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).

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*

- Computer with control software
- Software
- Load Screen
- Task Screen
- Load Screen
- Alpha
- 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

*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
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
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 $\frac{3}{4}''$ 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).
A 2 x 2 ANOVA was accomplished on the data

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<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>η²</th>
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<td>.041</td>
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<td>Gender x Movement</td>
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</table>

This analysis showed a significant main effect for Gender but not for movement.

η² calculated using SPSS v21 (.124 = large effect size)
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.

<table>
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<th>Source</th>
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</table>

These results point towards a possible gender effect in the way that movement is processed in working memory. $\eta^2$ calculated using SPSS v21 (.110 = relatively large effect size)
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).
ToTEL-X – Time on Task Exogenous Load Index vs. NASA-TLX

$r$ Values for Concurrent Validity Tests

- 20 numbers with 7 digits
- 15 numbers with 6 digits

Correlation ToTEL-X & NASA-TLX

Higher

Lower

ALL Data Pts.  Movement ON  Movement OFF
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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