Effects of Motion in the Far Peripheral Visual Field on Cognitive Test Performance and Cognitive Load

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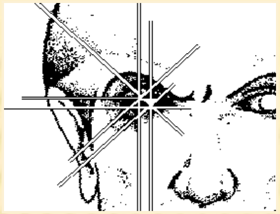


Research Question

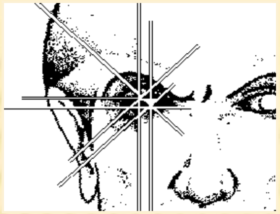
Will a survival-related stimuli, such as movement in the far peripheral visual field (80-90 degrees off-center) produce measurable cognitive load outside of human selective attention?

Related Questions:

✓Biological motion is known to ‘grab’ attention (Jokish, Troje, Koch, Schwarz, & Daum, 2005; Thorpe, Gegenfurtner, Fabre-Thorpe, & Bluthoff, 2001). Does non-biological motion have the same effect? Is it processed outside of attention?

✓Is non-biological motion a biologically primary stimulus? (Geary, 2002; Geary, 2007; Paas & Sweller, 2012)

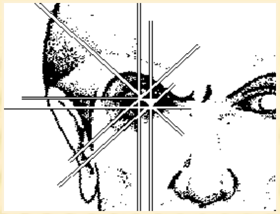
If extraneous movement in the learning environment can induce cognitive load through far peripheral vision outside of attention, then it can also affect cognitive performance and by extension, learning



