Brain Slap! A Fast-Paced Card Game Designed to Teach Neuroanatomy

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INTRODUCTION

The National Science Foundation recently reported that teenagers in the United States perform poorly on assessments of mathematics and science relative to other developed countries. In a recent review of education practices in the U.S. (Pashler et al., 2007), a panel of cognitive psychologists determined that methods known to enhance learning and retention were not being employed in schools. Among the methods recommend to enhance learning, quizzes and game-based learning were cited as being the most effective way to improve retention. Consequently, we developed a simple game system that could be used to teach a wide variety of structure-function relationships in neuroscience. Increased attention required for the game should result in increased activity in the amygdala, which is known to facilitate encoding of long-term memories. It was predicted that engagement and repetition present in the game would result in improved learning relative to traditional teaching methods that use text-based resources without game mechanics.

METHODS

Subjects

136 volunteers were recruited from the York College Research Subject Pool after providing informed consent. A majority of the volunteers were 18-year-old freshmen from a broad distribution of ethnicities. Subjects were randomly placed in either an experimental or control group. Subjects in the experimental group played a game with game mechanics that were designed to reinforce learning, and subjects in the control group were exposed to the game materials but not the game mechanics. Subjects received course credit for participation. All research was conducted in accordance with the CUNY Institutional Review Board.

Apparatus

Subjects in the experimental condition played a fast-paced card game. Half of the cards contained brain structures that were marked in red (Figure 1). The other half of the cards contained brain functions that were to be matched with the corresponding structure cards. In this version of the game, 8 structure-function pairs were repeated 10 times to yield 80 cards. In addition to the 80 Structure and Function cards, there were 8 Wild Cards. A 20-minute timer was used to time each round of gameplay. Subjects could refer to a "Cheat Sheet" that had all the structure-function relationships on them. Paper and pencils were used to keep score and respond to the post-treatment assessment (Figure 2).

Procedures

In the game, competitors must successfully pair structure-function relationships that appear on separate decks of playing cards. The player who makes the most successful pairings wins. The game requires both speed and accuracy to win. The rules of the game are as follows:

How to Play:

- Players draw 5 cards from their deck.
- Player can only lay down a Structure or Function card on top of its corresponding card. For example, you can lay down a "Vision" Function Card on an "Occipital Cortex" Structure Card or *vice versa*.
- Players who get a Wild Card can lay it down on any pile to keep the entire pile.
- Players who catch their opponent making a mistake get to keep the entire pile.
- All claimed cards go into a player's discard pile, which is separate from their deck.
- You can refer to the "Cheat Sheet" at any time, but you must leave it face down.
- If no players can lay down a card, keep drawing individual cards until someone can.

