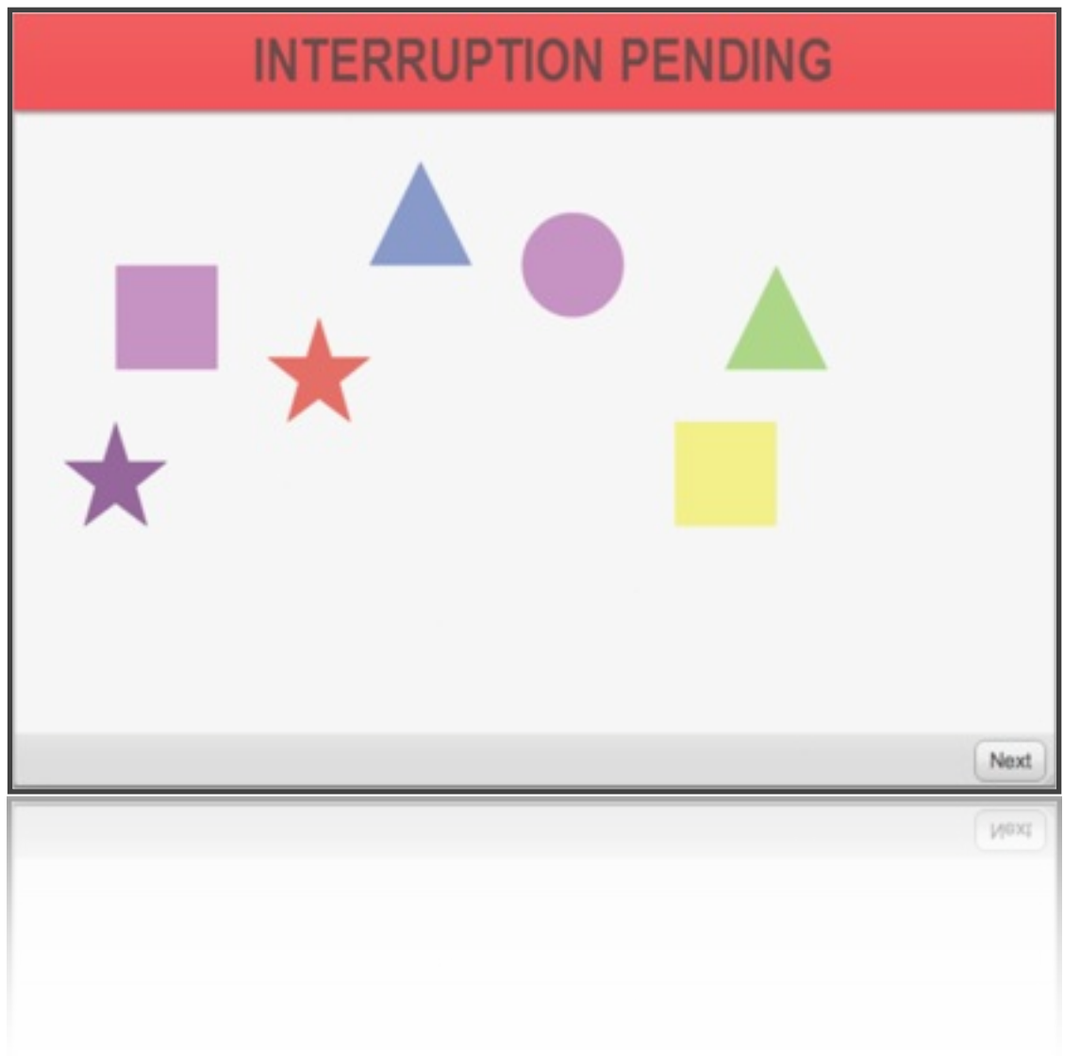
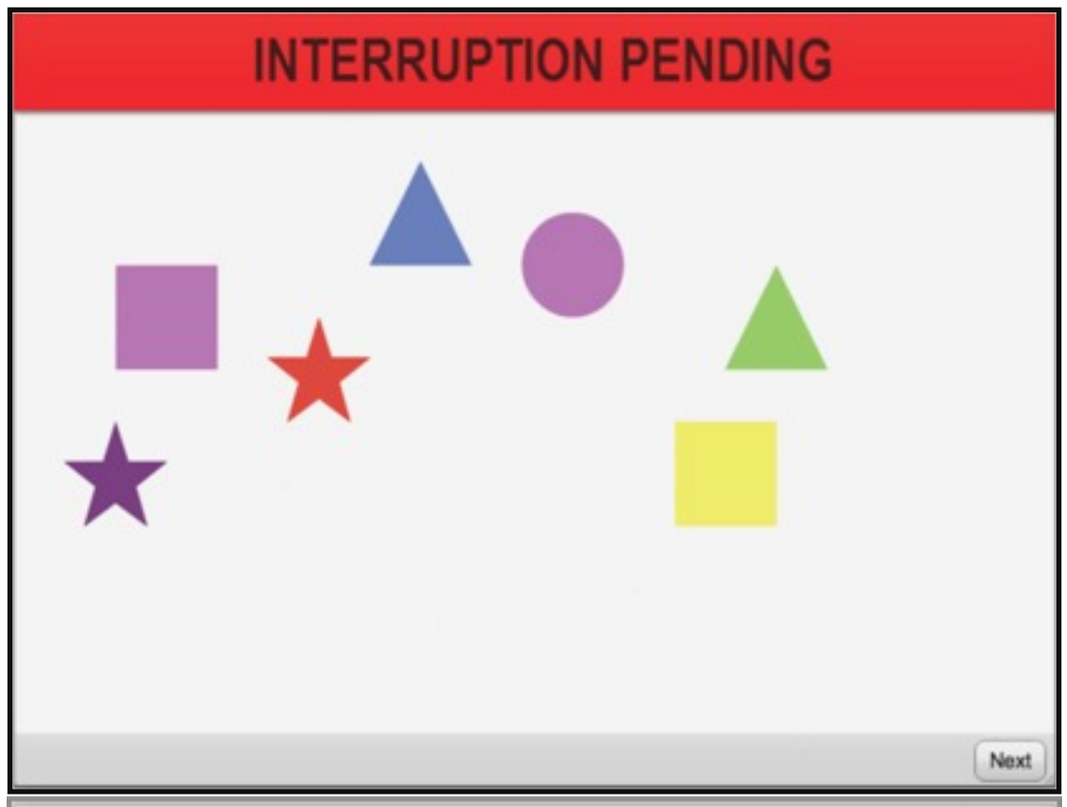
Matthew Brehmer, Joanna McGrenere, Charlotte Tang, Claudia Jacova

Investigating **interruptions** in the context of **computerised cognitive testing** for older adults



Matthew Brehmer, Joanna McGrenere, Charlotte Tang, Claudia Jacova

Investigating **interruptions** in the context of **computerised cognitive testing** for older adults



C-TOC:

Cognitive Testing On a Computer

Jacova *et al* (2010)

C-TOC:

Cognitive Testing On a Computer

Jacova *et al* (2010)

Self-administered

Web-based

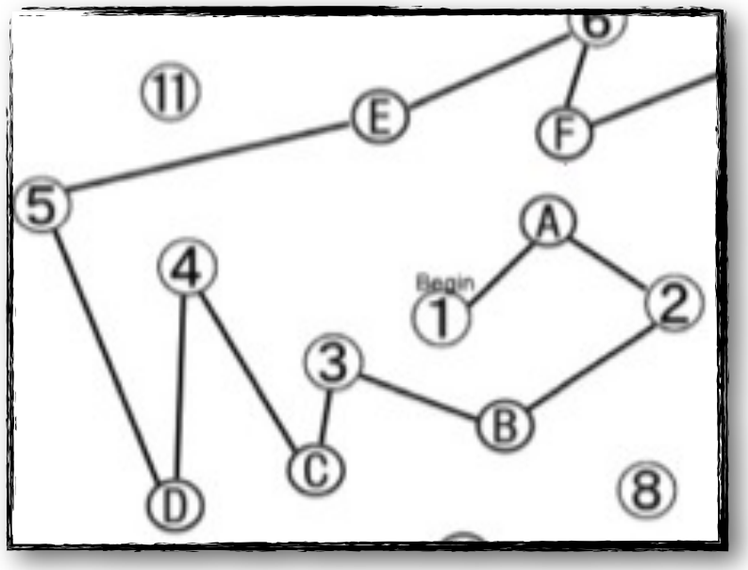
Long wait times

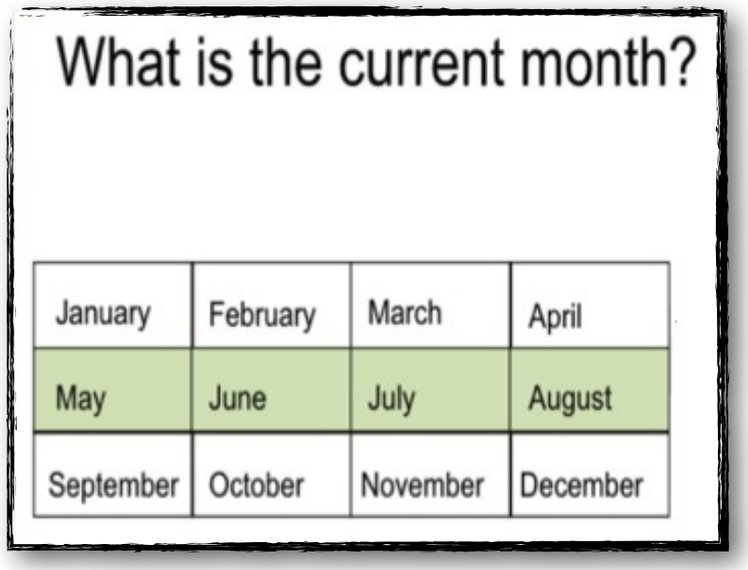
Jacova *et al* (2010)

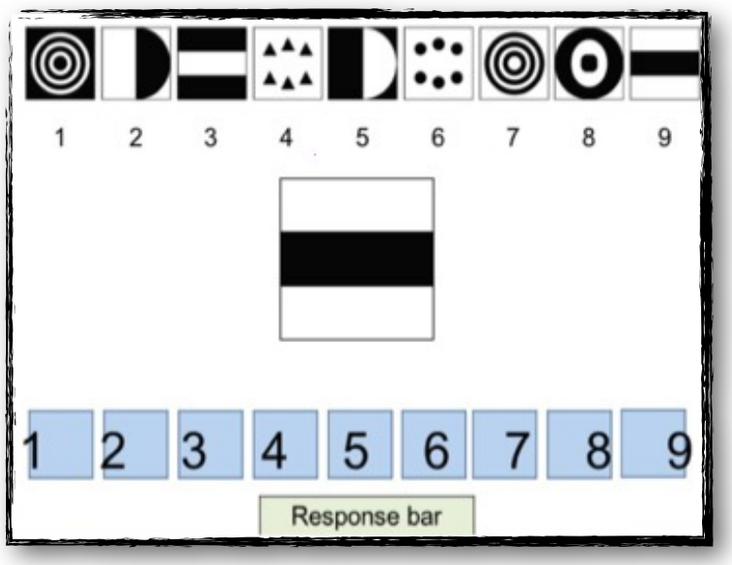
C-TOC:

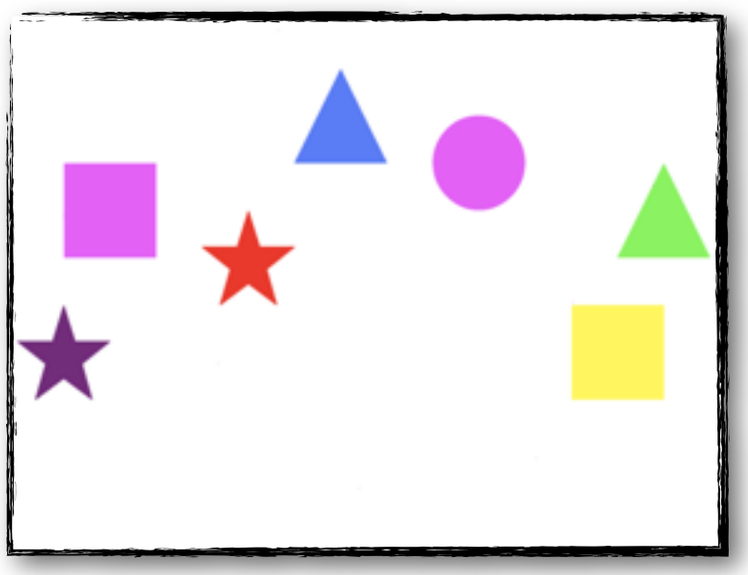
15 short tests

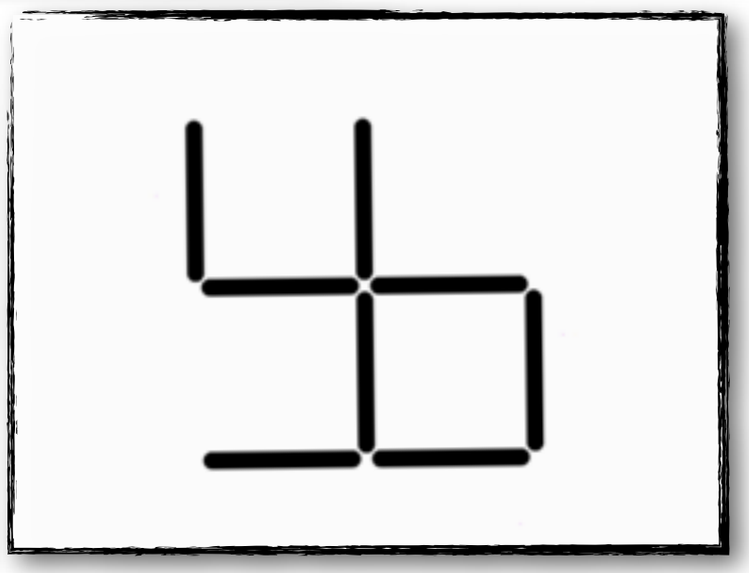
Jacova *et al* (2010)