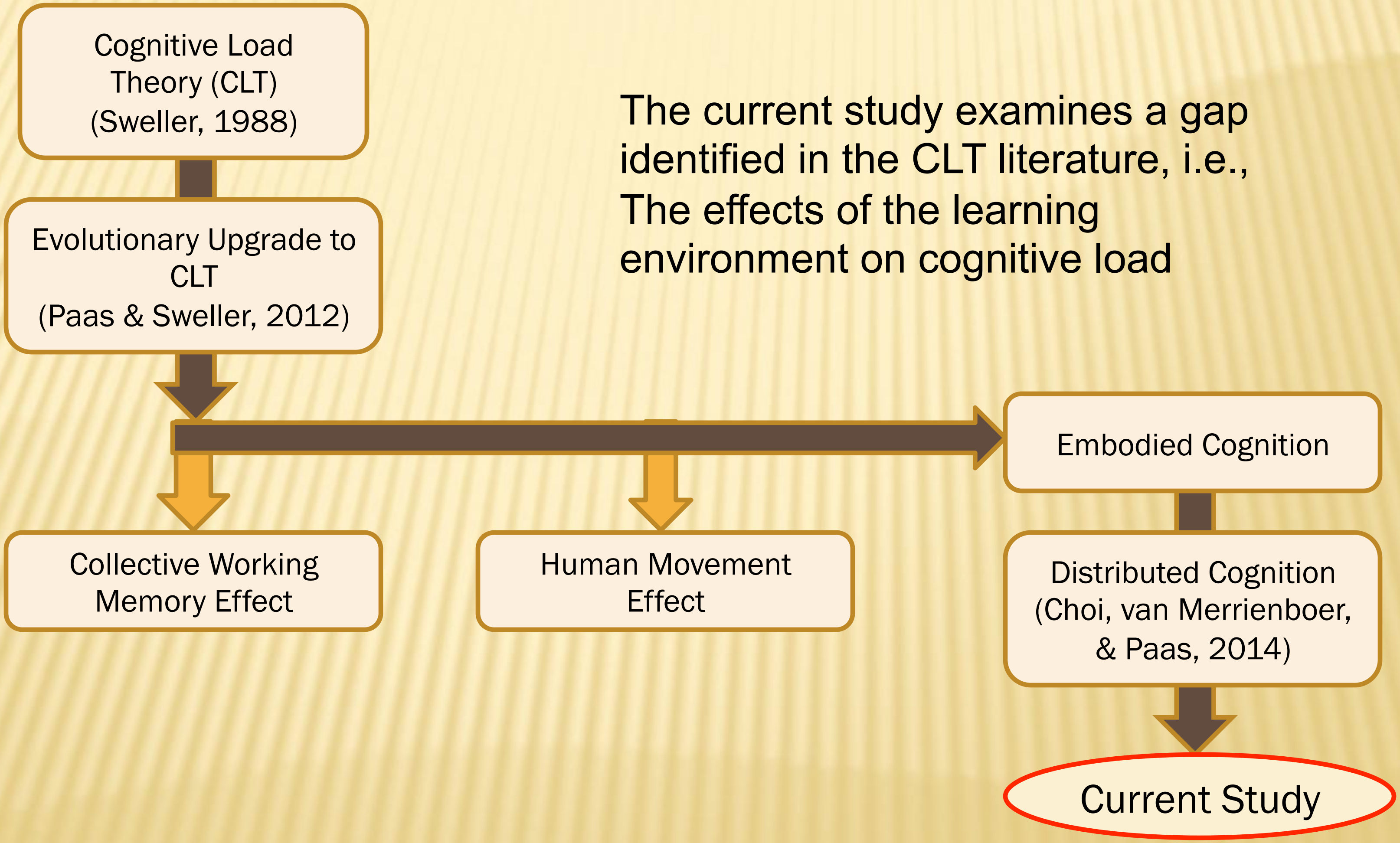
Non-Biological Movement

Non-Biological Motion. In opposition to biological motion, non-biological motion does not have any of the kinematic properties that would distinguish it as originating from a living organism. Non-Biological motion with some pattern or regularity that is not biological in nature is considered to be coherent motion whereas motion in a random or non-patterned style would be random motion (Grossman & Blake, 1999).

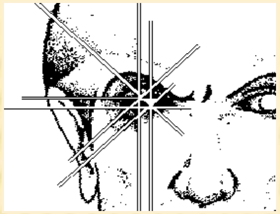
Grossman, E. D., & Blake, R. (1999). Perception of coherent motion, biological motion and form-from-motion under dim-light conditions. *Vision Research*, *39*, 3721-3727. Retrieved from http://visionlab.harvard.edu/members/Emmy/Reprints/ScotopicMotion_99VR.pdf



Cognitive Load Theory / Background



The current study examines a gap identified in the CLT literature, i.e., The effects of the learning environment on cognitive load

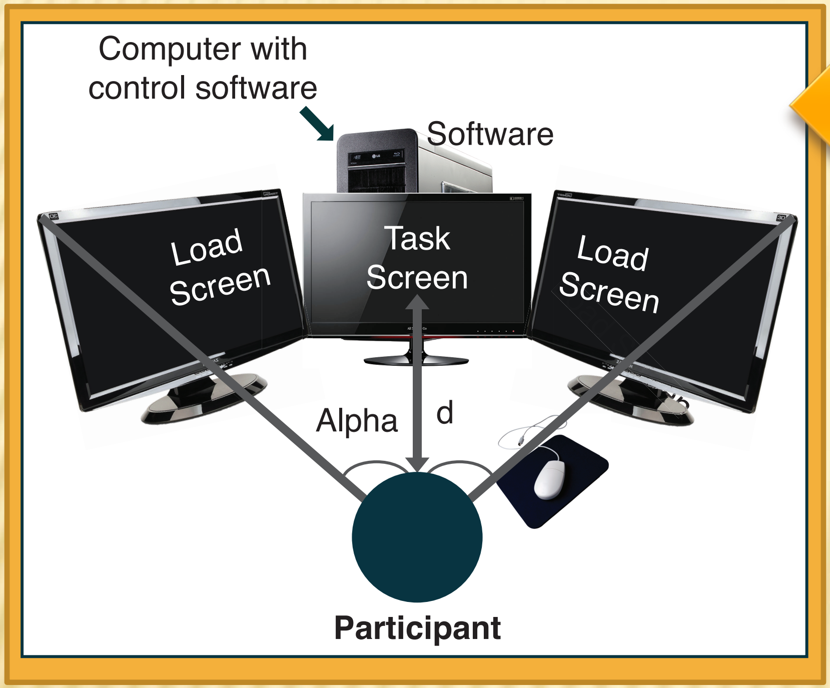


Hypothesis

Continuous non-biological movement in the far peripheral visual field will induce cognitive load outside of attention; specifically non-biological movement will increase cognitive load in both males and females even under high cognitive load conditions

- Independent variable 1 (IV1), Movement
  - Category 1 = Type of Movement, continuous non-biological
  - Category 2 = Type of Movement, No Movement
- Independent variable 2 (IV2): Gender
  - Category 1: Male
  - Category 2: Female
- The dependent variable (DV) is cognitive load as represented by time-on-task for the primary cognitive task.