FIGURE 1

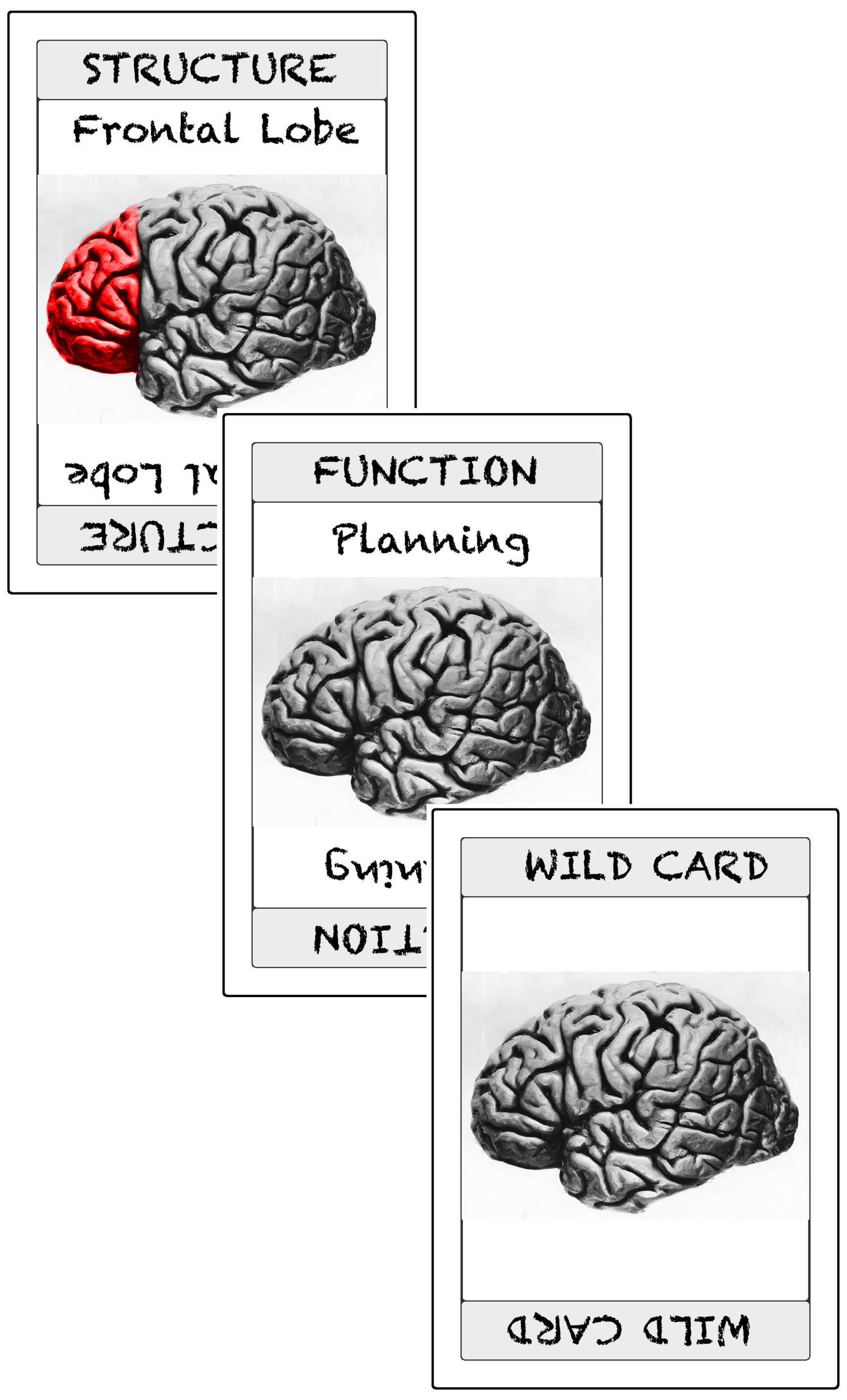


FIGURE 2: Post-Treatment Assessment

SUBJECT ID#______________________________

Match the brain structures on the left with the brain functions on the right.

STRUCTURES

1. Primary Motor Cortex
2. Brocca's Area
3. Primary Somatosensory Cortex
4. Wernicke's Area
5. Frontal Lobe
6. Temporal Lobe
7. Parietal Lobe
8. Occipital Lobe

FUNCTIONS

Planning and Reason ______
Spatial Awareness ______
Hearing and Language ______
Vision ______
Control of Movement ______
Sensation of Touch ______
Language Production ______
Language Comprehension ______

