summary of Results - VERBAL task

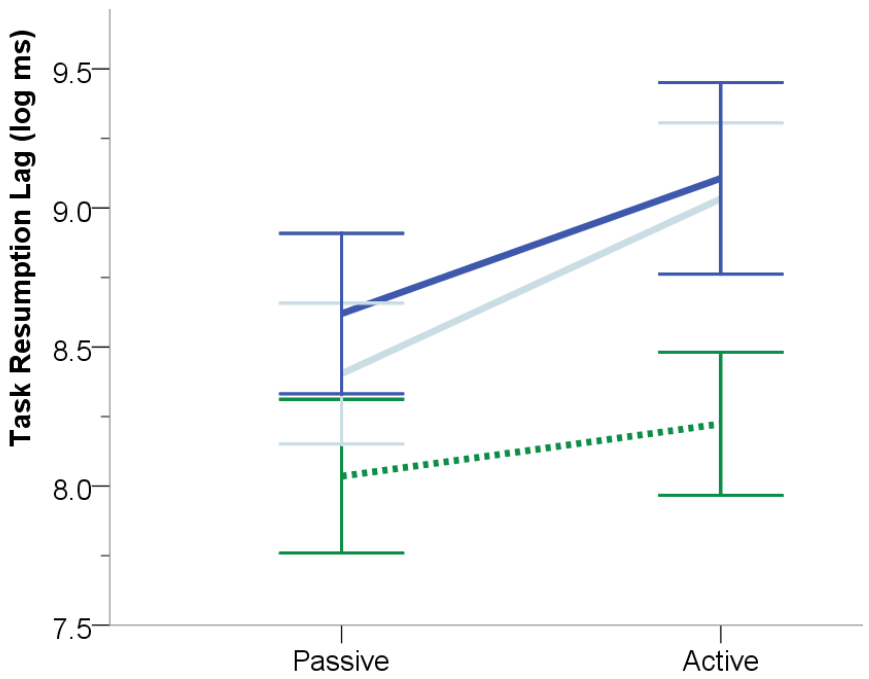
Completion time: All groups slower in ACTIVE cond.



Summary of Results - VERBAL task

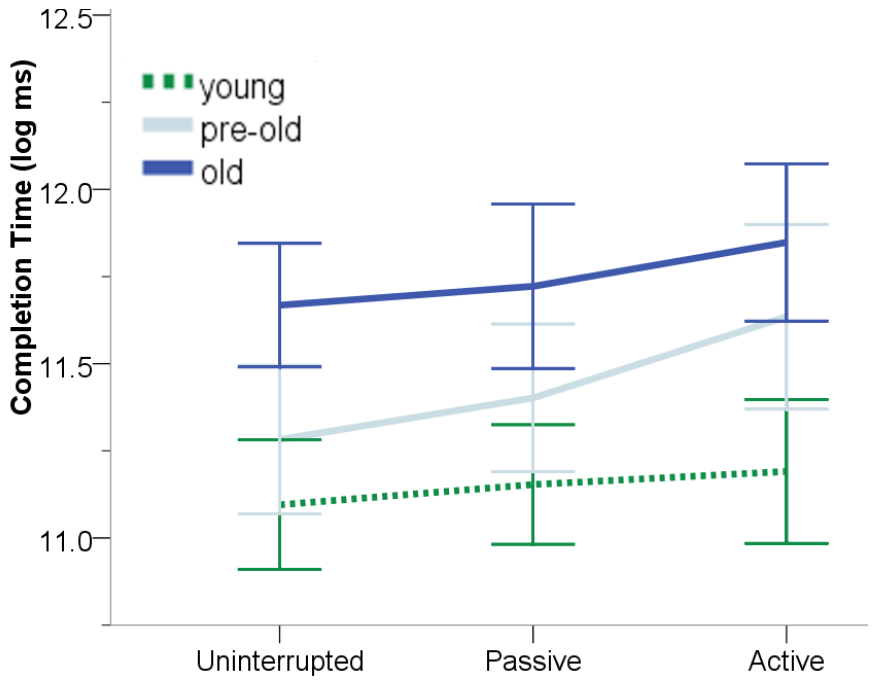
Completion time:	All groups slower in ACTIVE cond.
Resumption lag time:	OLD disproportionally slower in ACTIVE cond.