Experiment Design*

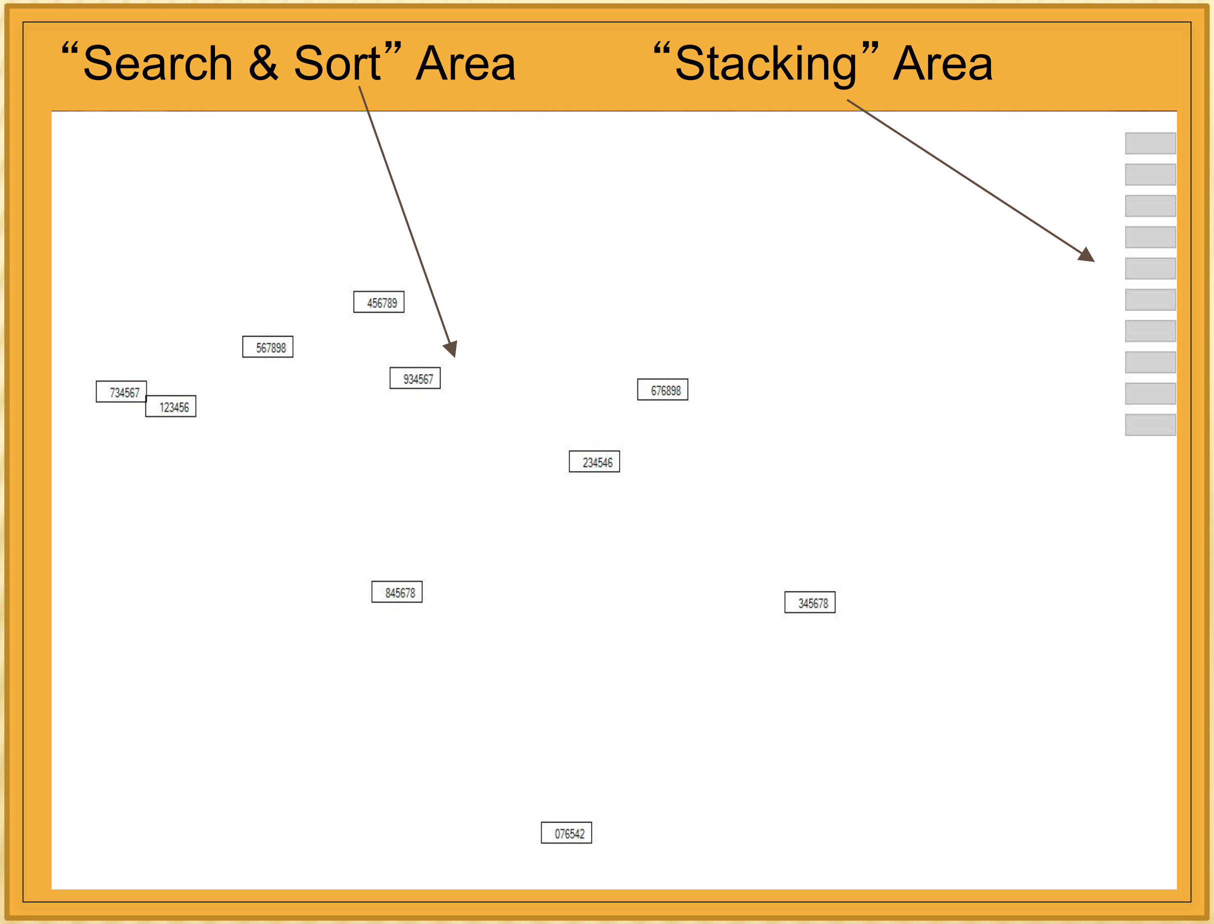


- ✓ Task (center) display contains the cognitive task
- ✓ Load (side) displays either display movement or no movement
- ✓ Difficulty of the Cognitive task can be increased/decreased by adding more numbers or more digits
- ✓ Stop/start using the mouse. Time on task is automatically measured and displayed/saved to Excel

Imitation: No chin rest used

*Experiment approved by the Grand Canyon University IRB

Cognitive Test: Search, Sort and Stack



- ✓ Test can be configured to use 1 to N numbers
- ✓ Numbers can be 1 to N digits long
- ✓ Numbers are randomly distributed on the screen
- ✓ Subject must search for the lowest number, drag it and drop it in order from top to bottom of the stacking area

Test provides a scaleable intrinsic load, exercises both visual pathways (Goodale & Milner, 1992), and keeps the subject's attention (flow).