FIGURE 3

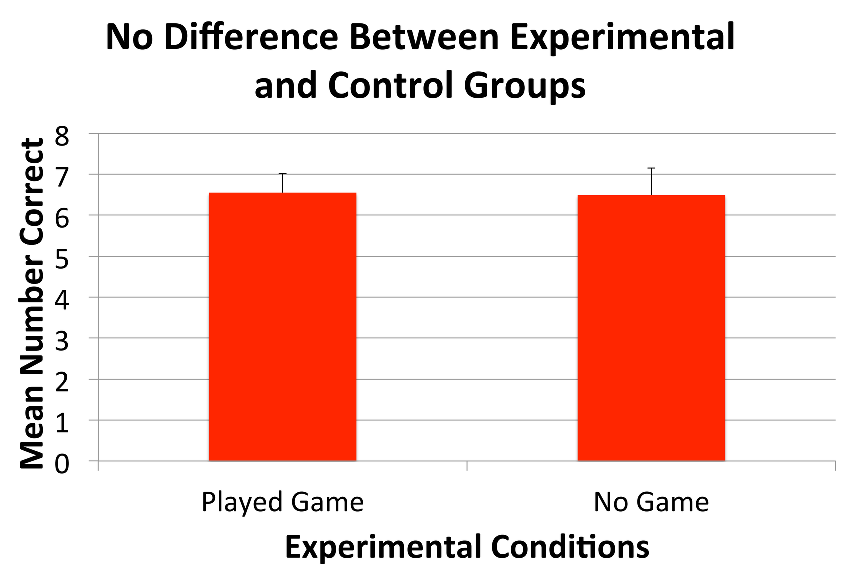


FIGURE 4

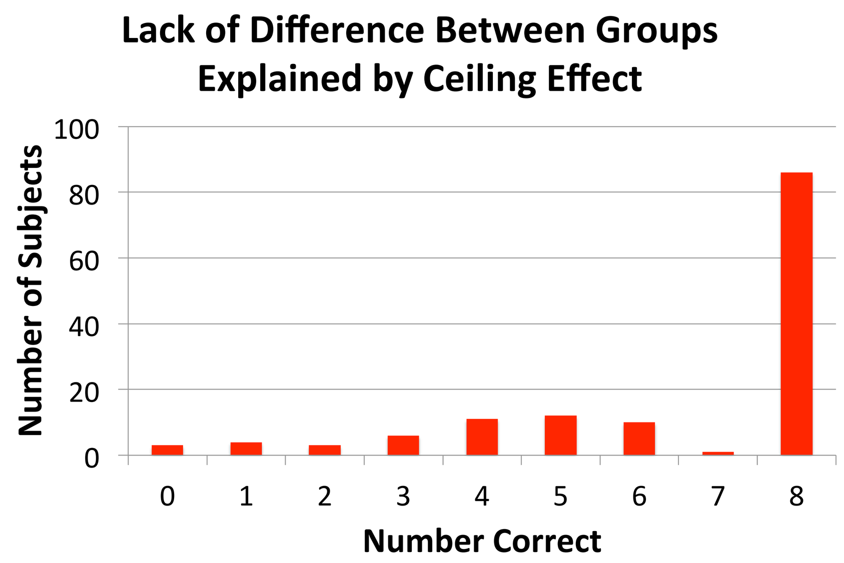
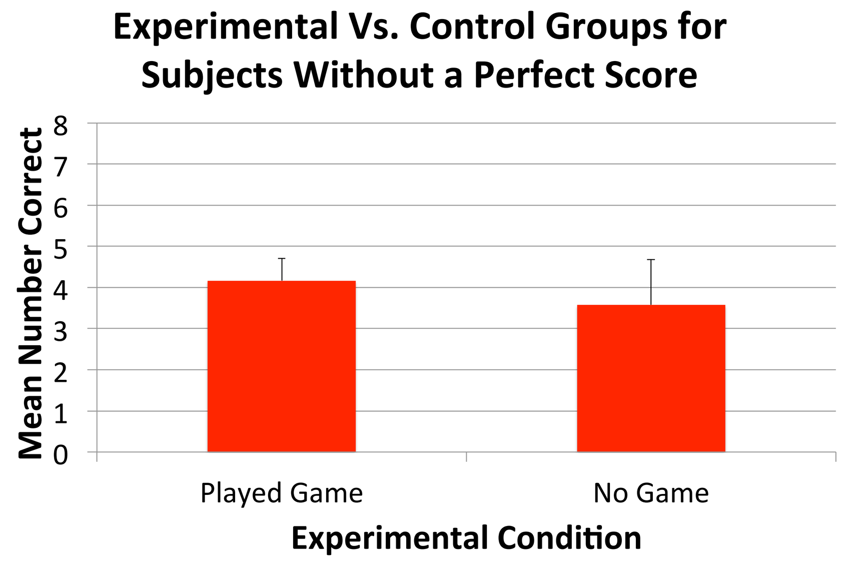


FIGURE 5



METHODS (Continued)

Ending the Game:

- Players may play as many rounds as they can in 20 minutes.
- At the end of 20 minutes, players count the total cards in their discard pile.
- The player with the most cards in their discard pile wins.
- If players exhaust the deck before 20 minutes, or if they just want to keep playing, keep score by writing the total cards in your discard pile down between decks. Then, collect all the cards, reshuffle, deal, and start again!

RESULTS

In the post-treatments assessment, subjects were given a list of 8 structures and 8 functions to compare (**Figure 2**). Each structure could be uniquely paired with one of the 8 functions presented. This method of assessment is easier to record data and grade than a four-alternative forced choice (4-AFC) method, and the odds of getting all the answers correct by guessing are dramatically reduced. The odds of getting all 8 structure-function pairs by chance is $1/8! = 2.48 \times 10^{-5}$. Both Experimental and Control groups performed far better than chance (one-tailed t-test; all $p < 0.0001$). The mean number of correct answers for 79 subjects in the experimental group was 6.54 (+/- 0.46). The mean number of correct answers for 57 subjects in the control group was 6.49 (+/- 0.65). As the data in **Figure 3** show, there was no difference in performance between subjects in the experimental and control groups (two-tailed t-test; $p > 0.10$).

The lack of a difference between the two groups might be explained by a ceiling effect. A majority of the subjects performed perfectly on the post-test (63%), which indicates that there wasn't a sufficient range of difficulty in our game (**Figure 4**). Removing the data for subjects who received a perfect score revealed a non-significant advantage for the experimental group (two-tailed t-test, $p = 0.33$)(**Figure 5**). The number of subjects in the experimental ($n = 30$) and control ($n = 19$) groups may have been insufficient to assess the difference between groups.

DISCUSSION

Several experiments have demonstrated that the behavioral contingencies in classic game mechanics reinforce learning (e.g., feedback, monitoring of resources, and real-time scaling of difficulty to achieve flow). Nevertheless, game mechanics did not have an obvious improvement on making simple paired associations between brain anatomy and function in this game. Most likely, the lack of an effect could be attributed to the restricted range of difficulty our subjects were faced with. A wider range of topics and a discrete method for scaling difficulty would most likely expose any influence of game mechanics on learning. Removing subjects who performed at ceiling levels revealed a slight trend that favored the inclusion of game mechanics for learning. However, more data is required. Future studies have been planned to incorporate a broad range of difficulty that scales according to performance. It is predicted that the inclusion of a quantitative means of controlling flow will improve learning relative to conditions where no game mechanics are used.

REFERENCES

Pashler, H., Bain, P., Bottge, B., Graesser, A., Koedinger, K., McDaniel, M., and Metcalfe, J. (2007) *Organizing Instruction and Study to Improve Student Learning* (NCER 2007-2004). Washington, DC: National Center for Education Research, Institute of Education Sciences, U.S. Department of Education. Retrieved from http://ncer.ed.gov.

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