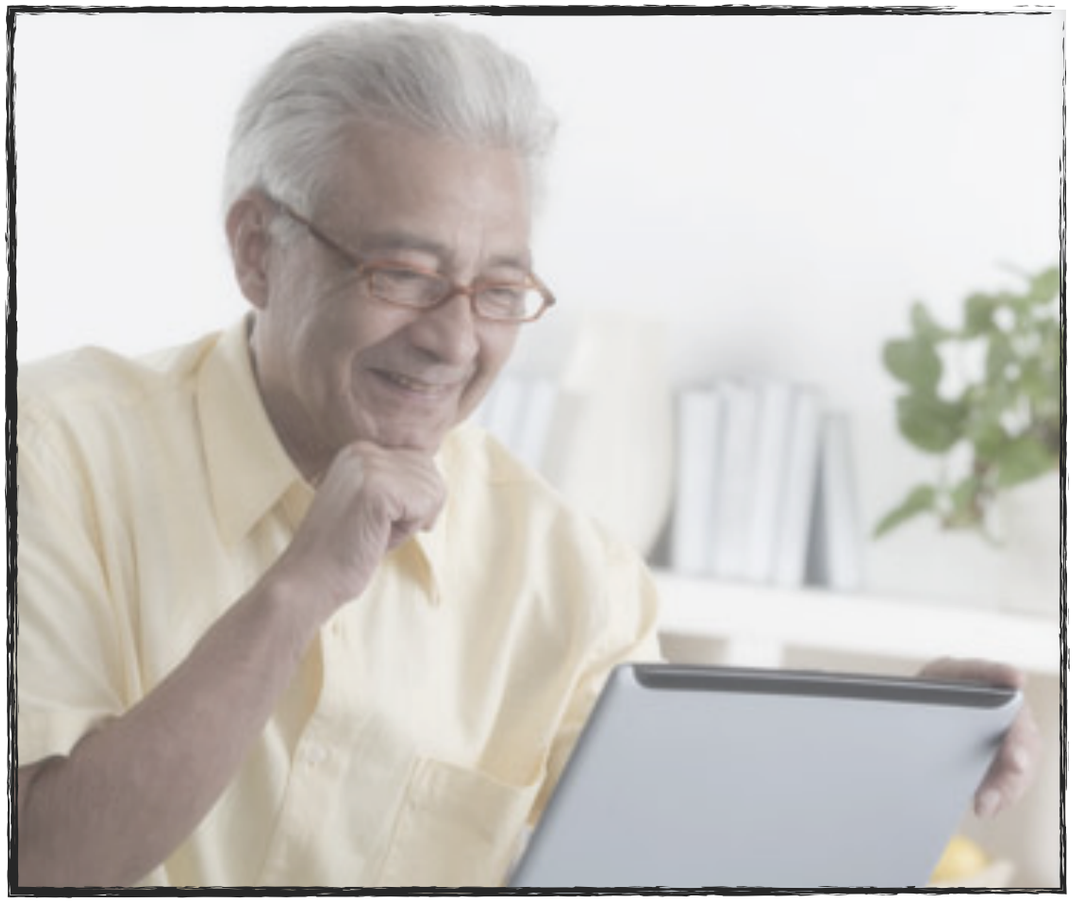








C-TOC Research Projects

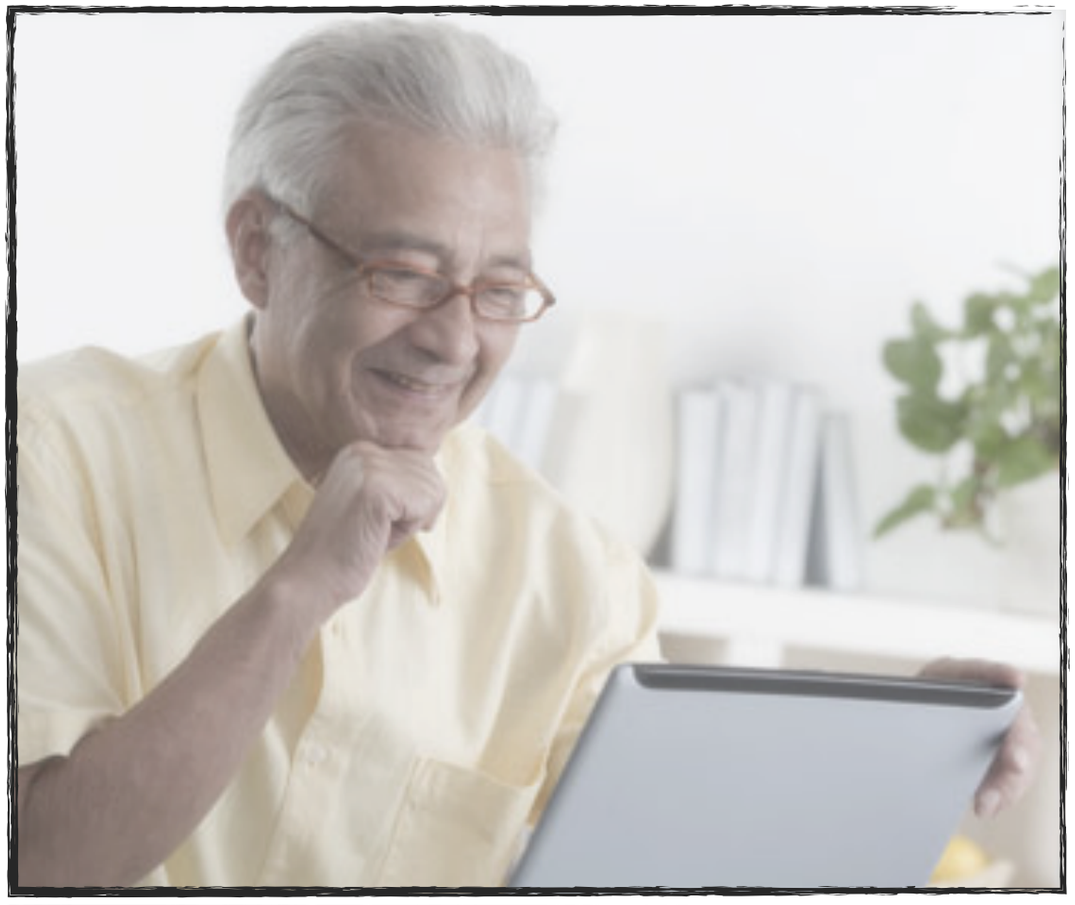


1. Does C-TOC produce valid results?

Jacova *et al* (2012)*

* Jacova, C., McGrenere, J., Lee, H., Wang, W., et al. (2012). Cognitive Testing On Computer (C-TOC): Development and validation of a novel computerized testing tool for office and home administration. Accepted for presentation at *Alzheimer's Association International Conference (AAIC)*.

C-TOC Research Projects



1. Does C-TOC produce valid results?

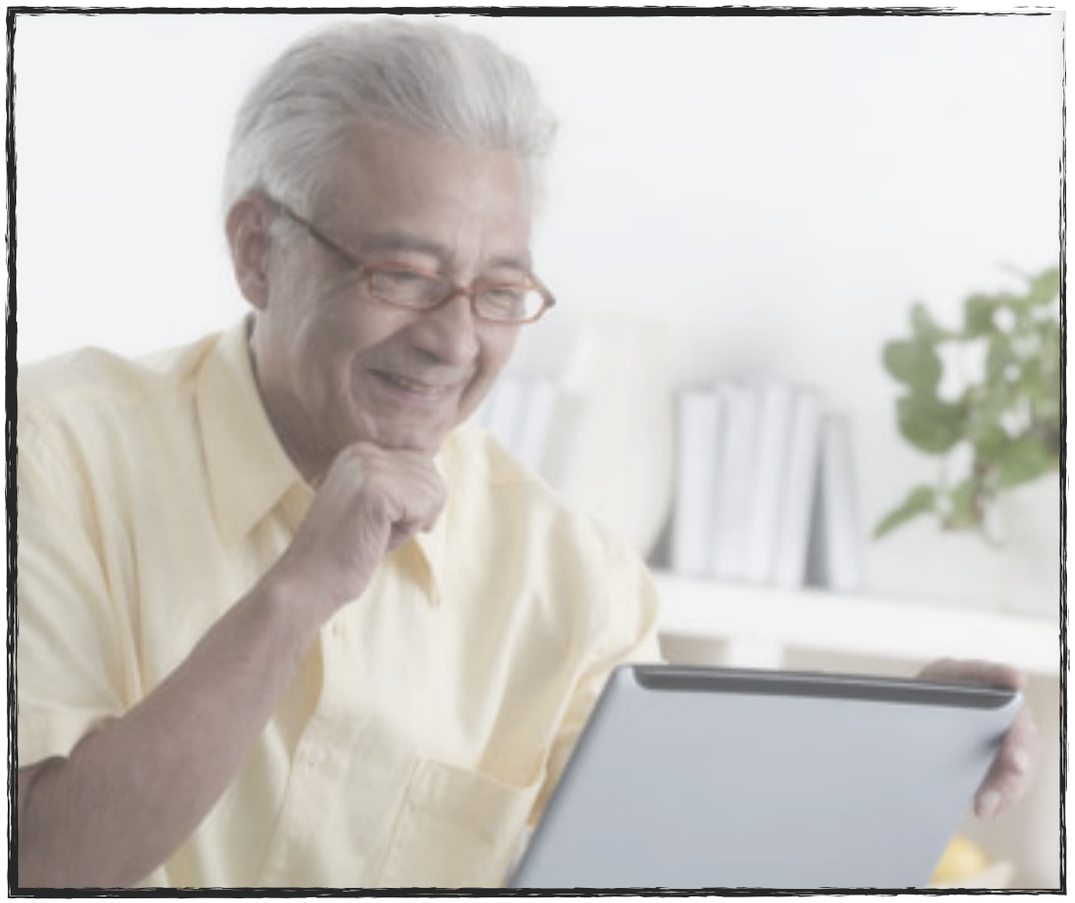
Jacova *et al* (2012)*

2. Is C-TOC usable by older adults?

Brehmer (2011)

* Jacova, C., McGrenere, J., Lee, H., Wang, W., et al. (2012). Cognitive Testing On Computer (C-TOC): Development and validation of a novel computerized testing tool for office and home administration. Accepted for presentation at *Alzheimer's Association International Conference (AAIC)*.

C-TOC Research Projects



1. Does C-TOC produce valid results?

Jacova *et al* (2012)*

2. Is C-TOC usable by older adults?

Brehmer (2011)

3. Will C-TOC work in the home?

* Jacova, C., McGrenere, J., Lee, H., Wang, W., et al. (2012). Cognitive Testing On Computer (C-TOC): Development and validation of a novel computerized testing tool for office and home administration. Accepted for presentation at *Alzheimer's Association International Conference (AAIC)*.

Problem: Impact of interruptions in the home?

Research goal:

The cost of interruptions on C-TOC performance

Research goal:

The cost of interruptions on C-TOC performance

Preserve test validity: prevent, detect, and mitigate interruptions

The cost of interruption and **C-TOC**

How do we **measure** it?

How do we **predict** it?

Factors of **task** and **age**

The cost of interruption and **C-TOC**

How do we **measure** it?

How do we **predict** it?

Factors of **task** and **age**

The cost of interruption and **C-TOC**

How do we **measure** it?

How do we **predict** it?

Factors of **task** and **age**

The cost of interruption and **C-TOC**

How do we **measure** it?

How do we **predict** it?

Factors of **task** and **age**

Measuring the cost of interruption

Error rate / **accuracy**

Gillie & Broadbent (1989), Oulasvirta & Saarilouma (2006)

Task **completion time**

Zijlstra et al (1999)

Task **resumption time**

Altmann & Trafton (2004), Iqbal & Horvitz (2007)

Measuring the cost of interruption

Error rate / **accuracy**

Gillie & Broadbent (1989), Oulasvirta & Saarilouma (2006)

Task **completion time**

Zijlstra et al (1999)

Task **resumption time**

Altmann & Trafton (2004), Iqbal & Horvitz (2007)

Measuring the cost of interruption

Error rate / **accuracy**

Gillie & Broadbent (1989), Oulasvirta & Saarilouma (2006)

Task **completion time**

Zijlstra et al (1999)

Task **resumption time**

Altmann & Trafton (2004), Iqbal & Horvitz (2007)

Measuring the cost of interruption

Error rate / **accuracy**

Gillie & Broadbent (1989), Oulasvirta & Saarilouma (2006)

Task **completion time**

Zijlstra et al (1999)

Task **resumption time**

Altmann & Trafton (2004), Iqbal & Horvitz (2007)

Predicting the cost of interruption

Primary task **demand**
Bailey et al (2000), Speier et al (2003)

Primary **task structure**
Iqbal & Bailey (2006)

Interrupting task **demand**
Gillie & Broadbent (1989), Oulasvirta & Saarilouma (2006)

Similarity of primary and interrupting tasks
Gillie & Broadbent (1989), Bailey et al (2000)

Duration of interruptions
Bailey et al (2000), Monk et al (2008)

Frequency of interruptions
Zijlstra et al (1999)

Warning preceding an interruption (interruption lag)
Altmann & Trafton (2004)

Contextual and **social** factors
Iqbal & Horvitz (2007), Storch (1992)

Age and the cost of interruption

Natural cognitive aging:

- ⬇ Processing speed
- ⬇ Activation of working memory
- ⬇ Suppression and inhibition
- ⬆ Cognitive fatigue

Age and the cost of interruption

Natural cognitive aging:

- ⬇ Processing speed
- ⬇ Activation of working memory
- ⬇ Suppression and inhibition
- ⬆ Cognitive fatigue

Interruptions more disruptive

Clapp & Gazzeley (2005), Farrimond et al (2006)

Age and the cost of interruption

Natural cognitive aging:

- ⬇ Processing speed
- ⬇ Activation of working memory
- ⬇ Suppression and inhibition
- ⬆ Cognitive fatigue

Interruptions more disruptive

Clapp & Gazzeley (2005), Farrimond et al (2006)

Interruptions and **C-TOC**'s open-ended puzzle tasks?

Study Design

3 **Age Groups** N = 3 x 12
YOUNG 19 – 54
PRE-OLD 55 – 69
OLD 70 +

Craik and Salthouse (1982)

Study Design

3 **Age Groups** N = 3 x 12	2 **Primary tasks**
YOUNG 19 – 54	VERBAL working memory
PRE-OLD 55 – 69	SPATIAL problem solving
OLD 70 +	

Craik and Salthouse (1982)

Study Design

3 **Age Groups** N = 3 x 12	2 **Primary tasks**	3 levels of **Interruption demand**
YOUNG 19 – 54	VERBAL working memory	NONE no interruptions
PRE-OLD 55 – 69		LOW passive interruptions
OLD 70 +	SPATIAL problem solving	HIGH active interruptions

Craik and Salthouse (1982)

Study Design

3 **Age Groups** N = 3 x 12	2 **Primary tasks**	3 levels of **Interruption demand**
YOUNG 19 – 54	VERBAL working memory	NONE no interruptions
PRE-OLD 55 – 69		LOW passive interruptions
OLD 70 +	SPATIAL problem solving	HIGH active interruptions

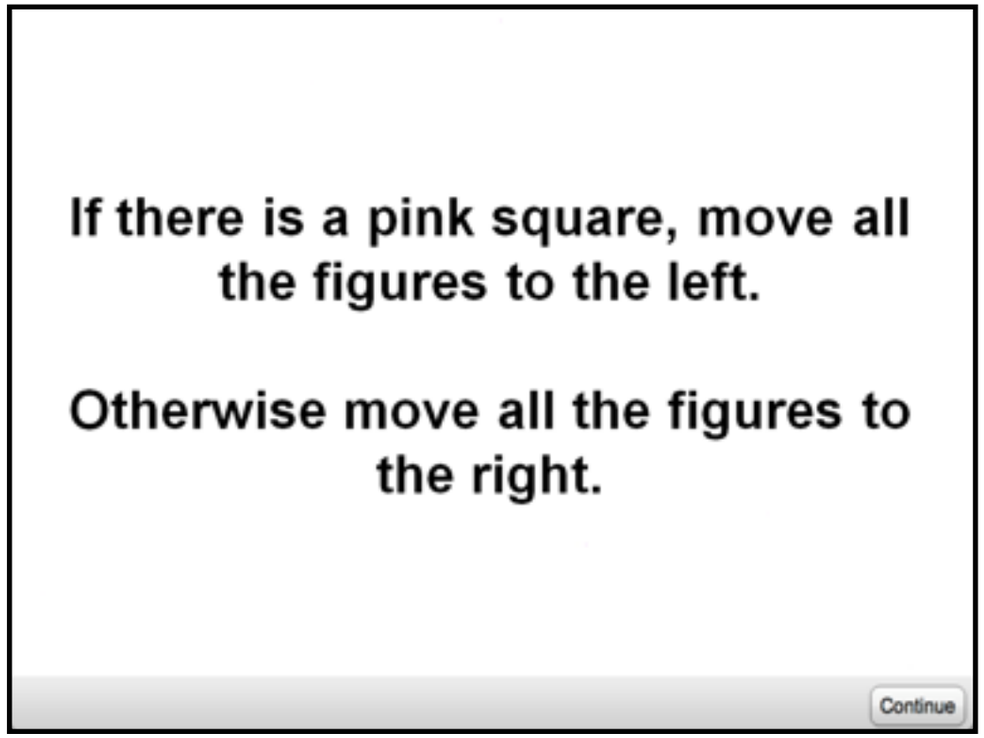
Craik and Salthouse (1982)