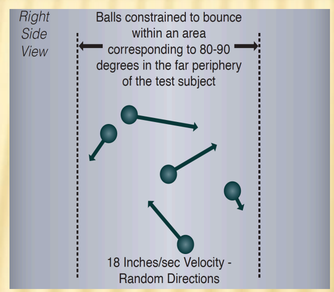
Test Sample and Process

SAMPLE:

- ✓ 50 Individuals tested, 39 data sets retained after data cleaning
- ✓ 22 Males and 17 Females
- ✓ Ages 26 - 77
- ✓ Recruited in Alabama and Ohio (USA)
- ✓ US Defense Industry employees whose day-to-day jobs involved the use of a computer with a mouse and display

PROCESS:

1) Provide a cognitive task to induce intrinsic load



2) Add a visual stimulus from the environment (outside of attention)

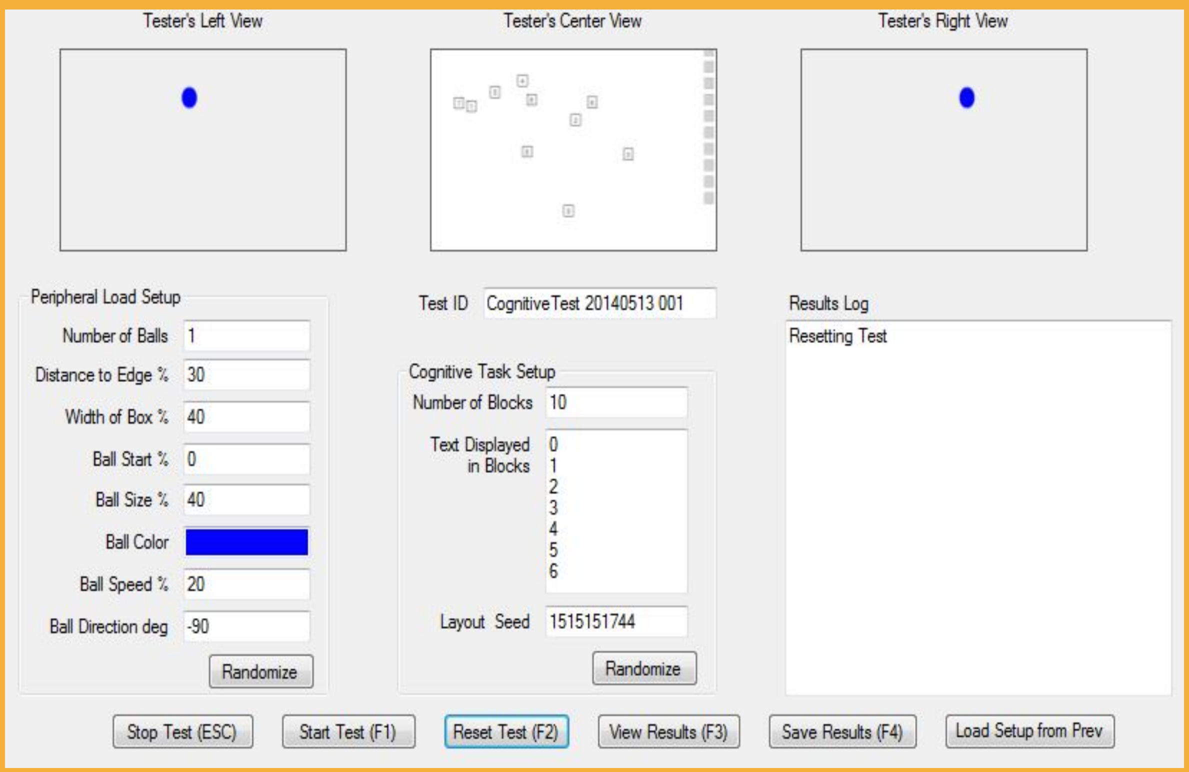
2) Don't Add a visual stimulus from the learning environment (Control Group)

