Blocks Rock! The Effect of Block Building on Mental Rotation Ability

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Introduction

Blocks Rock! is an educational block building game where young kids compete to build a color- and shape-specific structure faster than the other. For this study, we investigated how the game affected the mental rotation abilities of children and how it contrasted with playing a non-block building game. We had second and third graders complete pre and post fMRI scans during which they completed a mental rotation task. They played either Blocks Rock! or Scrabble for 5 days between scans. Response time and accuracy were recorded during the rotation activities to use as measures of improvement both within individuals and across conditions. The differences were determined between the games and how the results changed from before playing the game to after playing. We predicted that spatial reasoning abilities would improve more for children who played Blocks Rock!

Background

- Over the past decade, the United States has been plagued by a lack of qualified workers in its STEM (science, technology, engineering, and mathematics) field.
- Past research has shown that spatial thinking plays a critical role in STEM success (Bingham, 1937; Gardner, 1993; many others)
- Block building activities can improve spatial skills (Casey et al, 2008; many others).
- Until this study, there has not been research involving a structured training program and fMRI.

Materials and Methods

- Second and third graders completed a mental rotation task in a 3T MRI.

Figure 1. Examples of 'same' (l) and 'different' (r) mental rotation stimuli.

- The subjects played either Blocks Rock! or Scrabble for 30 minutes during 5 sessions.

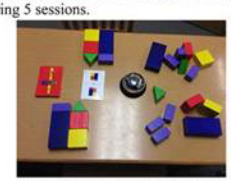

Figure 2. Example setup of a Blocks Rock! round.

- At the conclusion of the 5 game days, the child did the mental rotation task again during a second MRI session.
- SPM8 and xjView were used for fMRI analysis.

fMRI Results

Rotation - Fixation (post - pre), Block play*

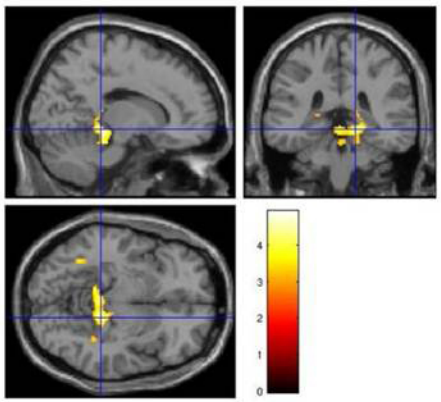

Figure 3. Depicts areas of higher activation (mainly in the parahippocampal area and part of the hippocampus) in the post condition compared to the pre condition among the Blocks Rock!/ experimental group. Also visible is the activation in the fusiform in the bottom left picture (activation island in left cerebrum). The parahippocampus has long been believed to be involved in spatial analysis (Aminoff et al, 2007), and hippocampus has been implicated in spatial memory as well (Maguire et al, 2000).

Rotation - Fixation (post - pre), Board game*

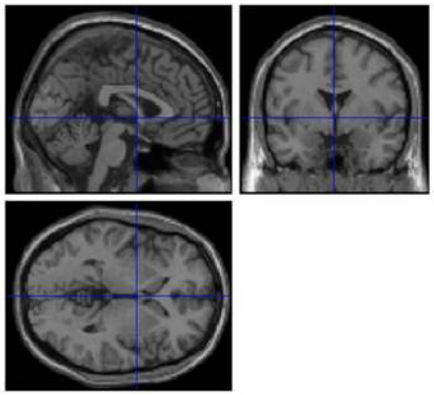

Figure 4. The board game/control group showed no significant activation from pre- to post- training. The non-block building game, Scrabble, did not lead the subjects to use a different problem solving strategy from pre- to post- training.

Experimental - Control (post)*

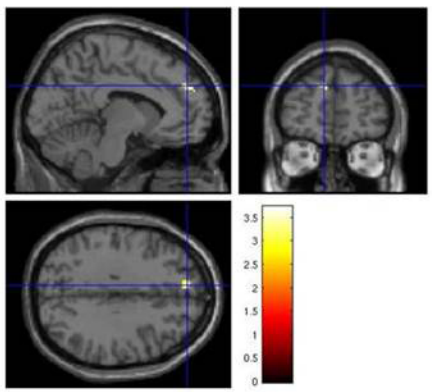

Figure 5. Depicts areas of higher activation among the Blocks Rock! group compared to the control group in the post condition. Activation in the left superior frontal gyrus of BA 9 is visible. The superior frontal gyrus has an important role in spatial working memory (Boisgueheneuc et al, 2006).

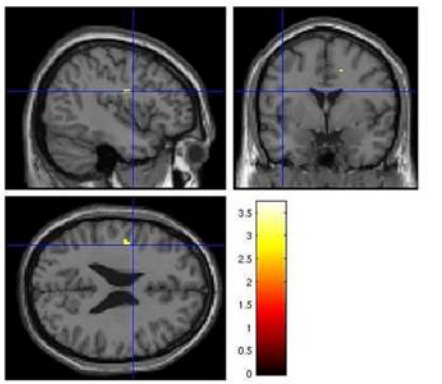

Figure 6. Depicts areas of higher activation among the board game group compared to the control group in the post condition. Activation in the precentral gyrus of BA 6 (top left and bottom left pictures) and the cingulate gyrus (top right picture) are visible. The precentral gyrus is important in imagining the rotation of objects (Lamm et al 2007). The link between the precentral gyrus and cingulate gyrus indicate deductive reasoning taking place in the experimental group (Knauff et al 2001).

*For all contrasts, $p \leq 0.005$, cluster size was set at 6.

Behavioral Results

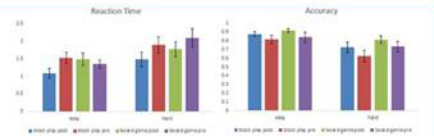

Figure 6. Easy problems had an angle of rotation that was 90° or less. Hard problems had an angle of rotation greater than 90° and less than 180°

The Block Rock! group showed a significant effect of training for both accuracy [F(1,14)=5.75; MSE=0.1; p=0.031] and RT [F(1,14)=8.92; MSE=2.72; p=0.0098].

The board game group failed to show an effect of training for either accuracy [F(1,13)=3.51; MSE=0.087; p=0.084] or RT [F<1].

Summary

- The important difference between the two groups was the activation of brain areas that were involved in spatial reasoning among the experimental group. This includes the paraphippocampus, hippocampus, left superior frontal gyrus (BA 9), and the precentral gyrus (BA 6).
- Block building and the mental rotation task require spatial reasoning, and these spatial reasoning skills developed in the experimental group.
- Functional specialization developed in the experimental group, a sign of efficient neural processing.
- Using a connection between the cingulate gyrus and frontal gyrus, the experimental subjects are utilizing deductive reasoning during the mental rotation task.
- Conclusions could not be drawn from the behavioral data due to too much insignificant data.
- Behavioral data-wise, it is notable that both groups performed well pre-training. Perhaps a more challenging mental rotation task should be have been used. That could have lead to larger improvements through training and more significant results.

Implications

This study corroborates with past research that structured block play needs to be a part of the young student's classroom experience. With block-building games, like Blocks Rock!, being played, students will develop higher spatial reasoning abilities. These students with higher spatial reasoning abilities will have a higher likelihood of furthering their education and future careers in STEM, a field that the United States so desperately needs to improve.

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