Study Design - Primary Tasks

2 **Primary tasks**

VERBAL

SPATIAL



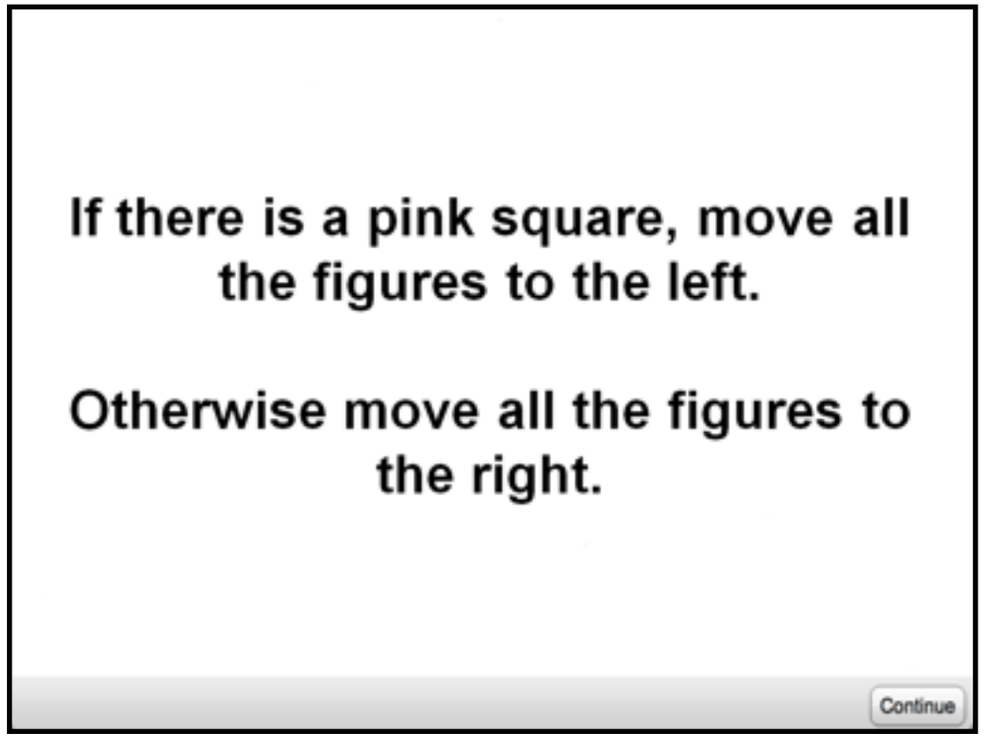
Step 1: Instruction

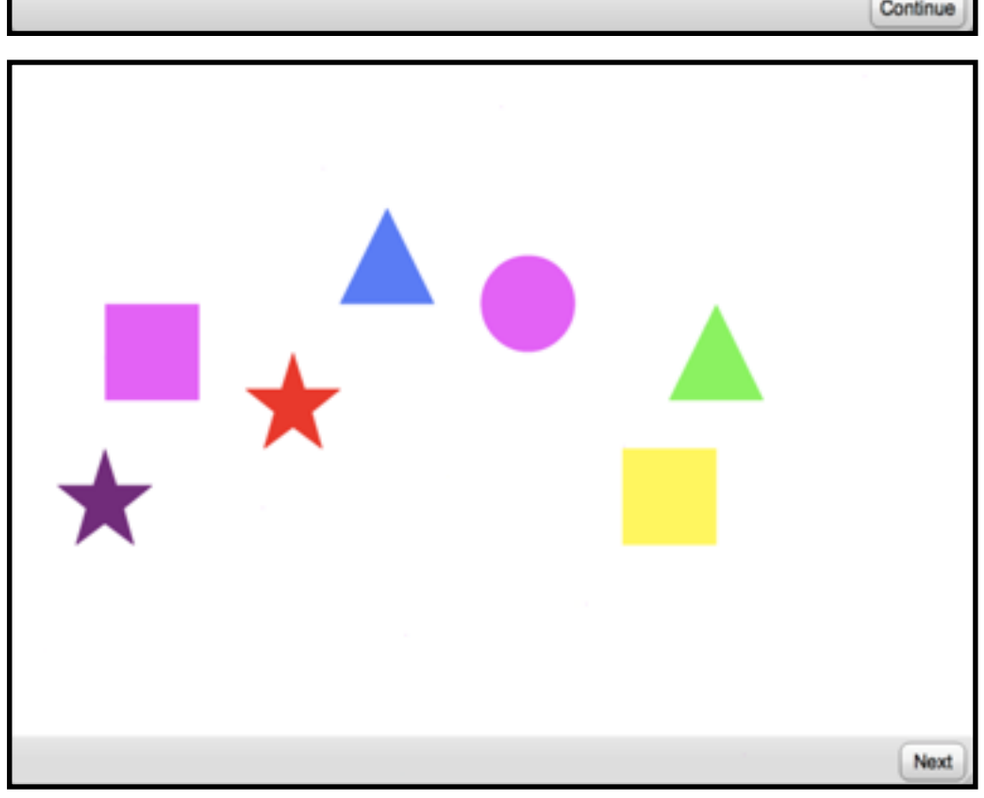
Study Design - Primary Tasks

2 **Primary tasks**

VERBAL

SPATIAL





Step 1: Instruction

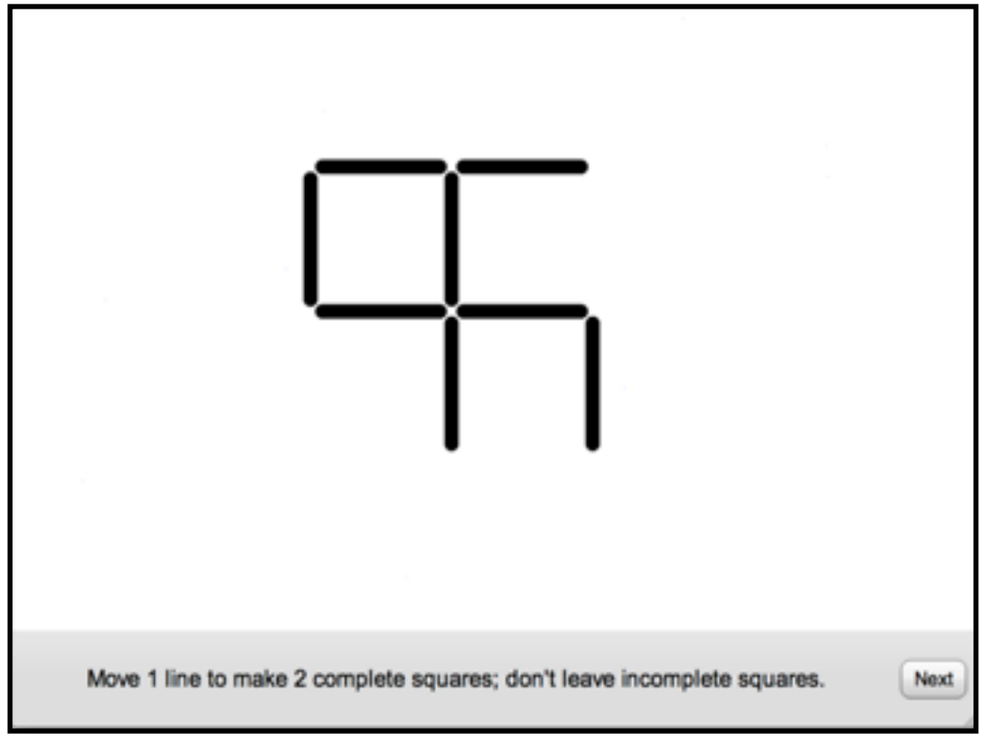
Step 2: Execution

Study Design - Primary Tasks

2 **Primary tasks**

VERBAL

SPATIAL



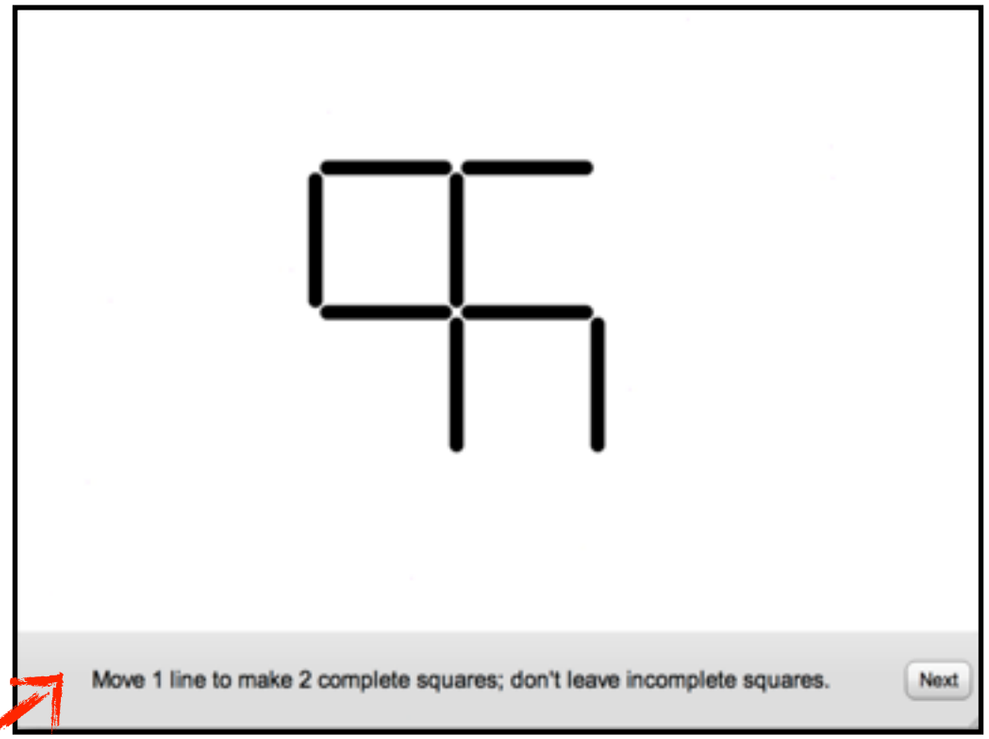
Initial

Study Design - Primary Tasks

2 **Primary tasks**

VERBAL

SPATIAL



Initial

*"Move **X** line(s) to make **Y** complete squares;*

don't leave incomplete squares."

Study Design - Primary Tasks

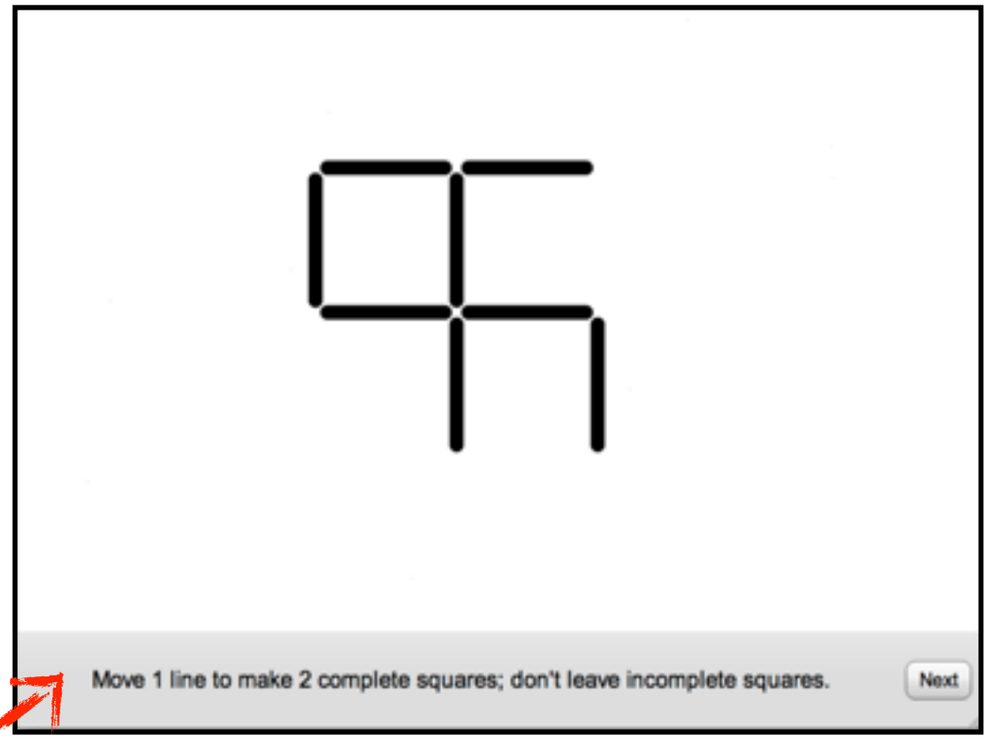
2 **Primary tasks**

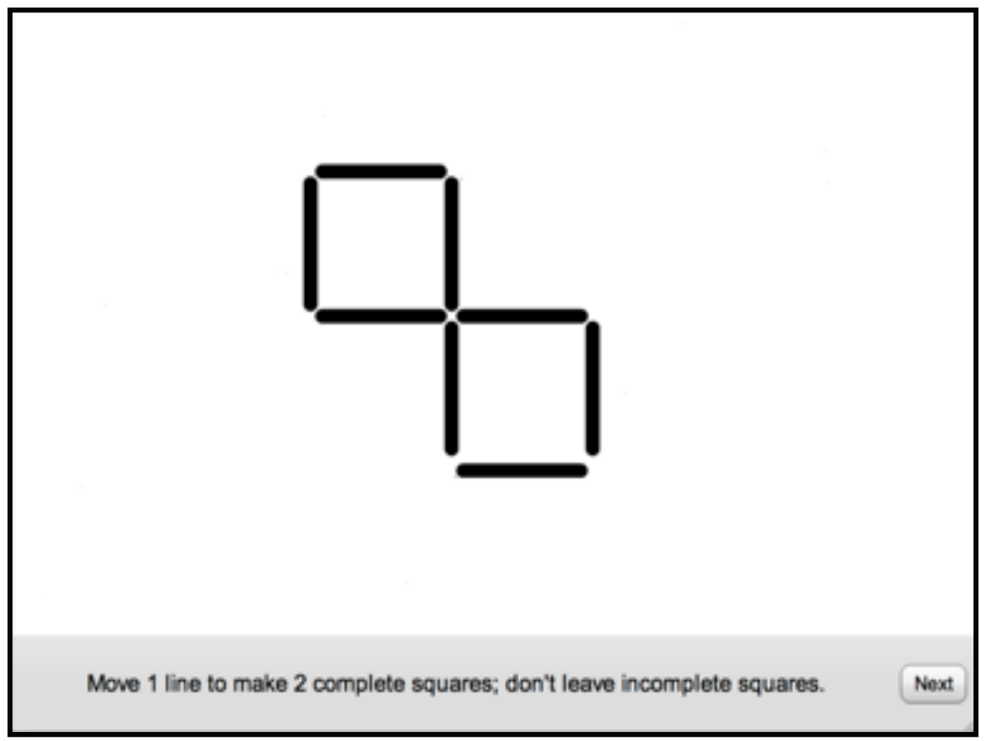
VERBAL

SPATIAL

*"Move **X** line(s) to make **Y** complete squares;*

don't leave incomplete squares."





Initial

Completed

Study Design

2 **Primary tasks**	3 levels of **Interruption demand**
VERBAL	NONE
	LOW
SPATIAL	HIGH

For each primary task,
3 sets of **10 trials**

Subset of 4 trials
interrupted in LOW and HIGH demand conditions

Fixed interruption
onset and **duration**

Study Design

2 **Primary tasks**	3 levels of **Interruption demand**
VERBAL	NONE
	LOW
SPATIAL	HIGH

For each primary task,
3 sets of **10 trials**

Subset of 4 trials
interrupted in LOW and HIGH demand conditions

Fixed interruption
onset and **duration**

Study Design

2 **Primary tasks**
VERBAL
SPATIAL

3 levels of **Interruption demand**
NONE
LOW
HIGH

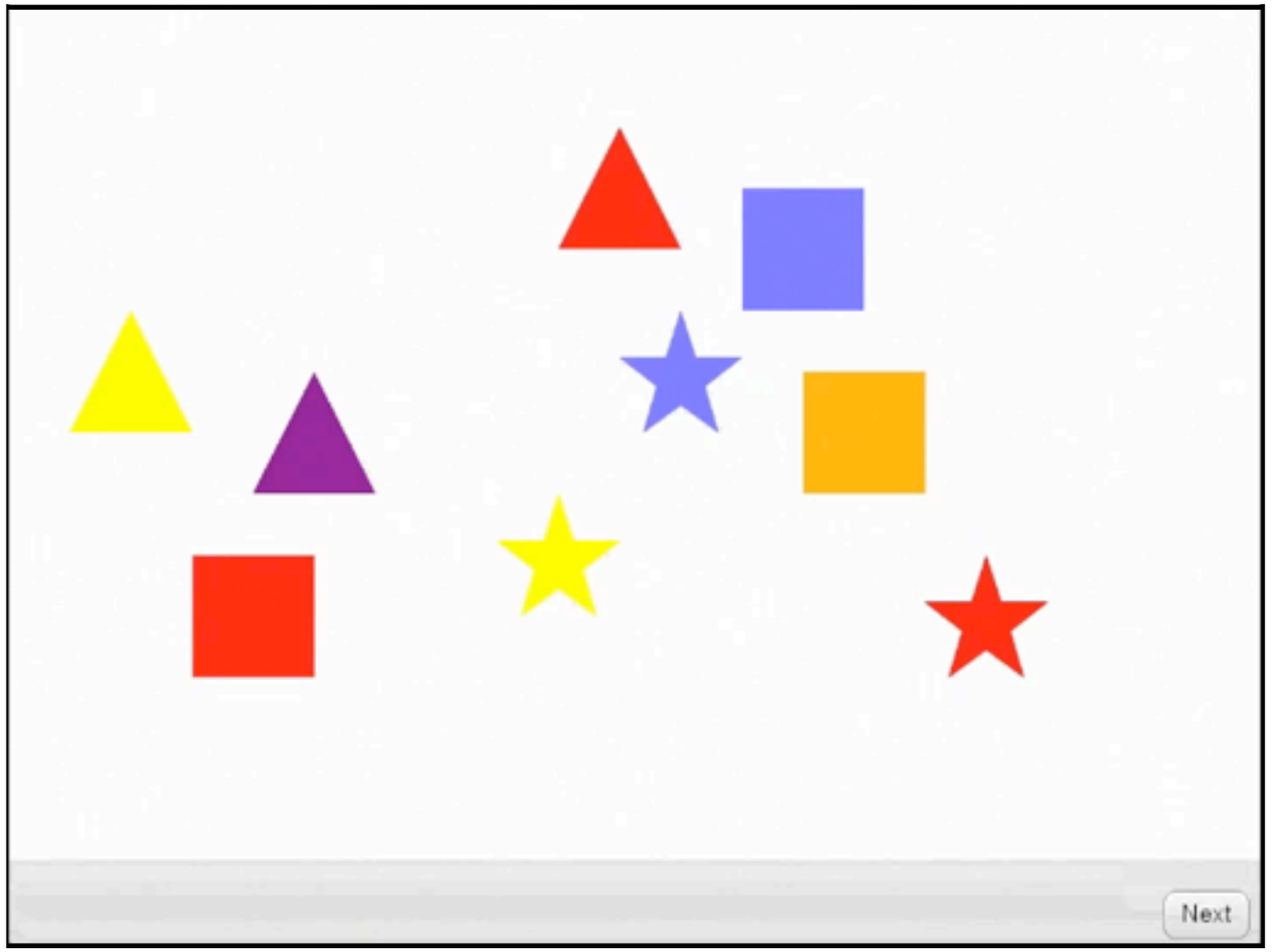
For each primary task,
3 sets of **10 trials**