3) Compare time on task

Test Instrument – ToTEL - X

ToTEL – X: Time on Task Exogenous Load Index

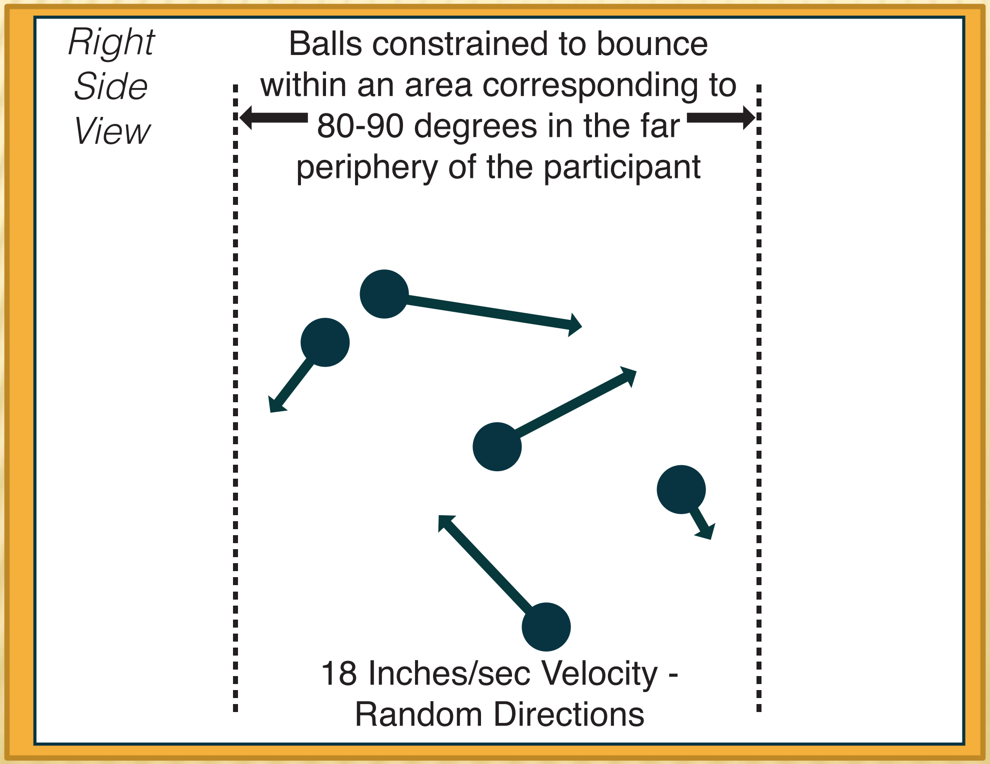
Measurement Software User Interface



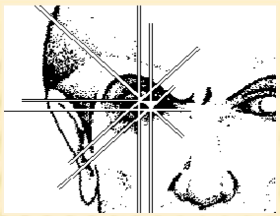
- ✓ ToTEL – X software
- ✓ Presents a cognitive task
- ✓ Captures the time required to make each move as well as total time
- ✓ Automated PC (not Mac) software application
- ✓ Saves each data file to Excel

Movement

Non-Biological continuous movement chosen because biological movement is already well researched. Also the continuous nature of the stimulus keeps its effects present throughout the entire cognitive test



- ✓ 5 each ¾" diameter balls bouncing randomly within a constrained region of the side displays (80-90 degrees from center).
- ✓ Incorporates all directions to mute preferential effects of motion vision (Blake, Sekuler, & Grossman, n.d.; Zeki & Lamb, 1994).