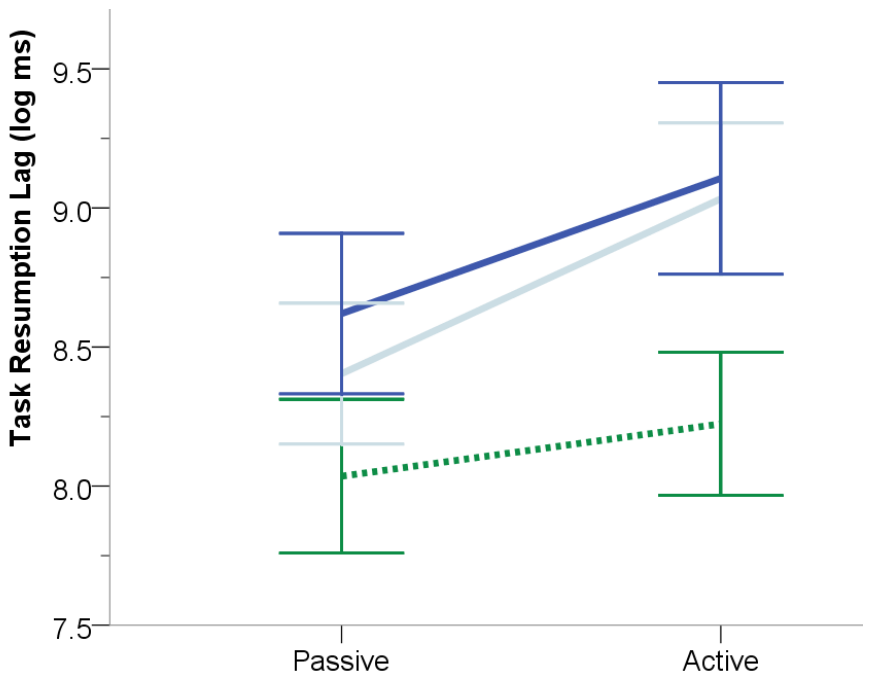




Summary of Results - VERBAL task

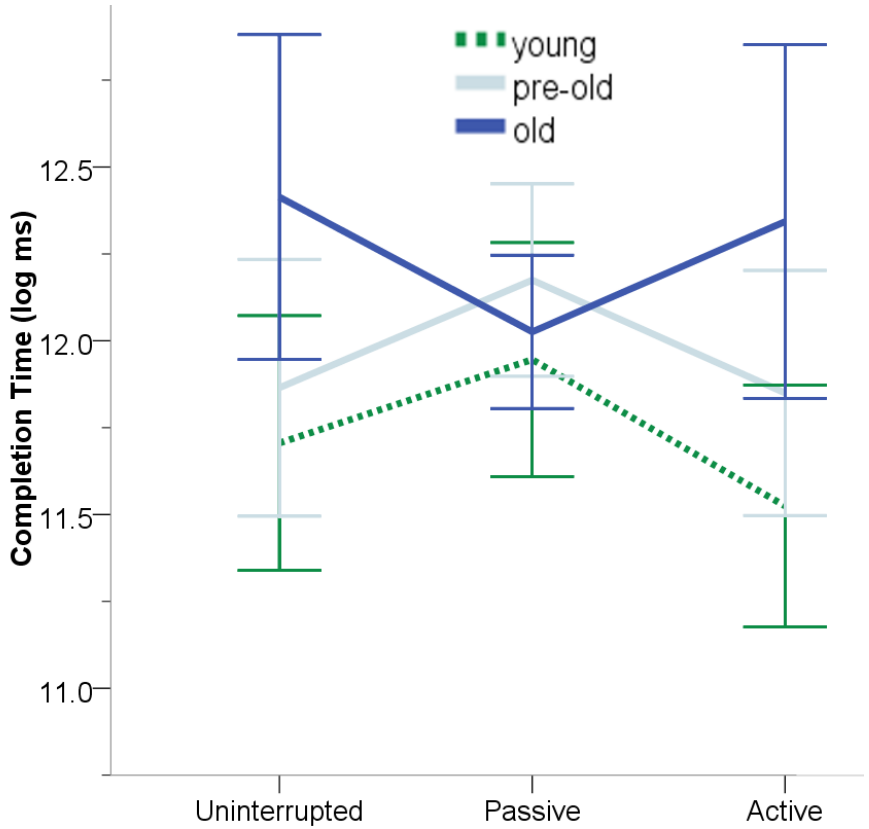
Completion time:	All groups slower in ACTIVE cond.
Resumption lag time:	OLD disproportionally slower in ACTIVE cond.
Accuracy:	Old less accurate