Subset of 4 trials
interrupted in LOW and HIGH demand conditions

Fixed interruption
onset and **duration**

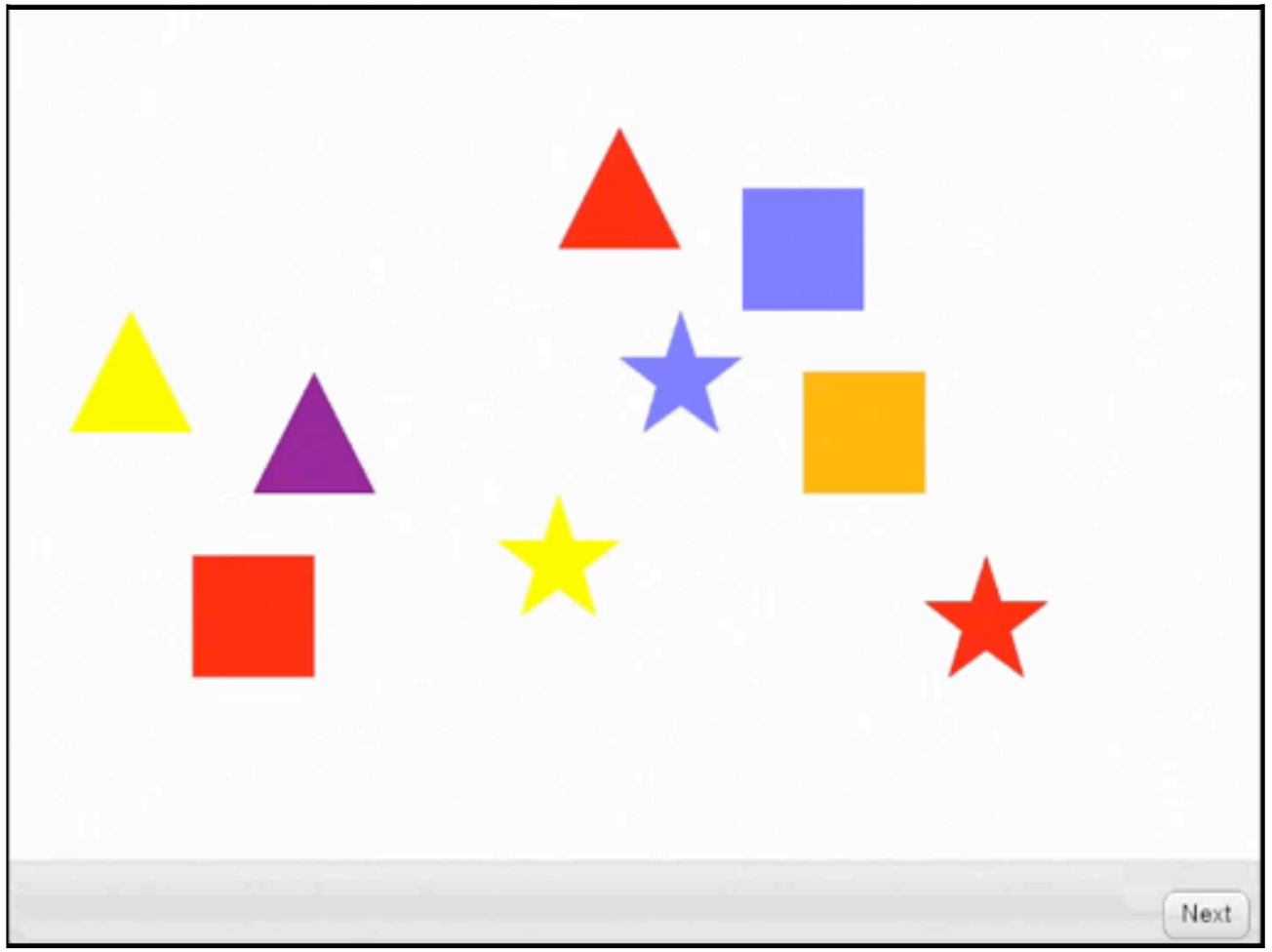
Study Design - Interruptions

Study Design - Interruptions



3 levels of **Interruption demand**
NONE
LOW
HIGH

Study Design - Interruptions



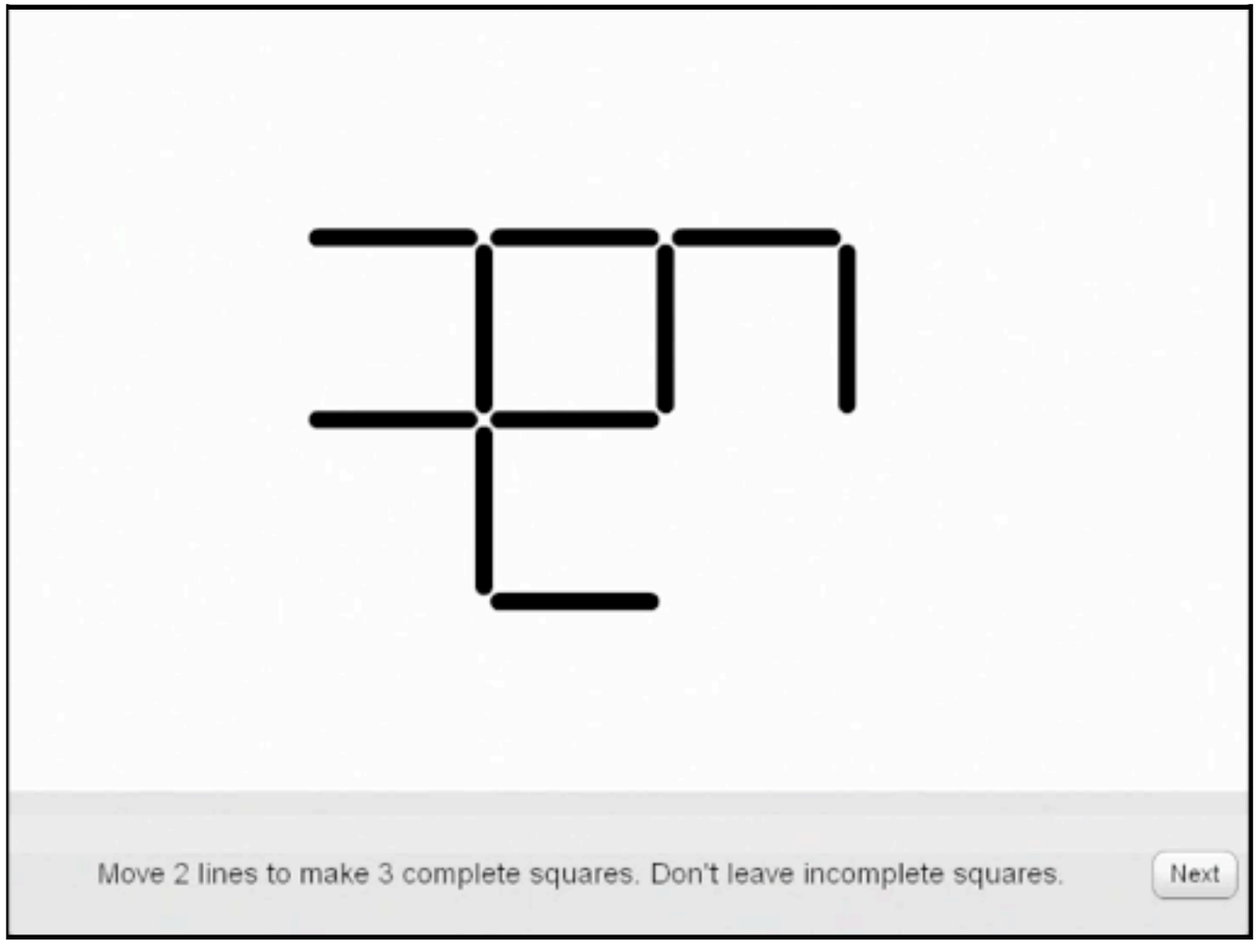
3 levels of **Interruption demand**
NONE
LOW
HIGH

Note: video playback speed is doubled

Study Design - Interruptions

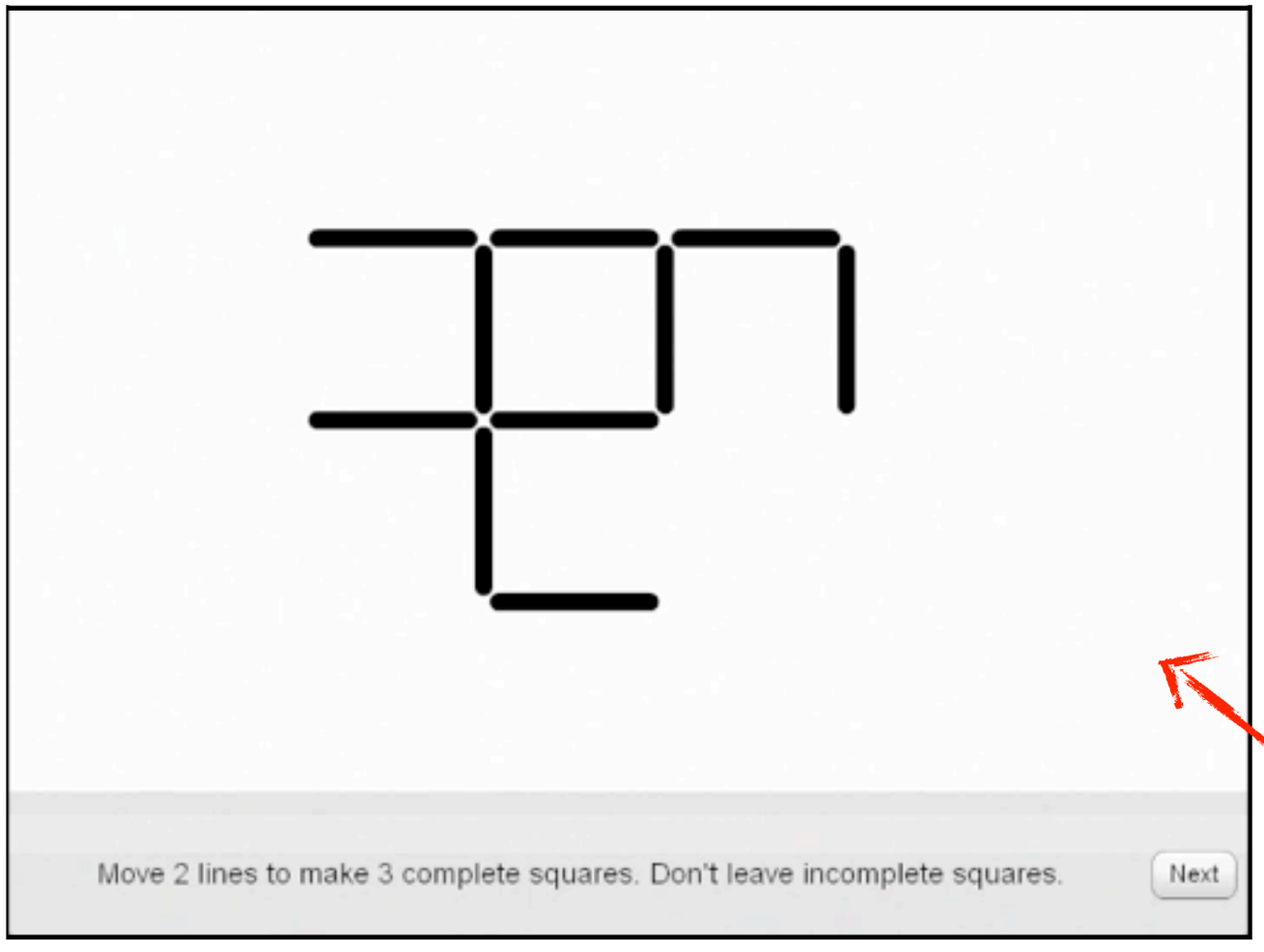
3 levels of **Interruption demand**
NONE
LOW
HIGH

Study Design - Interruptions



3 levels of **Interruption demand**
NONE
LOW
HIGH

Study Design - Interruptions



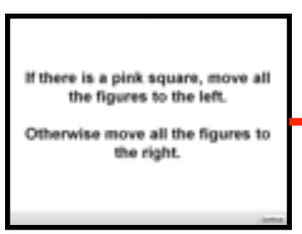
3 levels of **Interruption demand**
NONE
LOW
HIGH

*The **n-back** working memory task*
[Owen et al (2005)]

Note: video playback speed is doubled

Study Design - Interruption timeline

Study Design - Interruption timeline



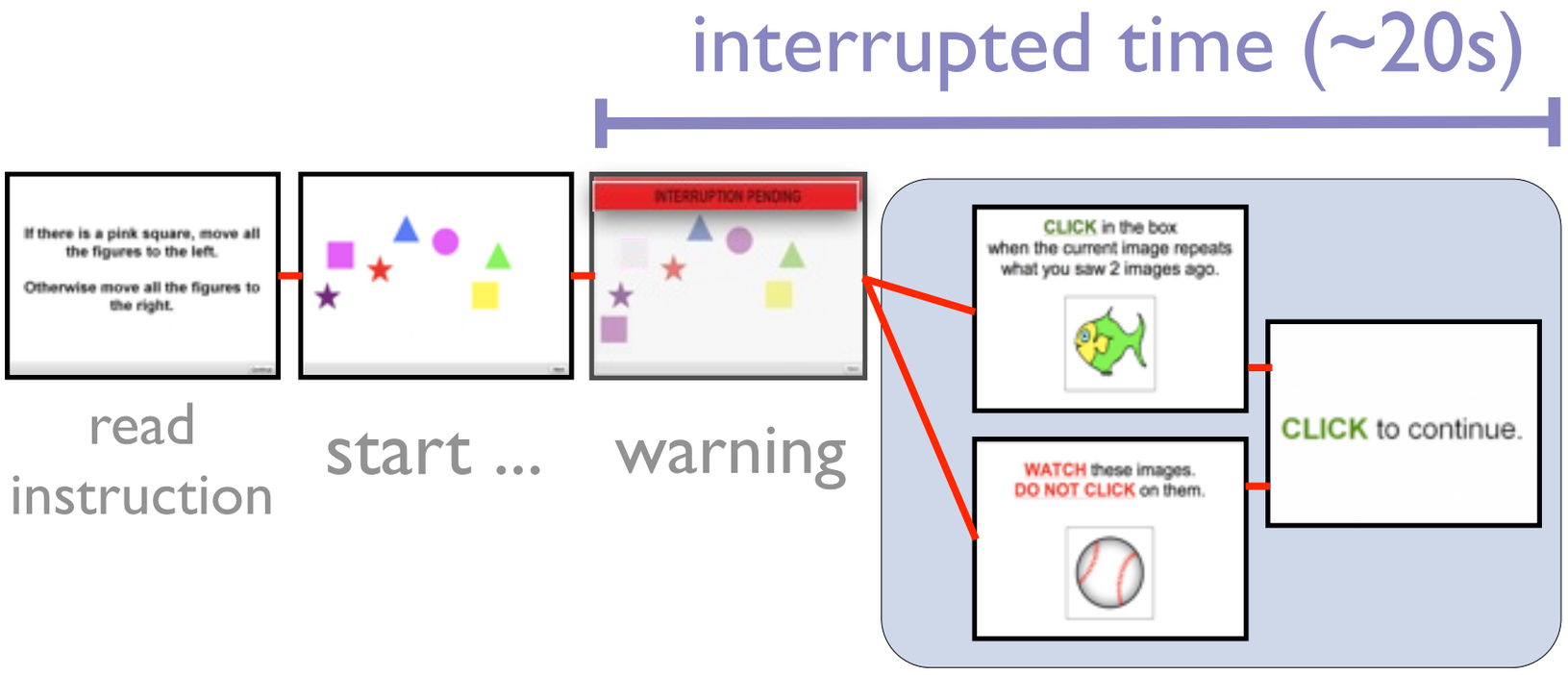
read instruction

start ...