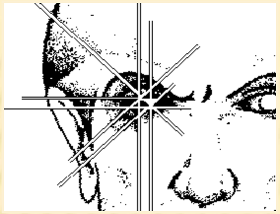


Analysis & Results

- ✓ A 2 x 2 ANOVA was accomplished on the data

Source	df	MS	F	p	η^2
Gender	1	21.8	4.94	0.033	.124
Movement	1	6.69	1.15	.227	.041
Gender x Movement	1	5.82	1.32	.259	.036
Error	35	4.42			

- ✓ This analysis showed a significant main effect for Gender but not for movement
- ✓ η^2 calculated using SPSS v21 (.124 = large effect size)



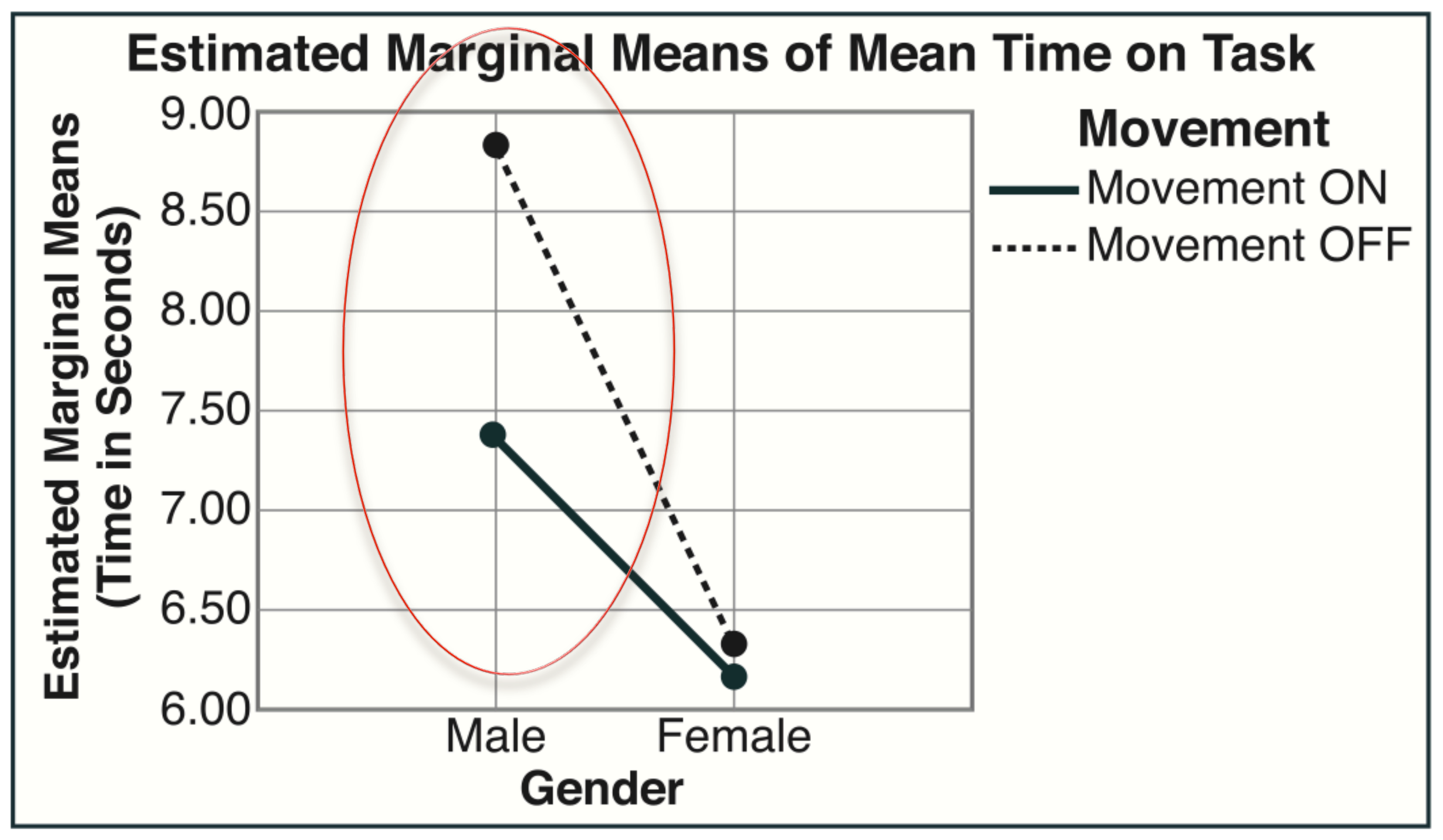
Analysis & Results (Cont.) - ANCOVA

- ✓ It is known that age is correlated with slower reaction/test times.
- ✓ A correlational analysis showed that age was indeed a covariate
- ✓ For this reason AGE was added as a covariate and an ANCOVA was run