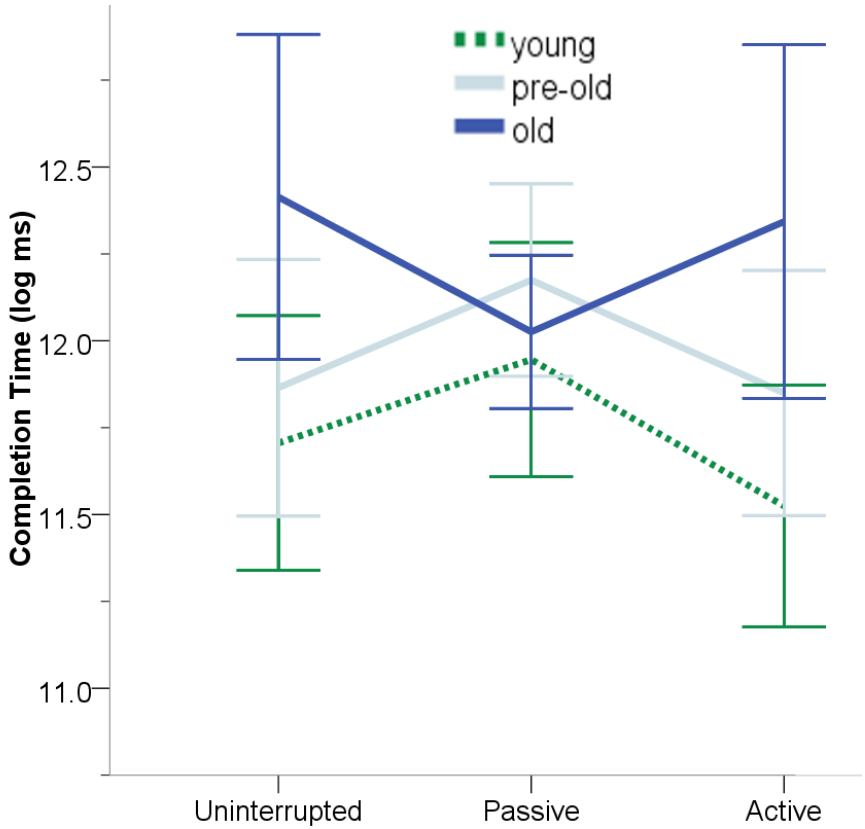
Summary of Results - SPATIAL task

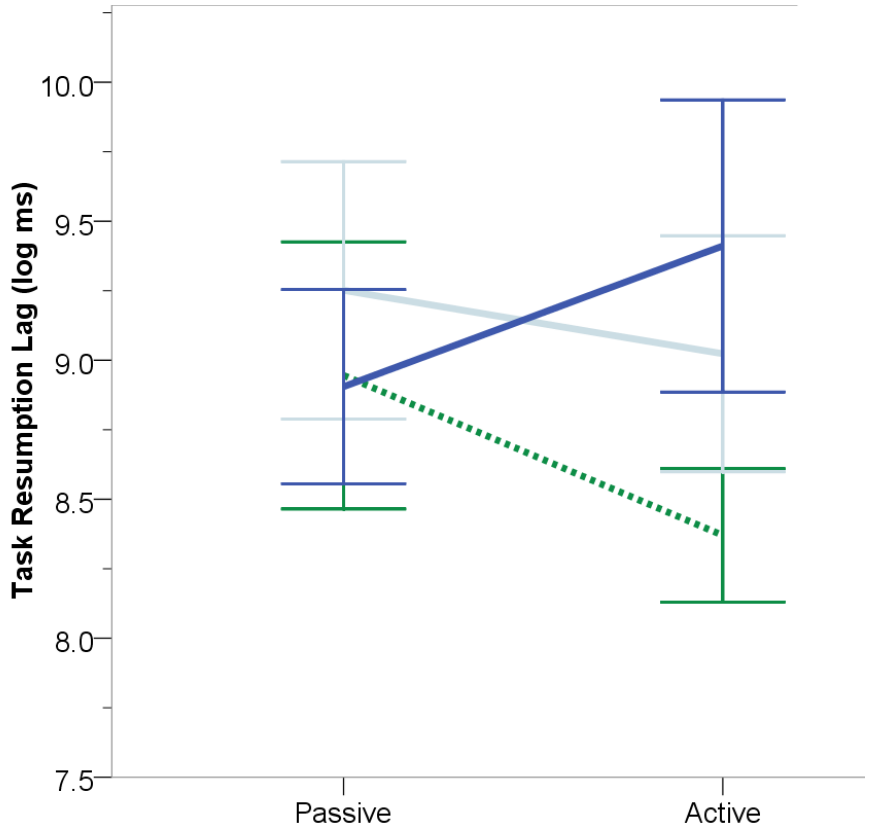
Completion time:	No age difference in PASSIVE cond.