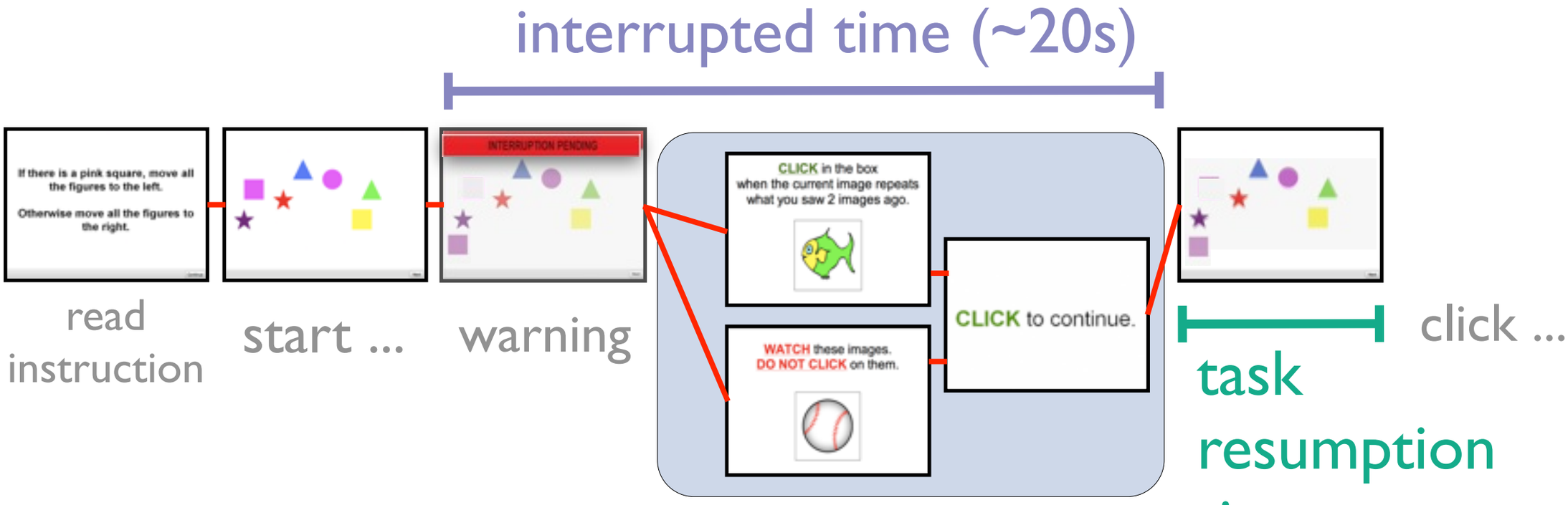
Study Design - Interruption timeline

read instruction → start ... → warning

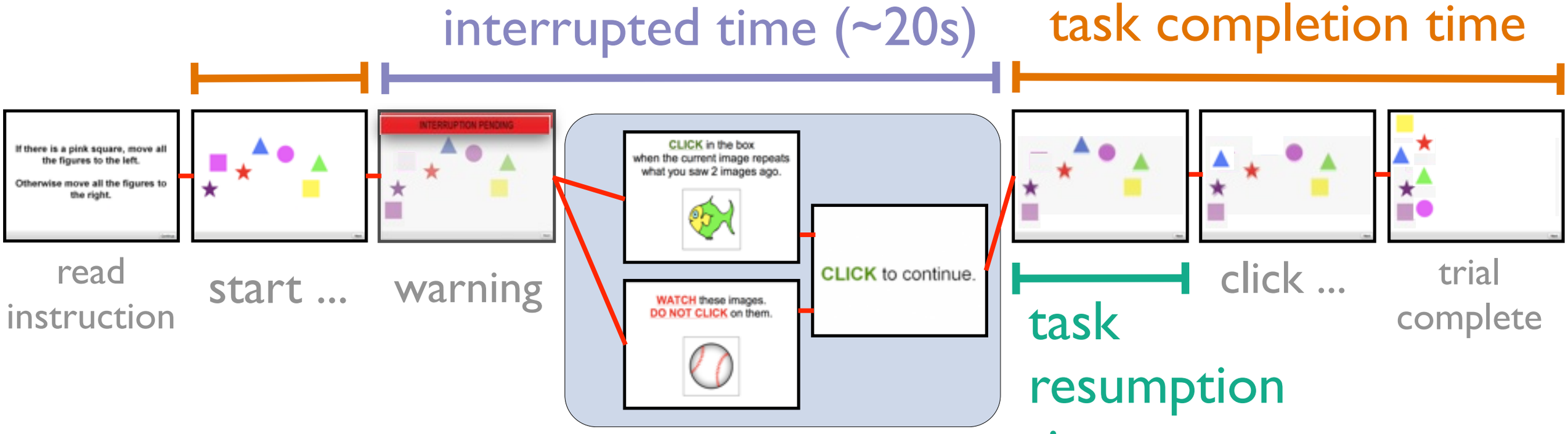
Study Design - Interruption timeline



Study Design - Interruption timeline



Study Design - Interruption timeline



Hypotheses

Hypotheses

H1. Overall, **YOUNG** adults will perform better than **OLD** adults.

Hypotheses

H1. Overall, **YOUNG** adults will perform better than **OLD** adults.

H2. **OLD** adults will incur a disproportionally greater cost of interruption

Hypotheses

H1. Overall, **YOUNG** adults will perform better than **OLD** adults.

H2. **OLD** adults will incur a disproportionally greater cost of interruption

H3. **H1** + **H2** will be more pronounced in the VERBAL task

Supported

H1. Overall, **YOUNG** adults will perform better than **OLD** adults.

Partially Supported

H2. **OLD** adults will incur a disproportionally greater cost of interruption

Partially Supported

H3. **H1** + **H2** will be more pronounced in the VERBAL task

Key Results:

YOUNG and **OLD**

Dependent measures:

- accuracy
- task resumption time
- task completion time

Key Results:

Dependent measures:

- accuracy
- task resumption time
- task completion time

YOUNG and **OLD**

OLD less accurate than **YOUNG**

Key Results:

YOUNG and **OLD**

Dependent measures:

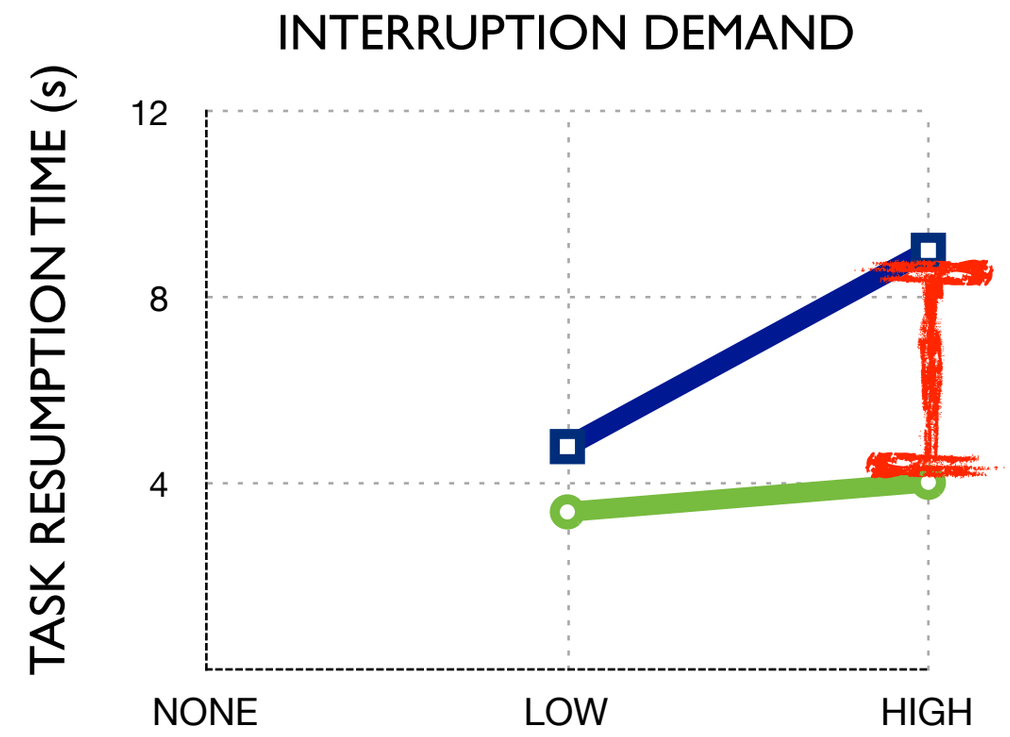
- accuracy
- task resumption time
- task completion time