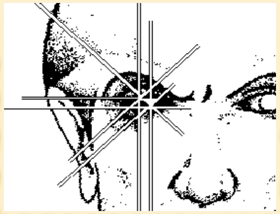
Source	df	MS	F	p	η^2
Age	1	13.09	3.14	.085	.085
Gender	1	17.59	4.22	.048	.110
Movement	1	5.46	1.31	.261	.037
Gender x Movement	1	4.36	1.05	.314	.030
Error	34	4.17			

- ✓ These results point towards a possible gender effect in the way that movement is processed in working memory.
- ✓ η^2 calculated using SPSS v21 (.110 =relatively large effect size)

Analysis & Results (Cont.)

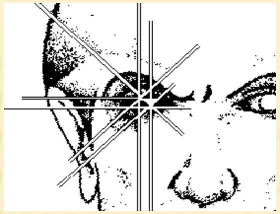


Continuous non-biological movement appears to reduce cognitive load levels for males but not females.



Discussion

- ✓ Current theories differ in their beliefs about how peripheral sensory inputs will be processed
- ✓ Our hypothesis that continuous non-biological movement outside of attention in far peripheral vision would induce cognitive load is rejected for the following reasons:
  - ✓ Although the experiment appears to show that cognitive load was induced outside of attention it differed significantly for males and females (Does not match our original hypothesis)
  - ✓ Males actually appear to perform the test *better* in the presence of this kind of movement---could it be a biologically primary stimulus for males and not females?
- ✓ Although we can speculate regarding the cause of this finding, confirmatory testing must be accomplished before cause and effect can be credibly established



Limitations

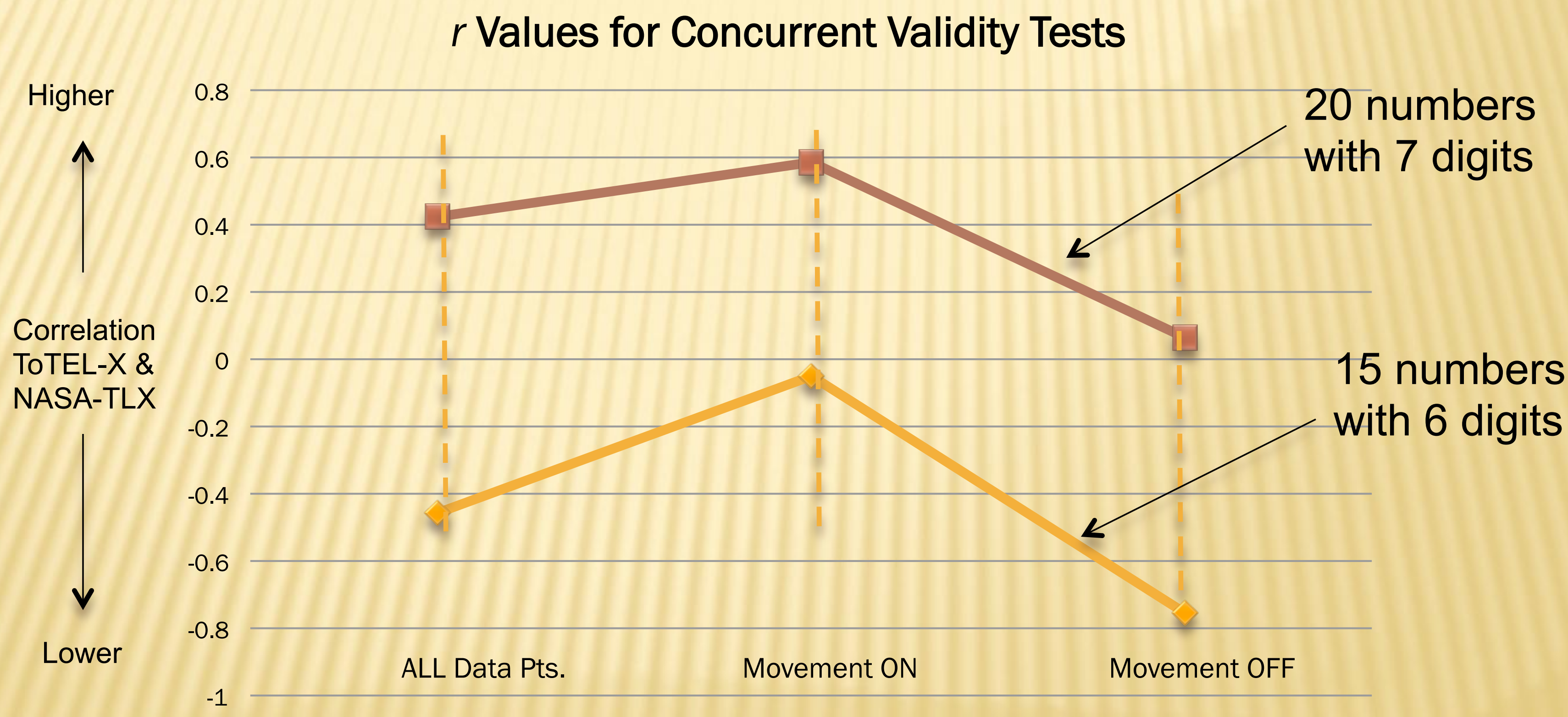
- ✓ Lack of active controls to keep attention on the cognitive task (chin rest)
- ✓ Sample size is small (39 subjects)
- ✓ Only one type (speed, pattern, color, etc.) of movement was tested