Summary of Results - SPATIAL task

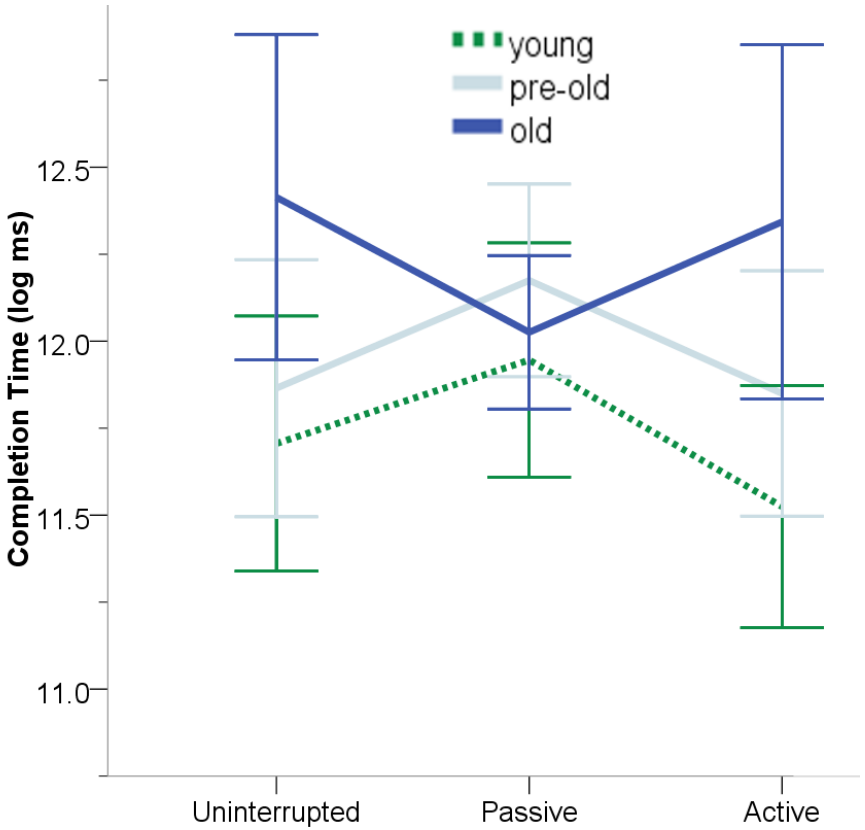
Completion time:	No age difference in PASSIVE cond.
Resumption lag time:	YOUNG faster in ACTIVE cond.