OLD **less accurate** than **YOUNG**

No effect of interruption demand on **accuracy**

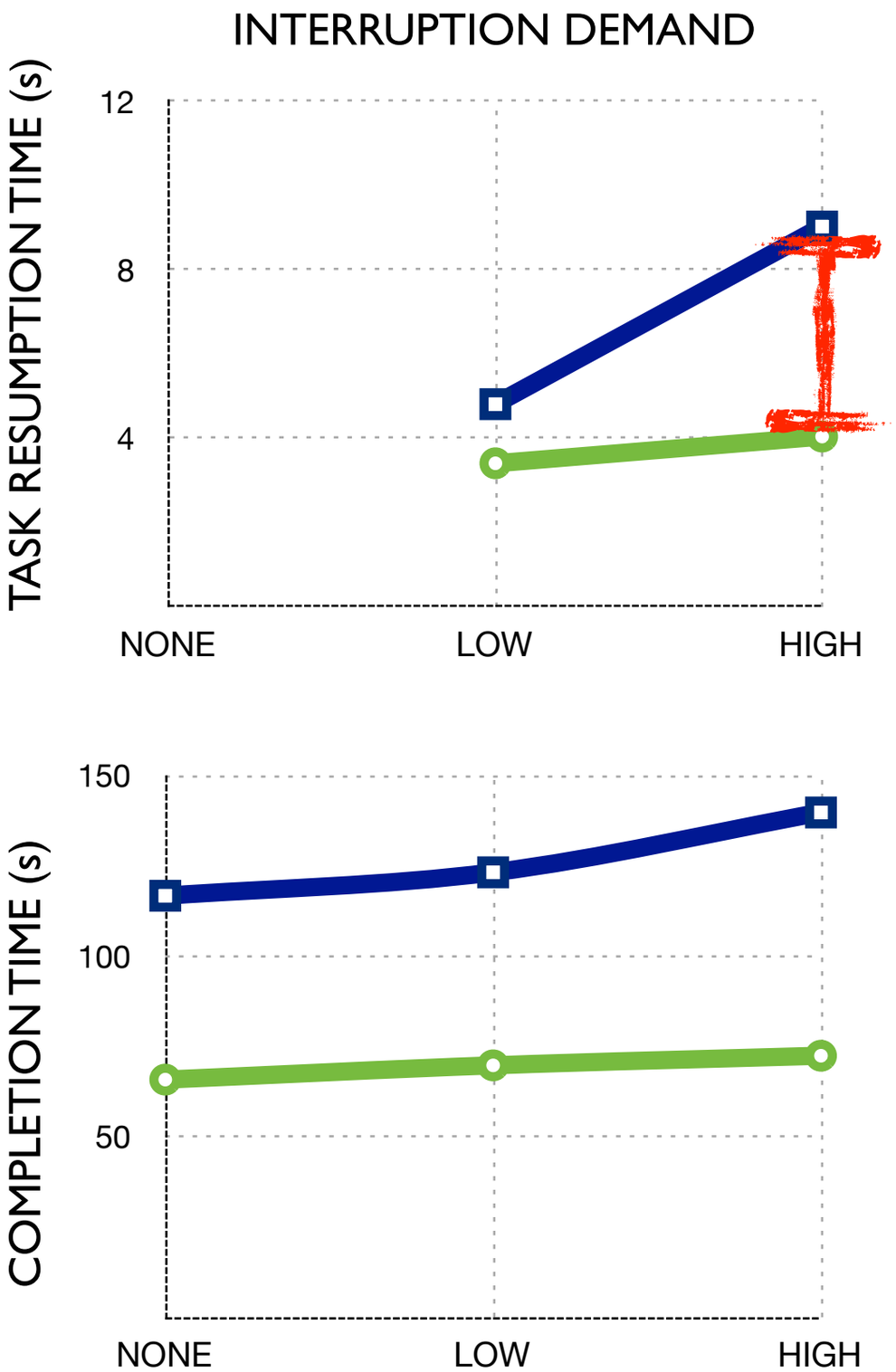
Key results - VERBAL task

Key results - **VERBAL** task



OLD disproportionally slower than **YOUNG** to resume the task

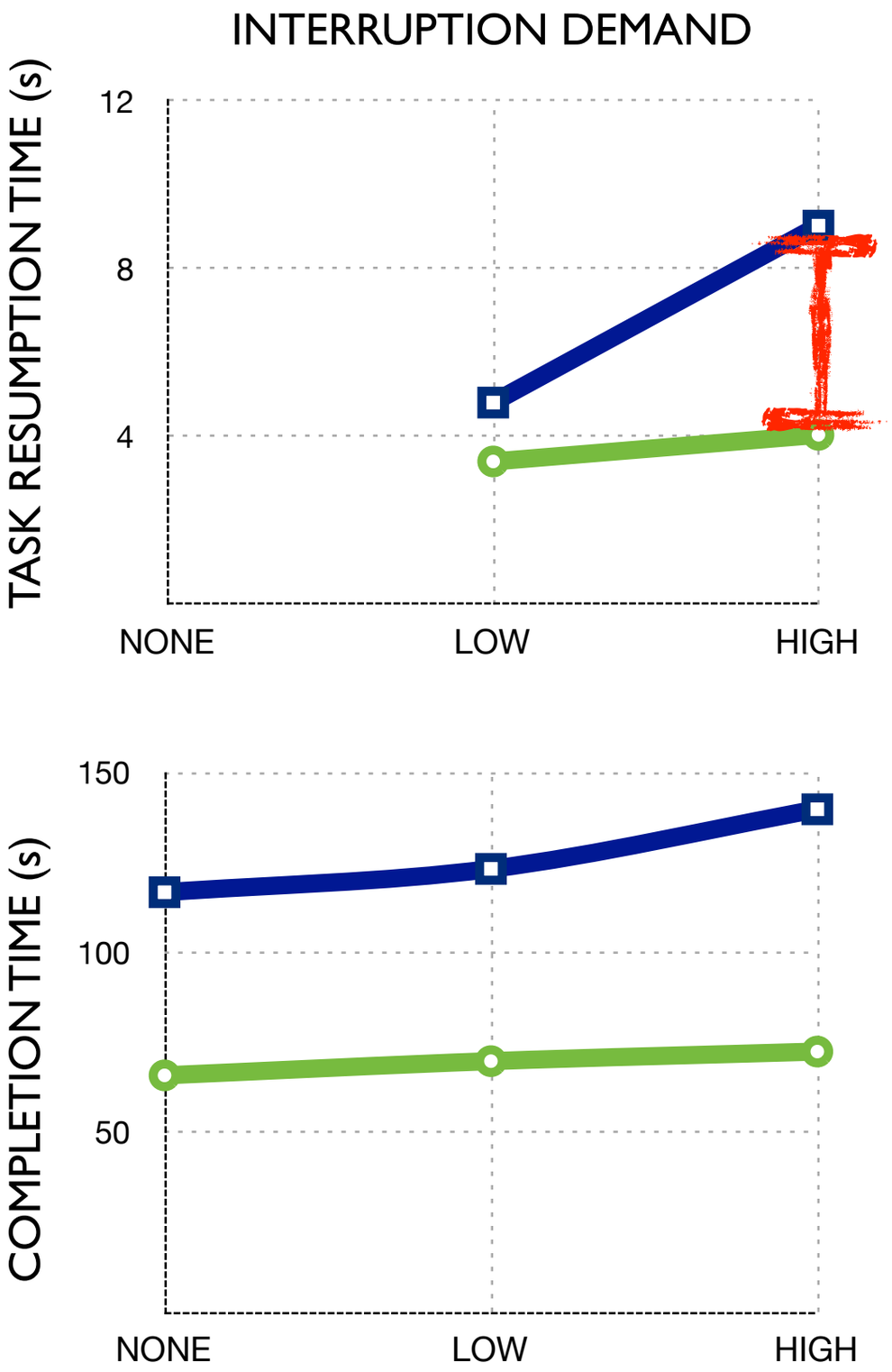
Key results - **VERBAL** task



OLD disproportionally slower than **YOUNG** to resume the task

OLD NOT disproportionally slower to complete the task

Key results - **VERBAL** task

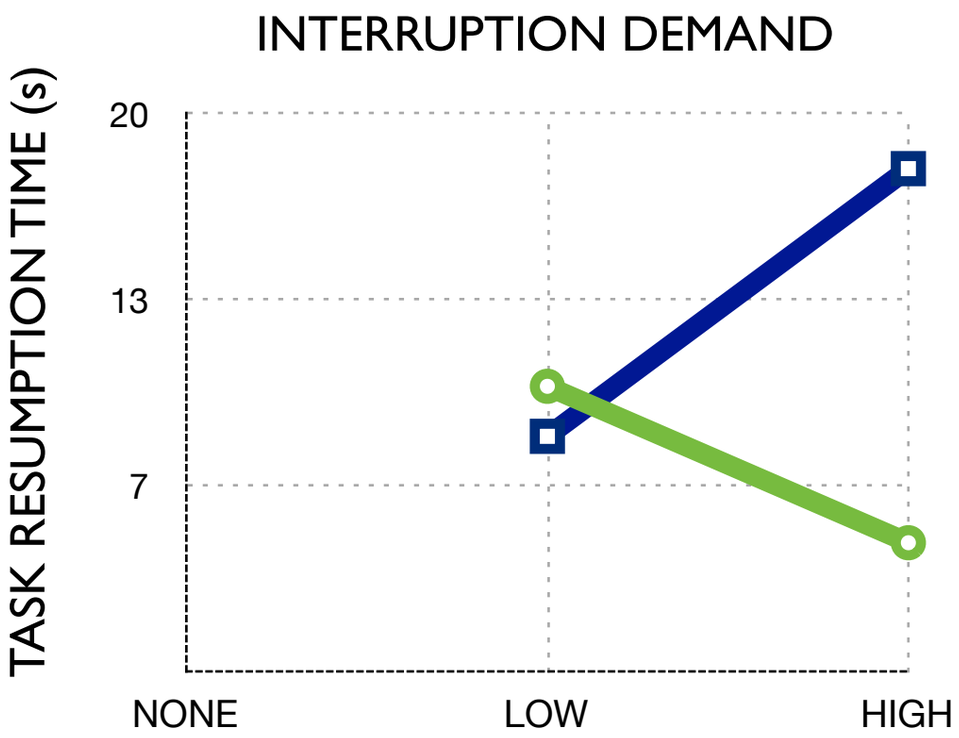


OLD disproportionally slower than **YOUNG** to resume the task

OLD NOT disproportionally slower to complete the task

Compensation following interruption

Key results - **SPATIAL** task



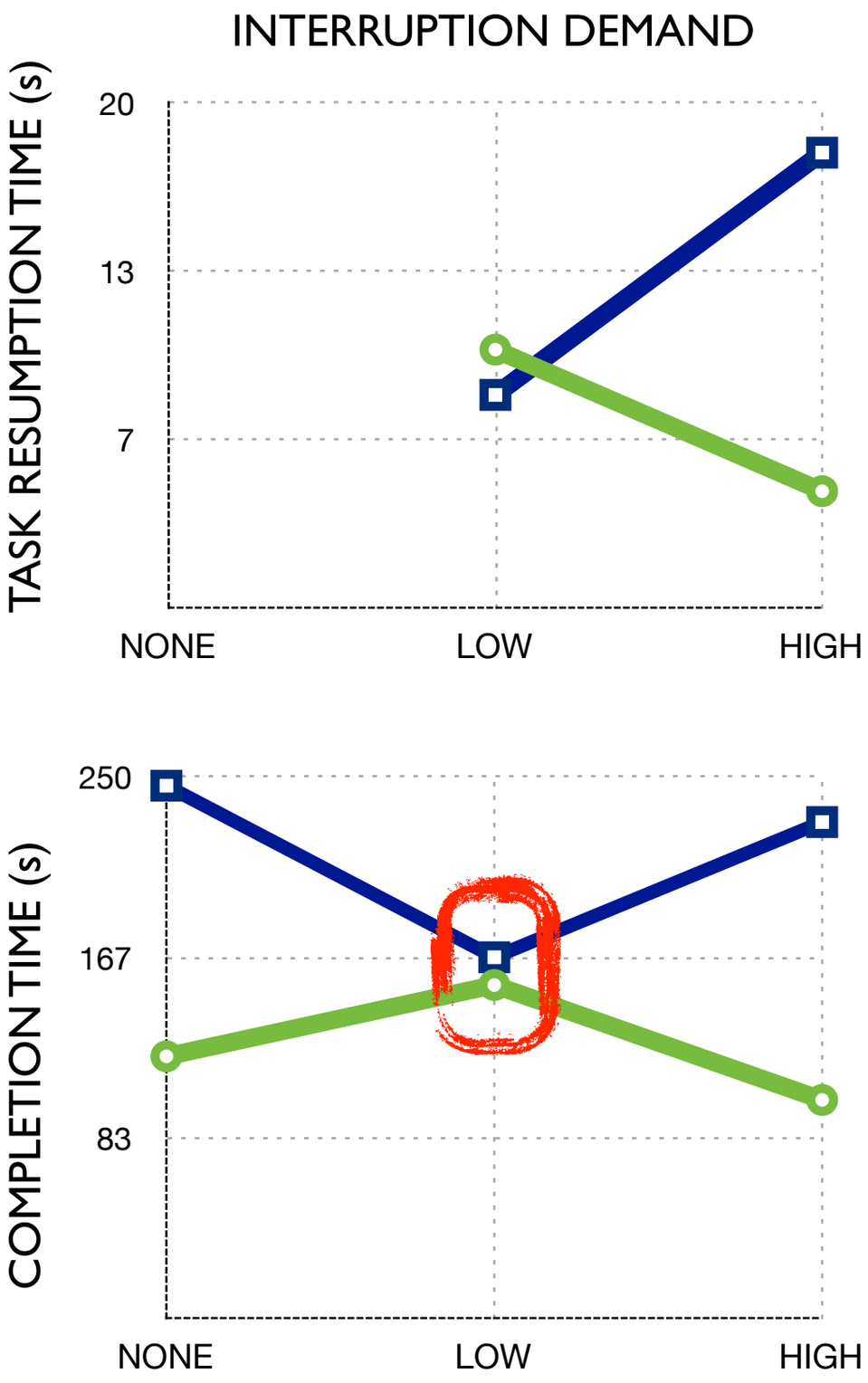
Interruption demand affected **YOUNG** and **OLD** differently

OLD **slower** to complete the task, **except** in LOW-demand condition

Possible mind wandering

OLD more conscientious?

Key results - **SPATIAL** task



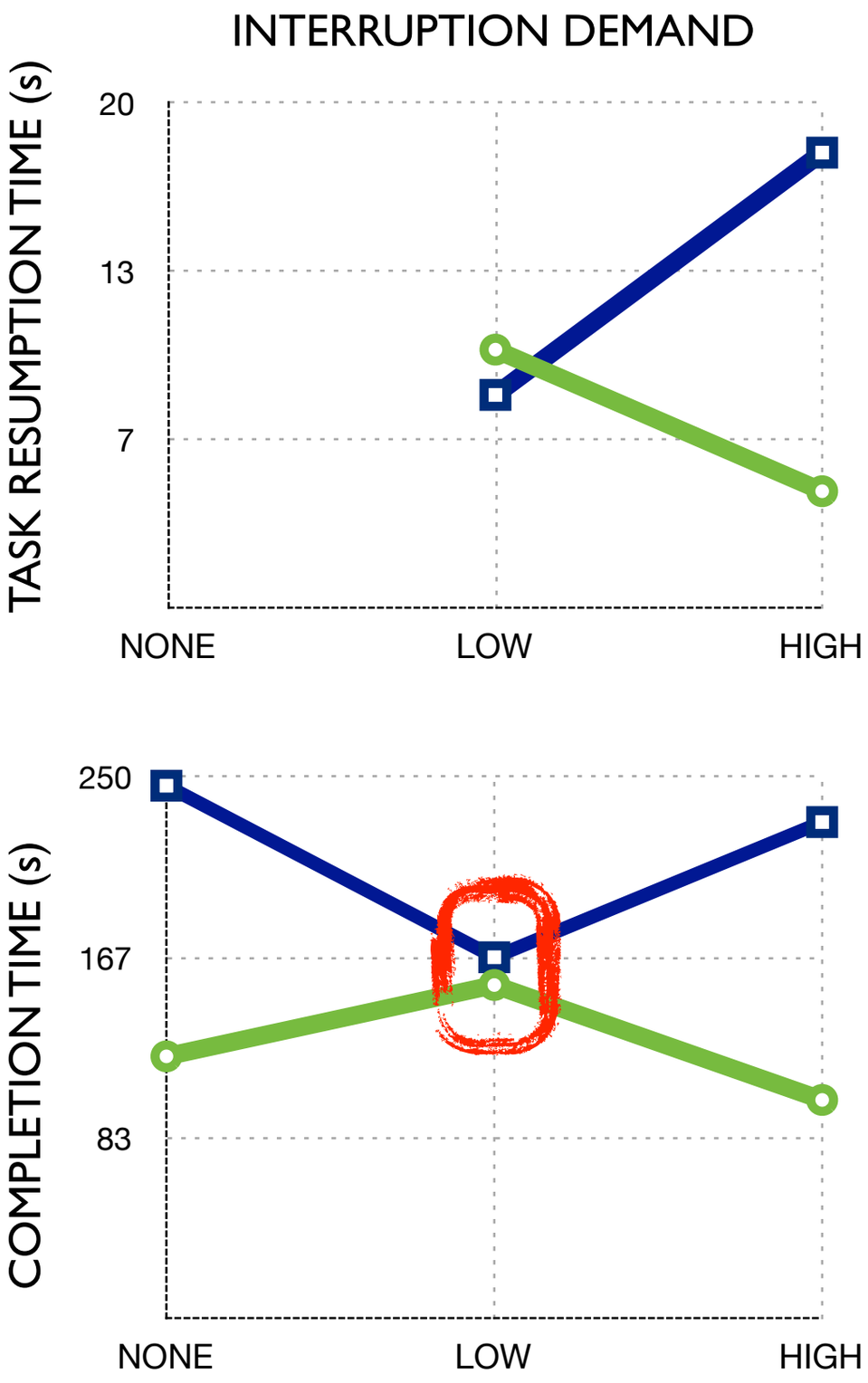
Interruption demand affected **YOUNG** and **OLD** differently

OLD **slower** to complete the task, **except** in LOW-demand condition

Possible mind wandering

OLD more conscientious?

Key results - **SPATIAL** task



Interruption demand affected **YOUNG** and **OLD** differently

OLD **slower** to complete the task, **except** in LOW-demand condition

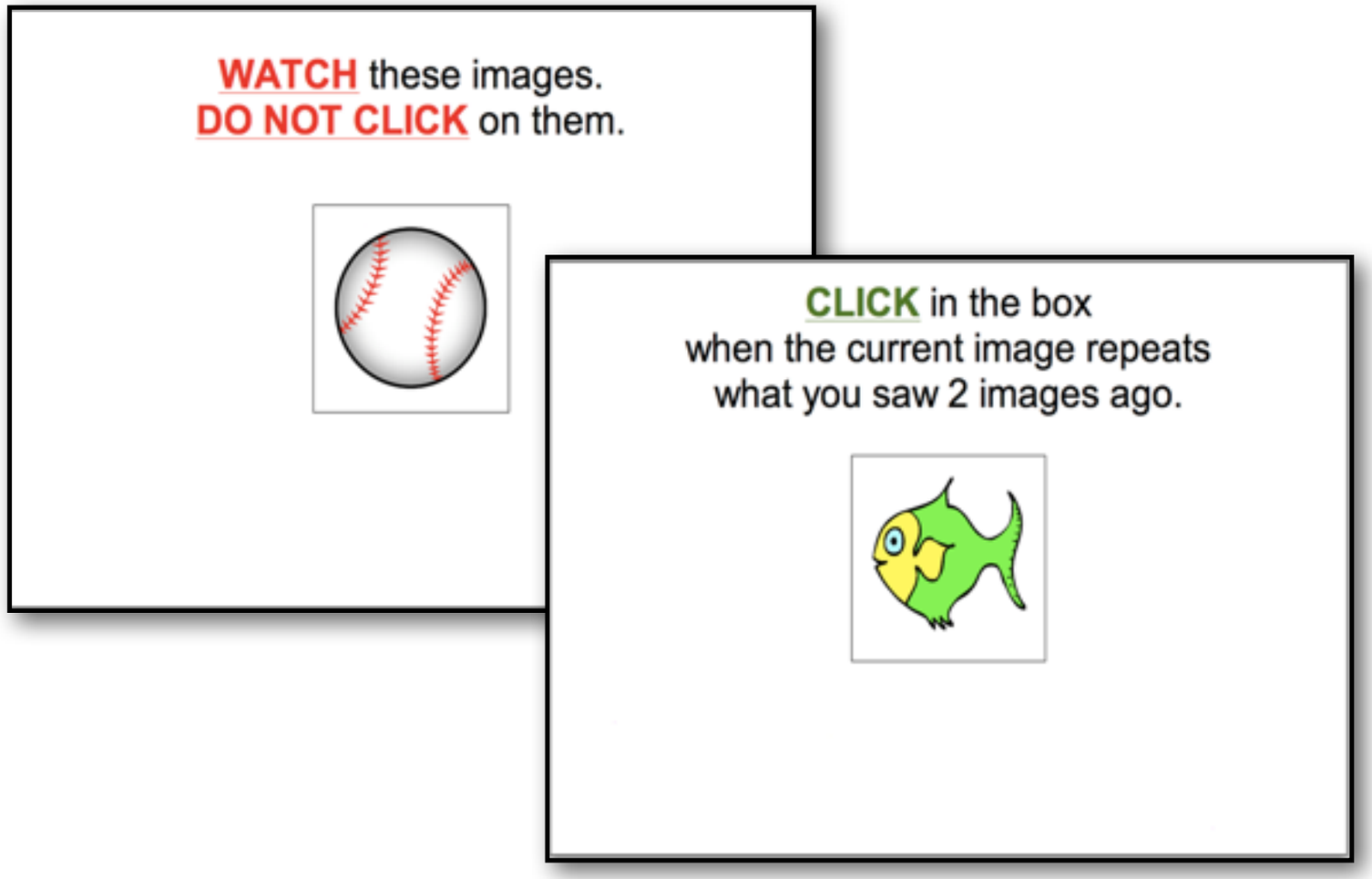
Possible mind wandering

OLD more conscientious?

Valid interrupting tasks: further research needed

Methodological implications:

Interruption Validity



Methodological implications:

Interruption Validity

Valid interrupting tasks: further research needed

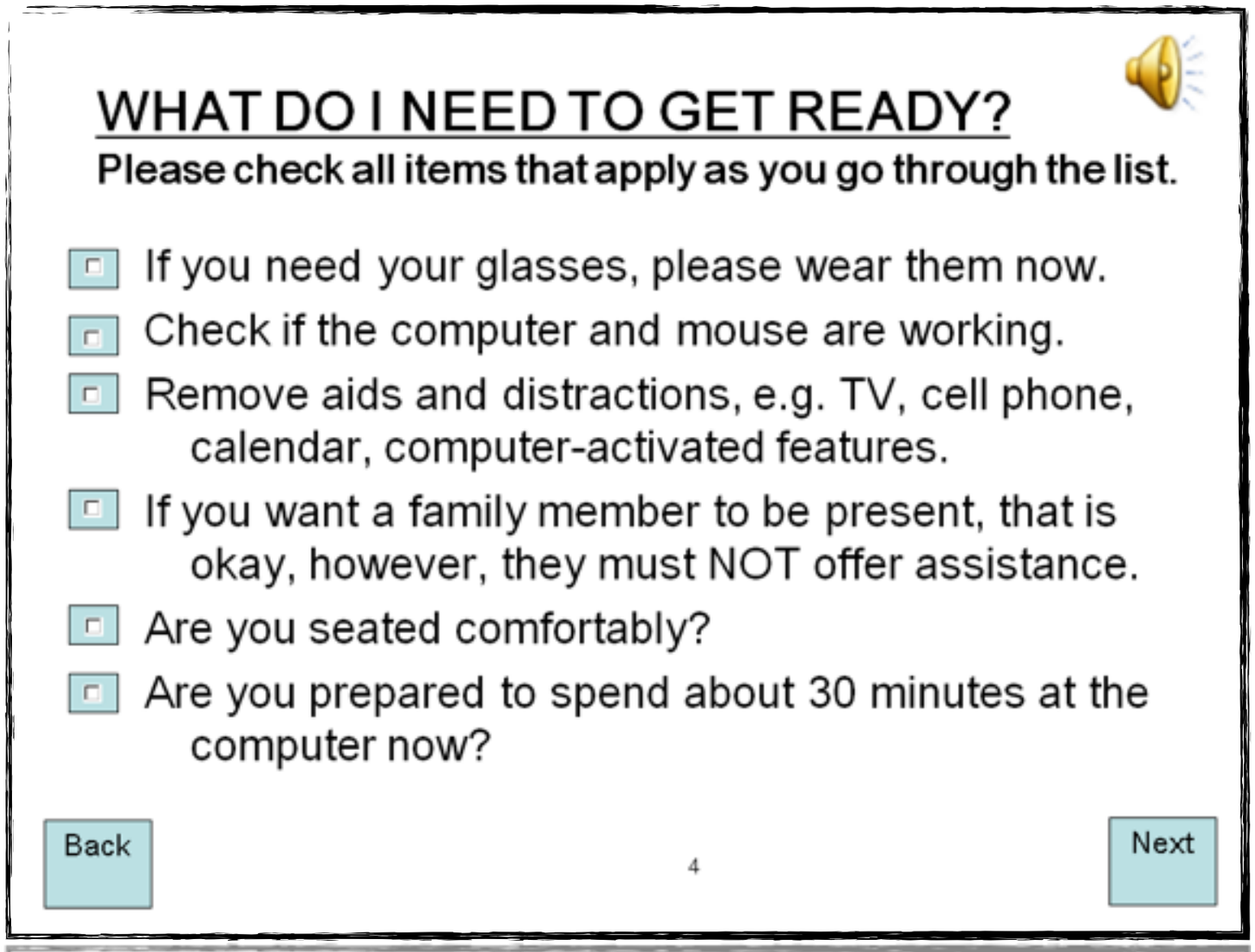
Design implications:

Preventing interruptions

Design implications:

Preventing interruptions

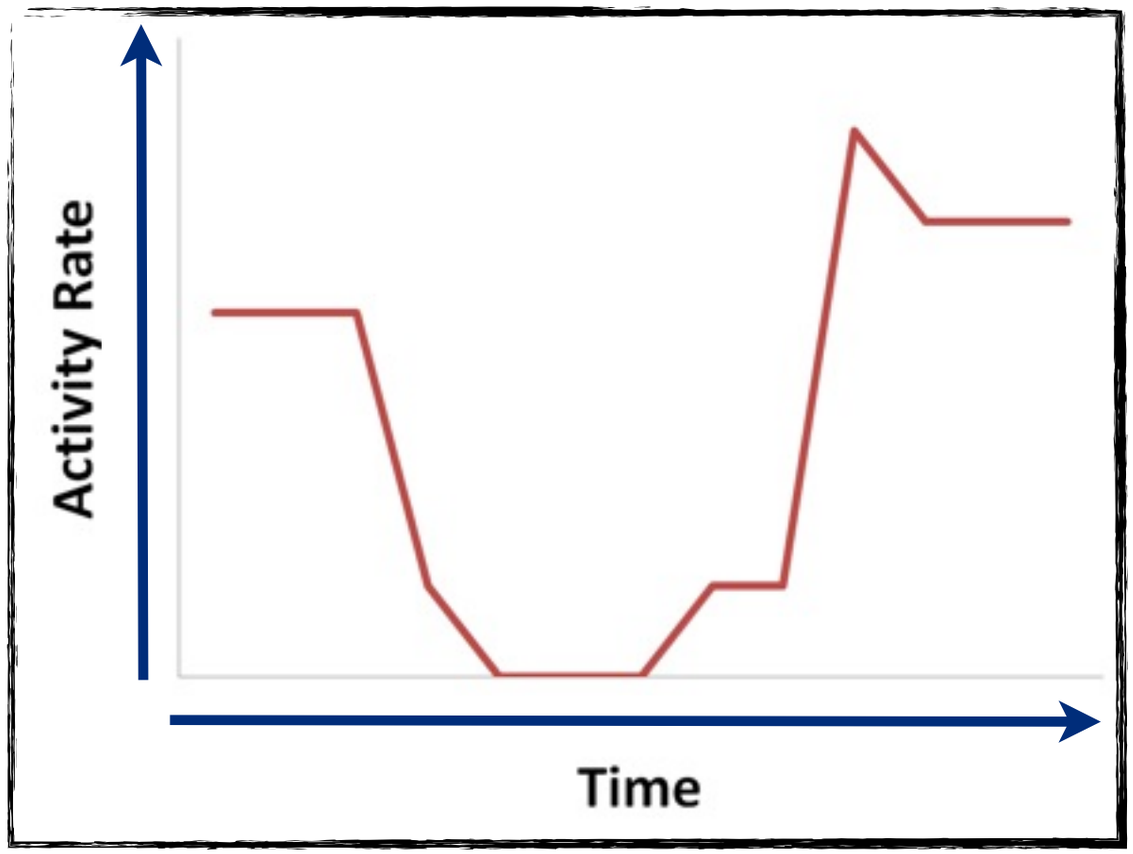
Prevent interruptions with prompts specific to each test



Design implications:

Detecting interruptions

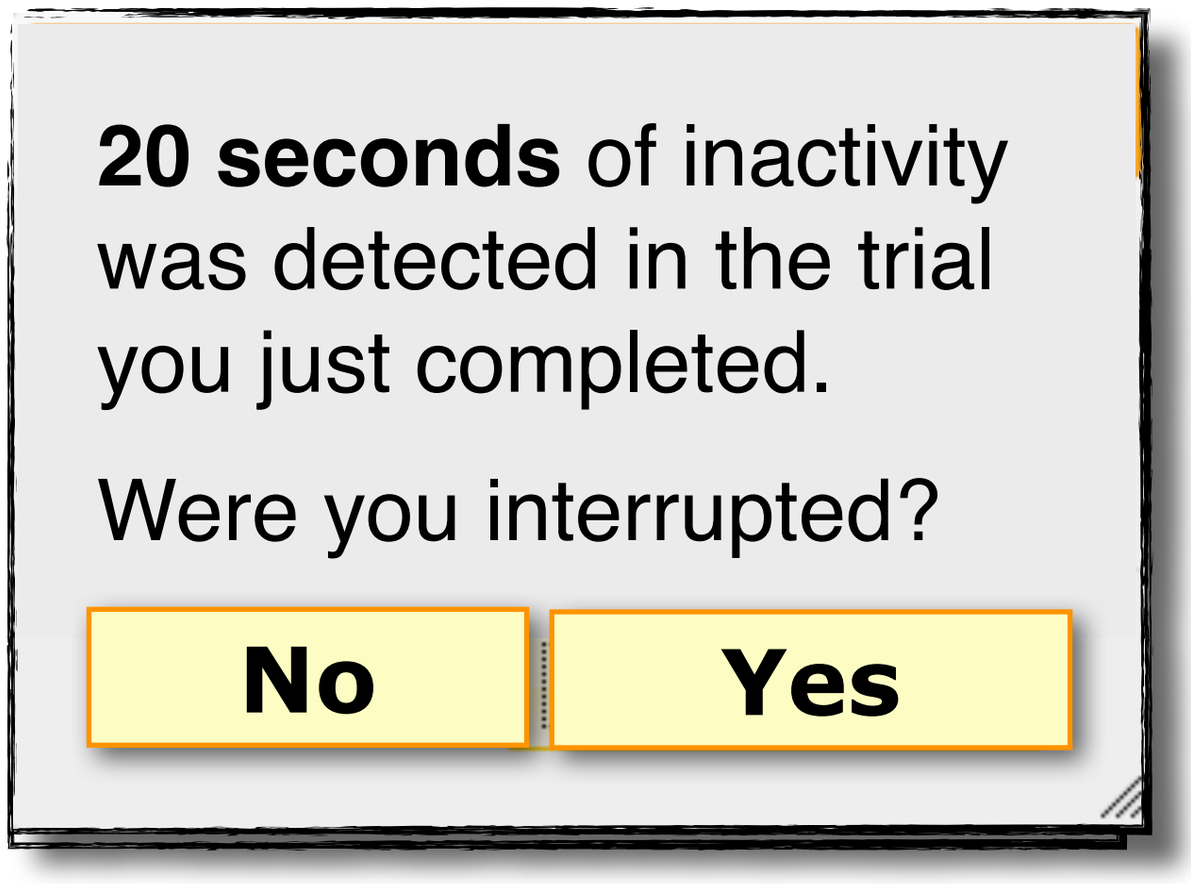
If completion time important, monitor activity rates.



Design implications:

Detecting interruptions

If completion time important, monitor activity rates.

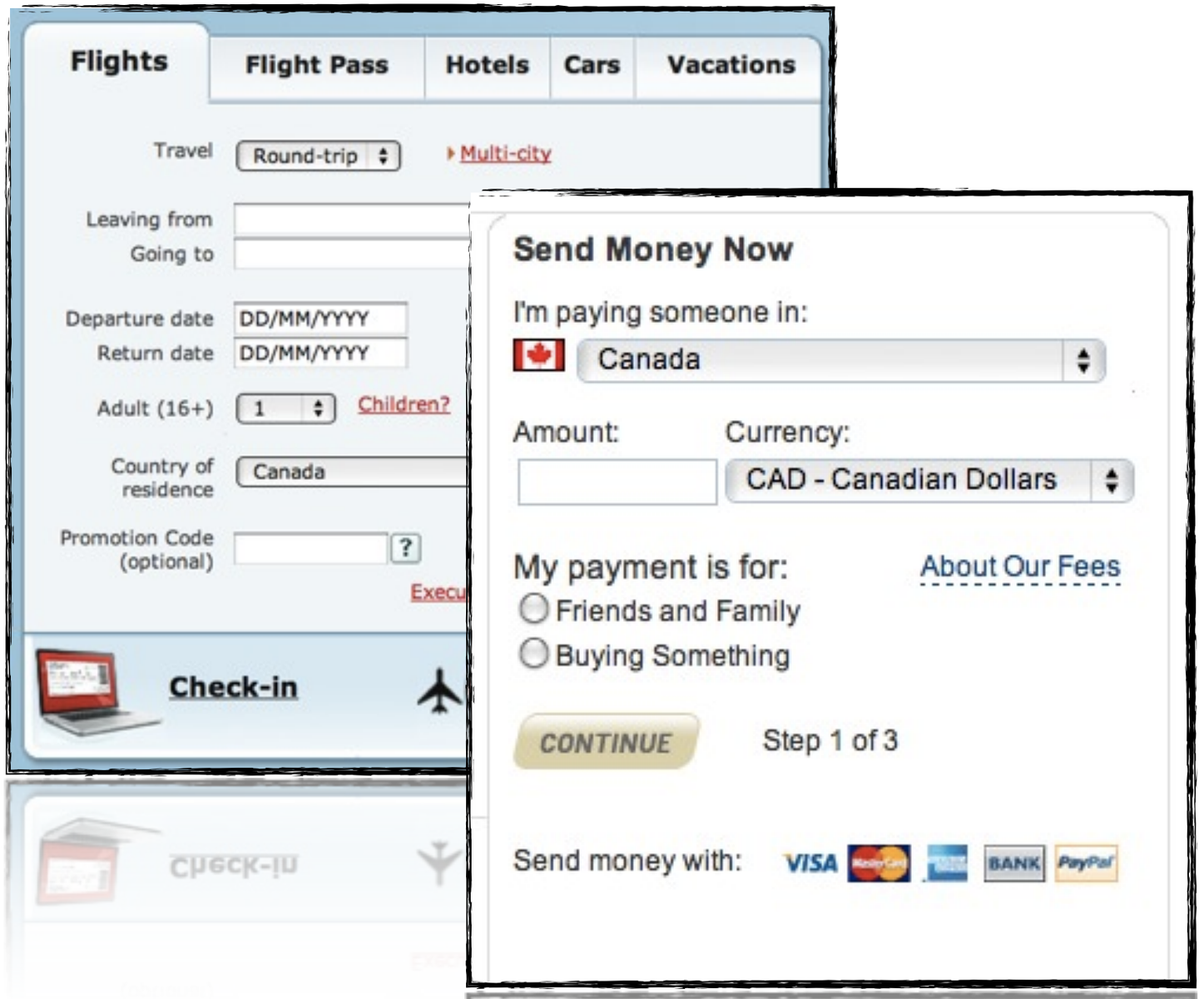


Replace interrupted trials or restart interrupted tests

Design implications:

Beyond C-TOC

Segment tasks,
set inactivity thresholds



Future Work

Interruptions and **clinical groups**

Future Work

Future Work

Interruptions and **clinical groups**

Designing **valid interruption levels**

Future Work

Interruptions and **clinical groups**

Designing **valid interruption levels**

Age and interruption **strategy**

Summary

Divergent effects of interruption demand between

- age groups
- primary tasks

Implications for C-TOC and other applications used by older adults

Matthew Brehmer, Joanna McGrenere, Charlotte Tang, Claudia Jacova

brehmer [at] cs.ubc.ca

Summary

Divergent effects of interruption demand between

- age groups
- primary tasks

Implications for C-TOC and other applications used by older adults

CIHR IRSC
Canadian Institutes of Health Research
Instituts de recherche en santé du Canada

NSERC CRSNG

Graphisme, animation et nouveaux médias
grand
Graphics, Animation and New Media

Hypotheses

H1. Overall, **YOUNG** adults will perform better than **OLD** adults.

H2. **OLD** adults will incur a disproportionally greater cost of interruption

H3. **H1** + **H2** will be more pronounced in the VERBAL task

Supported

H1. Overall, **YOUNG** adults will perform better than **OLD** adults.

H2. **OLD** adults will incur a disproportionally greater cost of interruption

H3. **H1** + **H2** will be more pronounced in the VERBAL task

Supported

H1. Overall, **YOUNG** adults will perform better than **OLD** adults.

Partially Supported

H2. **OLD** adults will incur a disproportionally greater cost of interruption

H3. **H1** + **H2** will be more pronounced in the VERBAL task

Supported

H1. Overall, **YOUNG** adults will perform better than **OLD** adults.