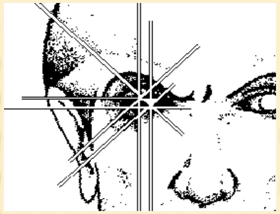
Reliability and validity experiments for the test instrument showed that the cognitive task was not strenuous enough because a negative correlation was found between it and the validated NASA-TLX instrument (Krigbaum, Bevilacqua, Chatterjee, & Paas, Unpublished Manuscript)

◆ Preliminary results show that increasing the difficulty of the cognitive test did increase the correlation with NASA-TLX into positive territory, providing concurrent validity of this method (within a certain range of task difficulty).

Reliability & Validity Study (Unpublished) Preliminary Results

ToTEL-X – Time on Task Exogenous Load Index vs. NASA-TLX





Implications and Future Research

If supported by further research this finding has the potential to:

1) Improve the ability of males to concentrate and learn
2) Improve the design of multimedia environments
3) Improve the design of physical learning environments

Future research should:

1) Replicate the initial results
2) Investigate the effects of other types of movement
    1) Intermittent movement
    2) Different speeds, motions, colors, etc.
    3) Utilize a more difficult primary cognitive task

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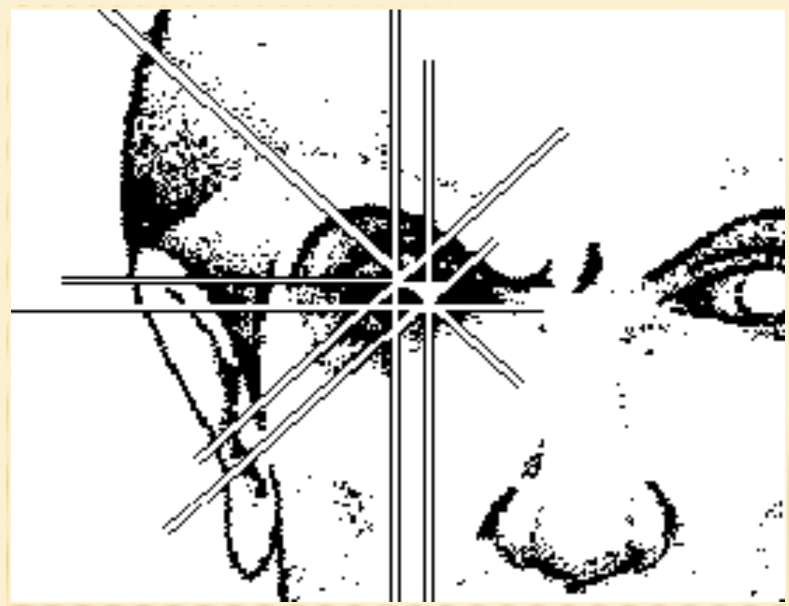

Thank you for your Attention

Questions?

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