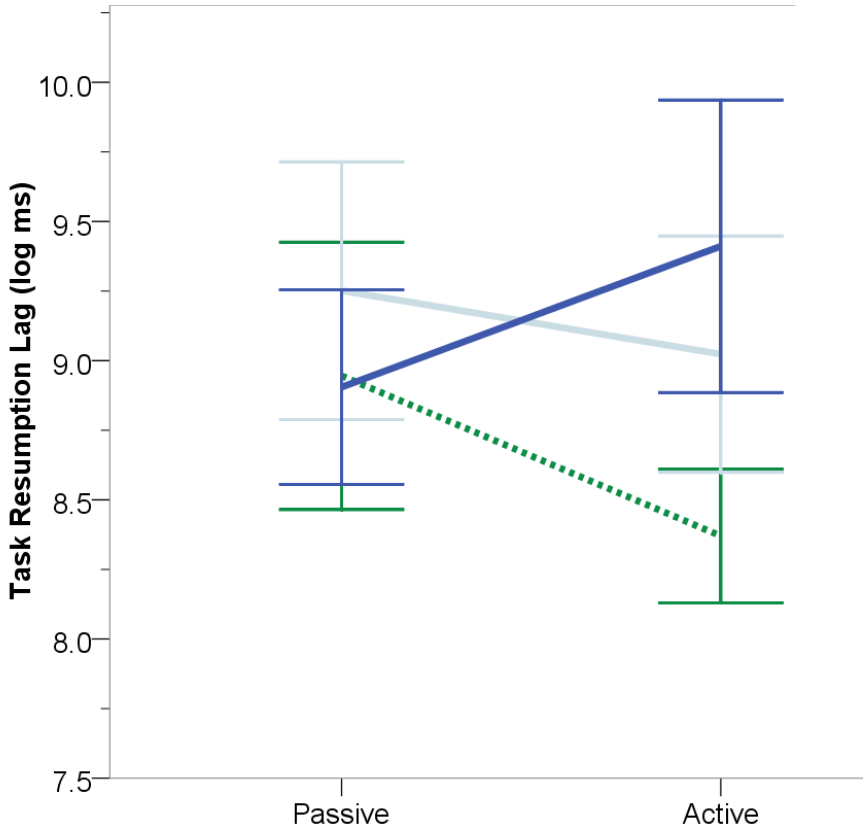




Summary of Results - SPATIAL task

Completion time:	No age difference in PASSIVE cond.
Resumption lag time:	YOUNG faster in ACTIVE cond.
Accuracy:	Age effect not sig.





Hypotheses Revisited: Age & Interruption Demand

- 1.1. *Overall,* YOUNG *adults will perform better than older adults.*
  - Supported.

Hypotheses Revisited: Age & Interruption Demand

- 1.1. *Overall,* YOUNG *adults will perform better than older adults.*
  - Supported.
- 1.2. *Older adults will incur a disproportionately larger* COI *when interruption demand increases*
  - Partially supported.

Hypotheses Revisited: Age, Task & Interruption Demand

- 2.1. *The* VERBAL *task places a greater load on memory. Therefore increased interruption demand will incur a disproportionately greater* COI *on the* VERBAL *task than on the* SPATIAL *task.*
  - Partially supported.

Hypotheses Revisited: Age, Task & Interruption Demand

- 2.1. *The* VERBAL *task places a greater load on memory. Therefore increased interruption demand will incur a disproportionately greater* COI *on the* VERBAL *task than on the* SPATIAL *task.*
  - Partially supported.
- 2.2. *This difference in* COI *will be greater for older adults.*
  - Partially supported.

Discussion

Discussion: The Results

- OLD adults compensate for slower task resumption.
  A *Zeigarnik* effect? [2] (improved performance on interrupted tasks)

[2] B. Zeigarnik. Das behalten erledigter und unerledigter handlungen. *Psychologische Forschung* (1927).

Discussion: The Results

- OLD adults compensate for slower task resumption.
  A *Zeigarnik* effect? [2] (improved performance on interrupted tasks)
- Primary task accuracy was not affected by interruptions.

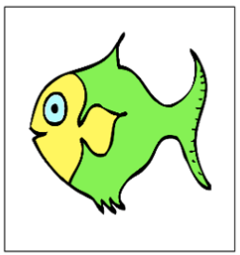
[2] B. Zeigarnik. Das behalten erledigter und unerledigter handlungen. *Psychologische Forschung* (1927).

Methodological Implications

- Low-demand interruptions need not be passive.
- High-demand interruptions may not have been difficult enough for young adults.