Partially Supported

H2. **OLD** adults will incur a disproportionally greater cost of interruption

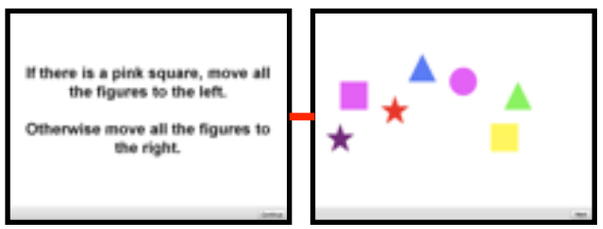
Partially Supported

H3. **H1** + **H2** will be more pronounced in the VERBAL task

Study Design - Interruption timeline

Study Design - Interruption timeline

read instruction



trial begin

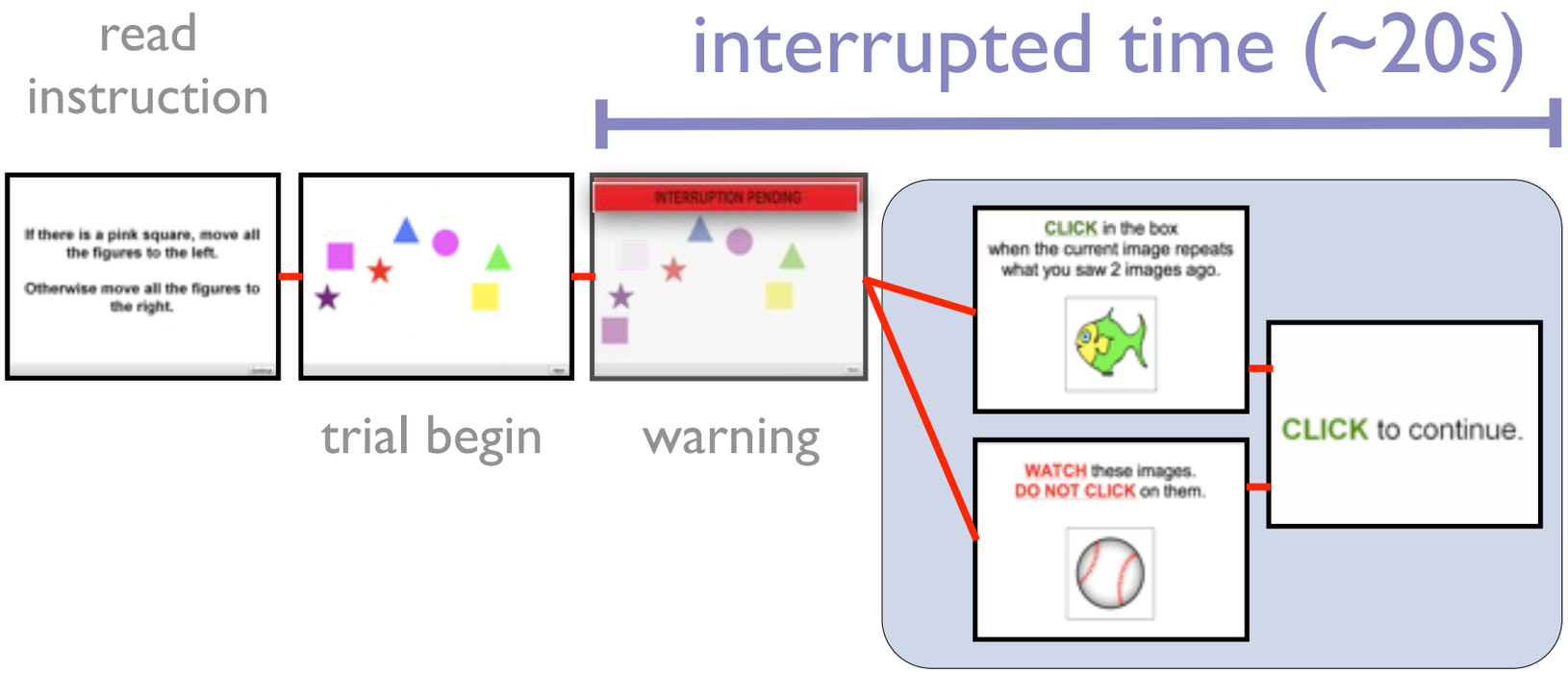
Study Design - Interruption timeline

read instruction

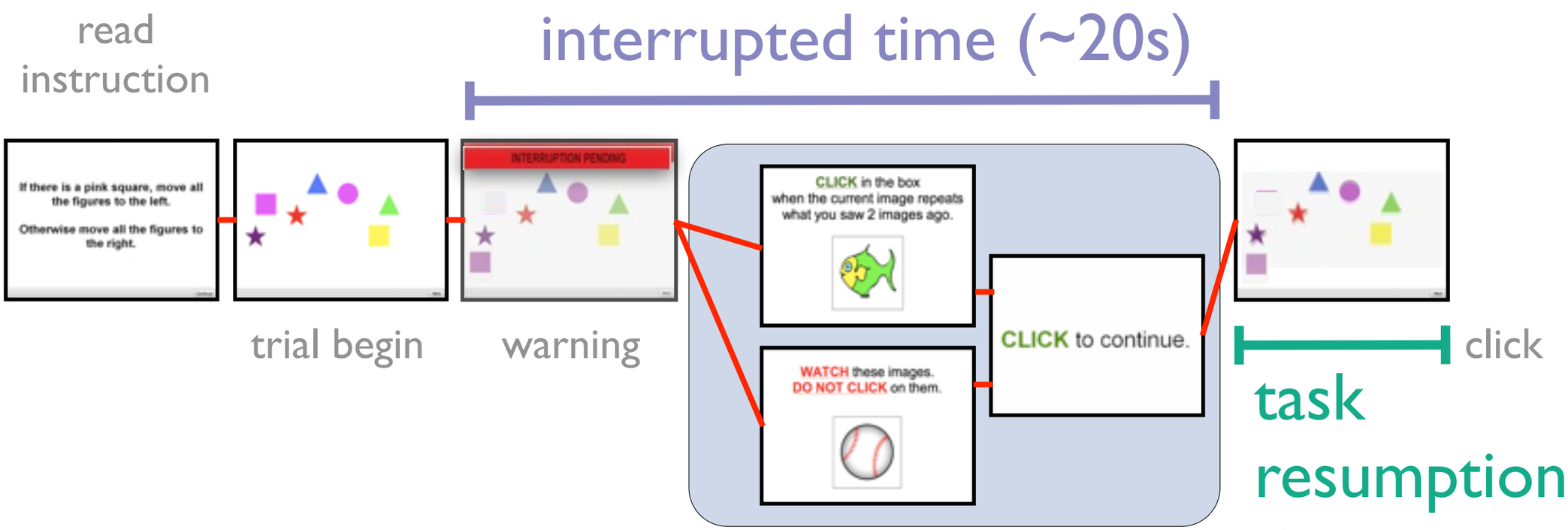
trial begin

warning

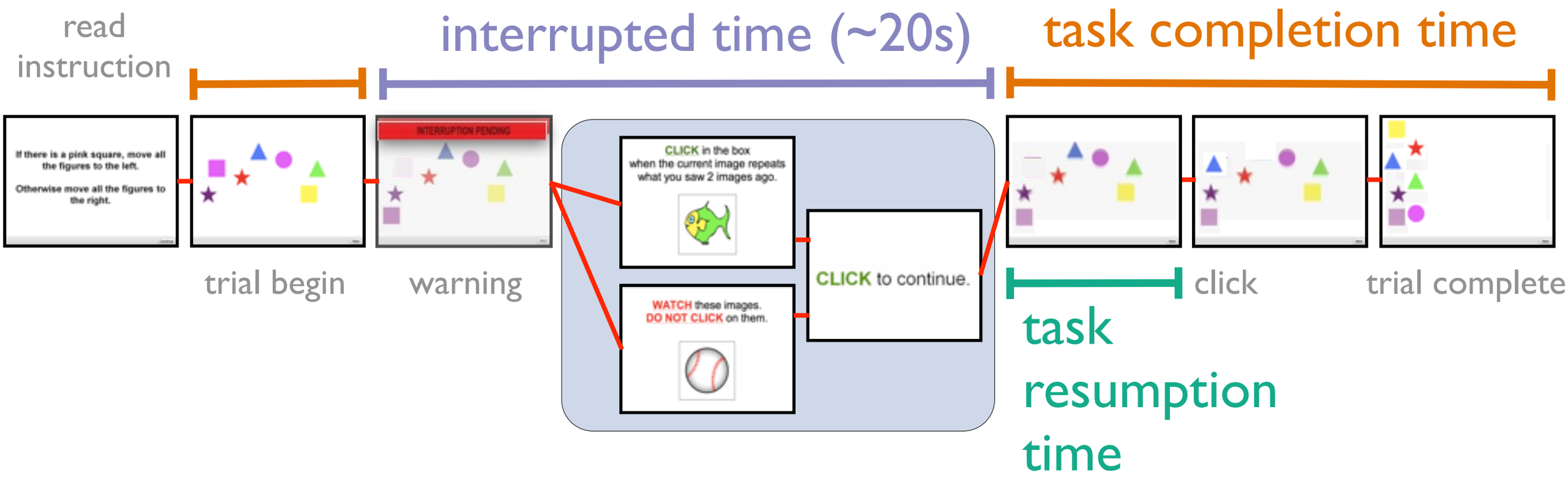
Study Design - Interruption timeline



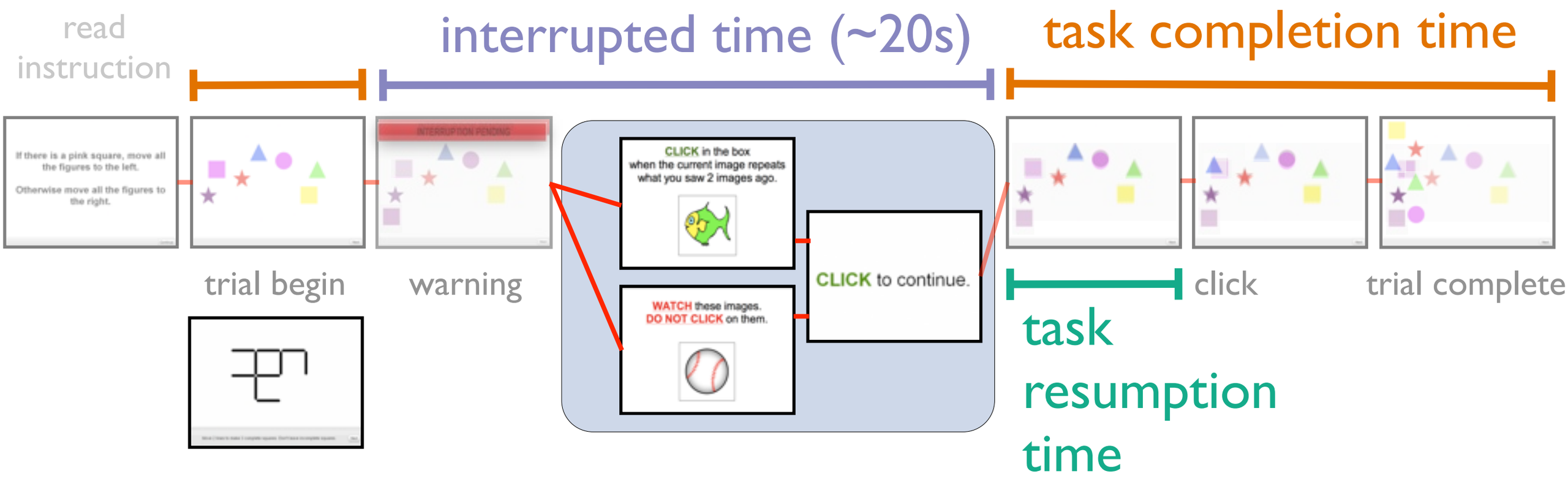
Study Design - Interruption timeline



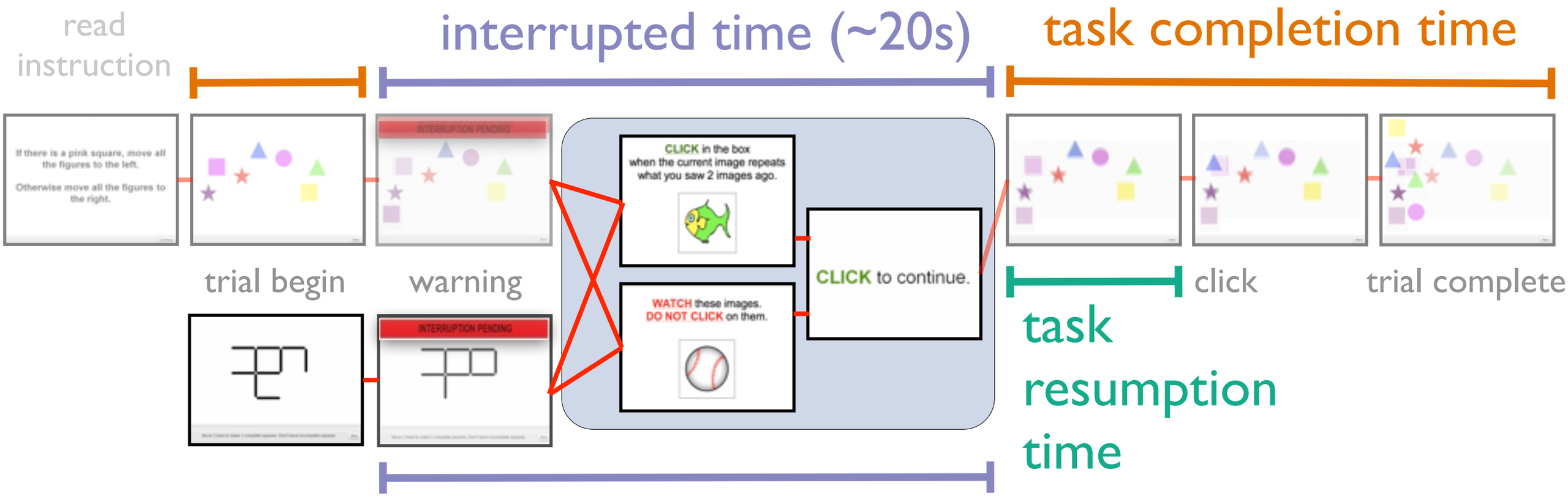
Study Design - Interruption timeline



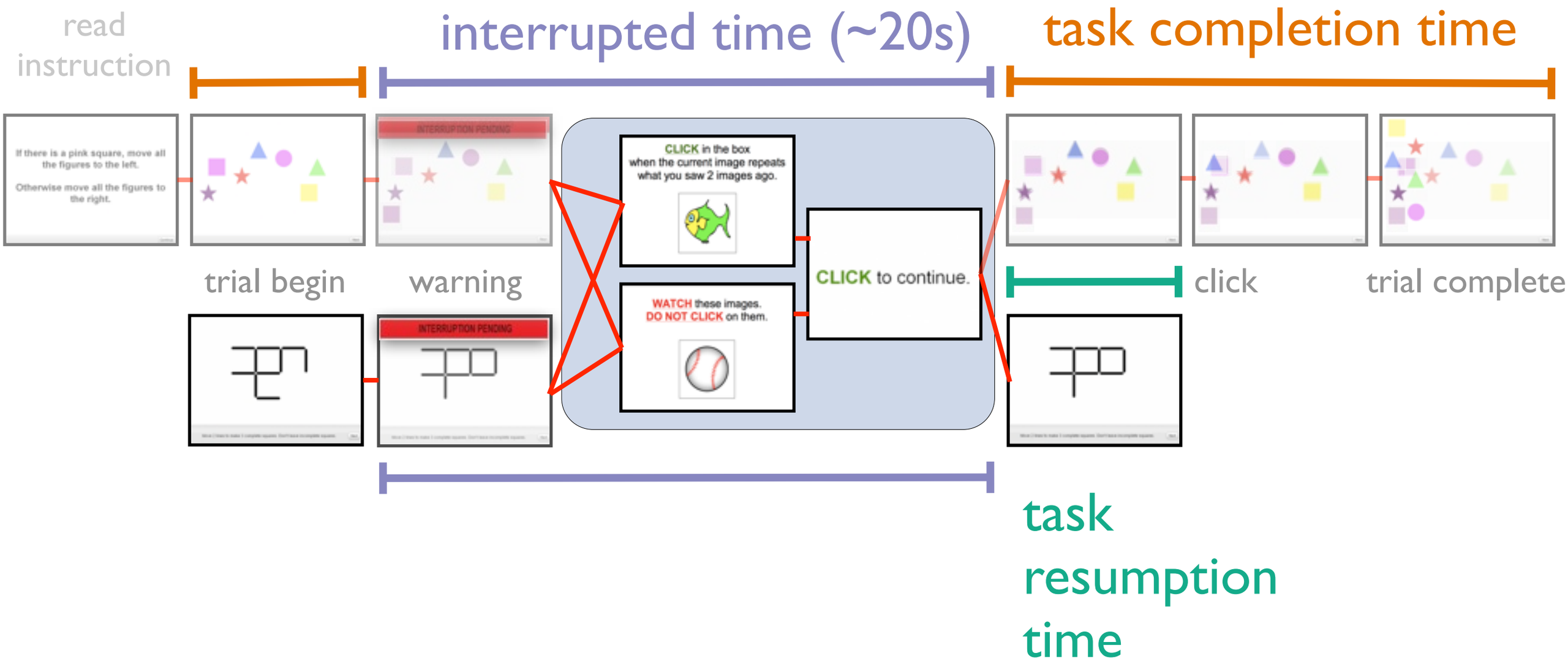
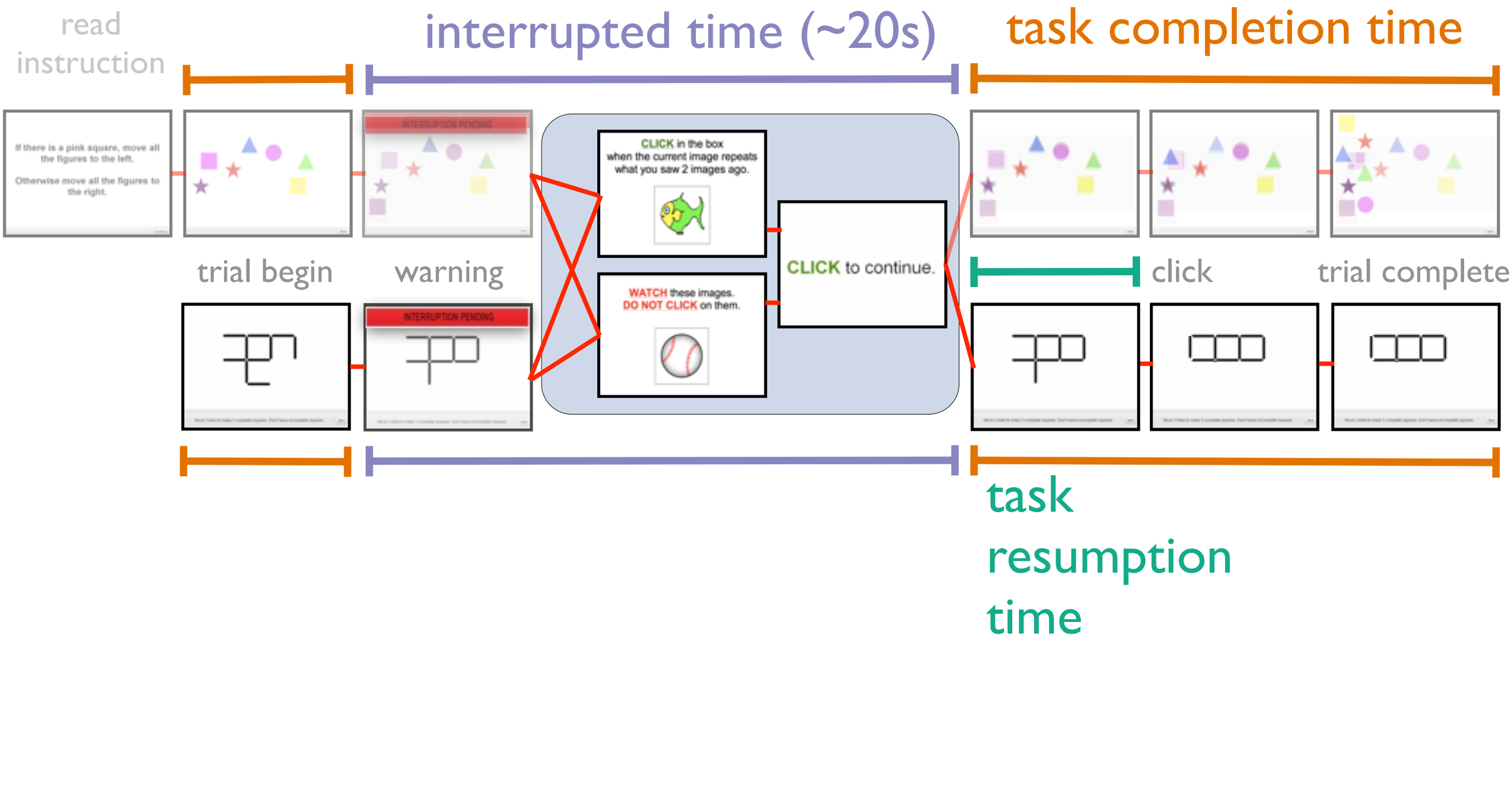
Study Design - Interruption timeline



Study Design - Interruption timeline



Study Design - Interruption timeline



Study Design - Interruption timeline