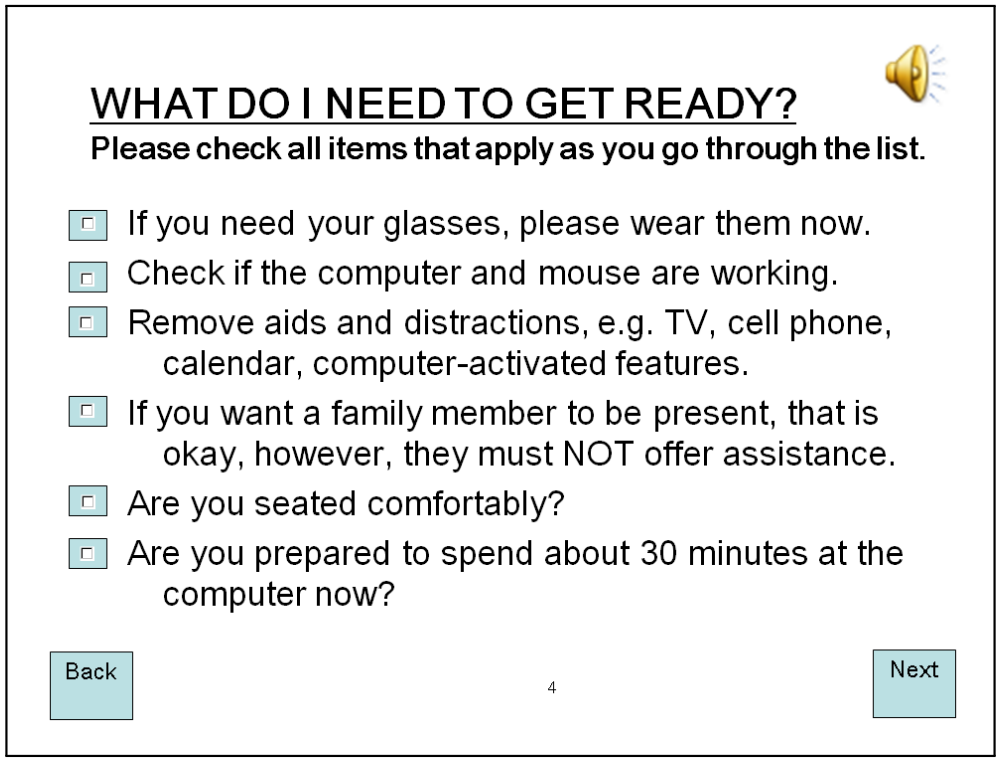
WATCH these images.
DO NOT CLICK on them.

CLICK in the box
when the current image repeats
what you saw 2 images ago.



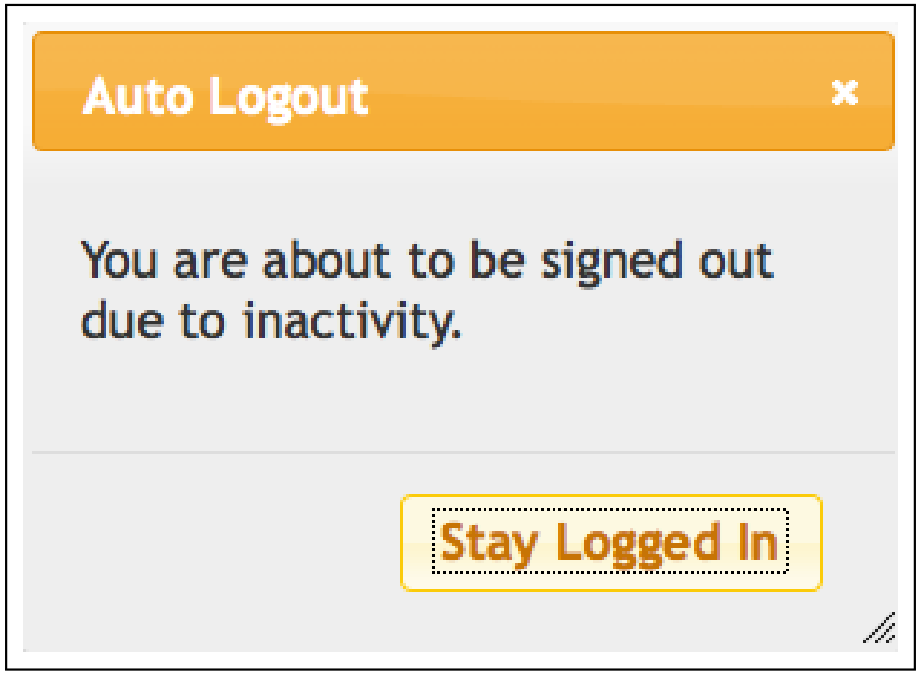
Design Implications

- Prevent interruptions with prompts tailored to each test.



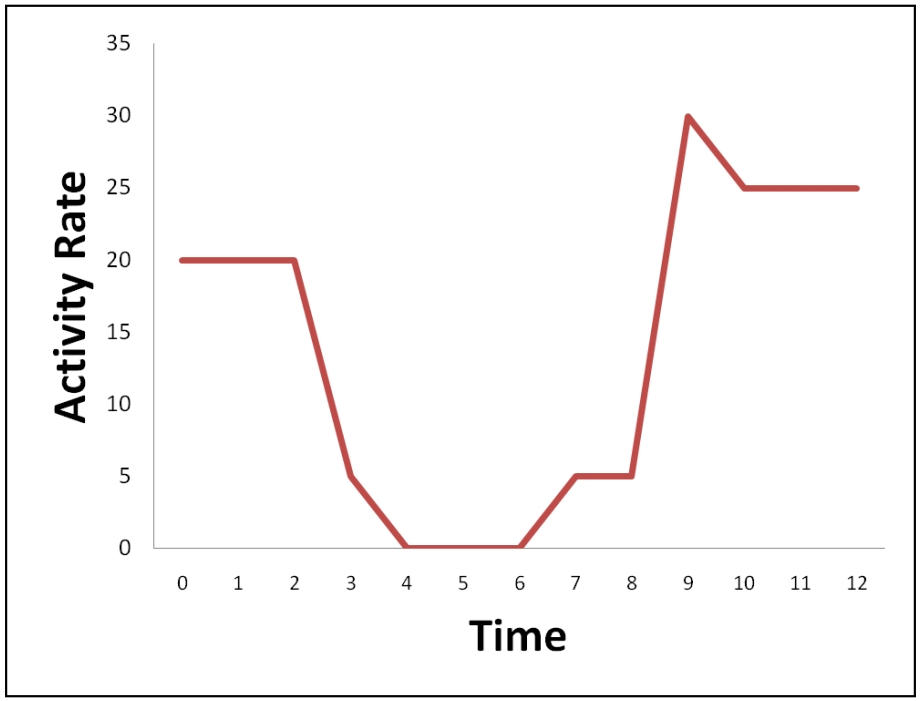
Design Implications

- Detect interruptions by requiring user response. Mitigate interruptions with trial replacement and test restarts.



Design Implications

- Detect interruptions by examining variation in task completion rates.

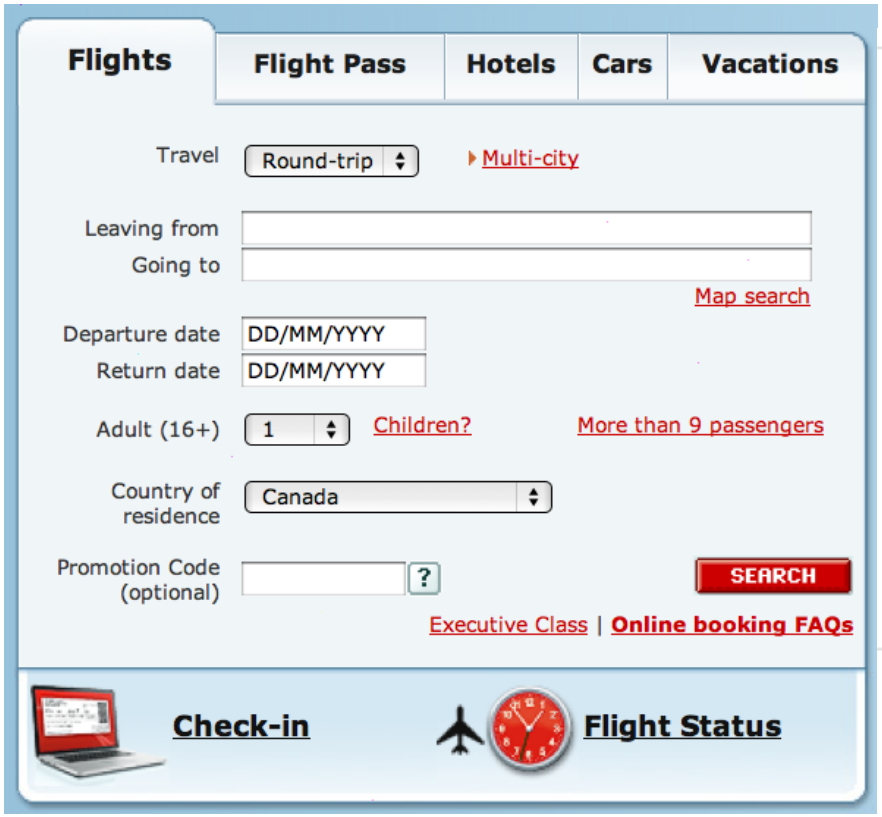


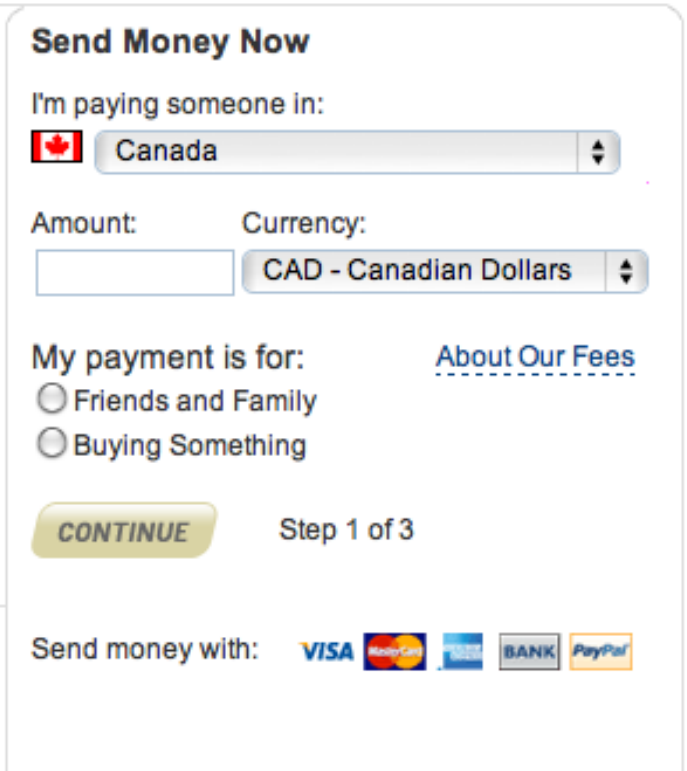
Design Implications

- The user was interrupted. Is their performance invalid?

Design Implications

- In general, segment tasks and determine inactivity thresholds.





Future Work

Future Work

- Effect of interruptions on other C-TOC tests

Future Work

- Effect of interruptions on other C-TOC tests
- Determining valid levels of interruption demand

Future Work

- Effect of interruptions on other C-TOC tests
- Determining valid levels of interruption demand
- Examining age differences in task resumption strategy

Future Work

- Effect of interruptions on other C-TOC tests
- Determining valid levels of interruption demand
- Examining age differences in task resumption strategy
- Manipulating other factors of interrupting and primary tasks

Future Work

- Effect of interruptions on other C-TOC tests
- Determining valid levels of interruption demand
- Examining age differences in task resumption strategy
- Manipulating other factors of interrupting and primary tasks
- Investigating the effects of interruptions on individuals with cognitive impairment

Future Work

- Effect of interruptions on other C-TOC tests
- Determining valid levels of interruption demand
- Examining age differences in task resumption strategy
- Manipulating other factors of interrupting and primary tasks
- Investigating the effects of interruptions on individuals with cognitive impairment
- Evaluating designs for preventing, detecting, and mitigating effects of interruptions in C-TOC

Acknowledgements

Thanks:
Joanna McGrenere, Claudia Jacova, Charlotte Tang, Peter Graf
Carmen Li, Hyunsoo Lee, William Wang

Conclusion / Bonus MUX Discussion

- Interactions of age, task, and interruption demand: additional insights?
- Are older research subjects more conscientious?
- Externally valid interruptions for older adults?
- Tips on recruiting older adults