The difference of neural correlates of text comprehension between with and without picture: fMRI study

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Introduction

In recent decades, several behavioral research studies have demonstrated that use of text-congruous illustrations help to reading comprehension, whereas use of text-incongruous illustrations leads to unfavorable outcomes.[1,2] However, the neural underpinning of such text-illustration effects is still poorly understood. In addition, it is still unknown whether there is a difference in neural processing of text comprehension when readers read text with congruous or incongruous illustrations.

Therefore, the aim of this study was to know the differences in neural correlates of text comprehension with and without illustrations using fMRI and to investigate possible differential neural processing of text comprehension with text-congruous and text-incongruous illustrations.

Material and Methods

Thirty native speakers of Korean who have learned English as a foreign language were recruited for this study. All subjects were female, right-handed, and university students (20.16 ± 1.70 years). They were healthy individuals with no psychiatric or neurological profiles. All subjects signed an informed consent and agreed to participate in the fMRI study. The study protocol was approved by the Institutional Review Board. The stimuli consisted of 45 short written passages (all in English), 15 passages for each of the three conditions: (a) passages with text-congruous illustrations, (b) passages with text-incongruous illustrations, and (c) passages without illustrations (Fig1). In this study, 'illustrations' are defined as color photographs that are representational in nature. A block design was used for presentation of stimuli. There were 15 blocks for each condition (text-congruous, text-incongruous, and text-only). The three conditions were randomly distributed. Each passage was presented for 10 seconds, and then immediately followed a question about passage during for 4 seconds.

BOLD functional images were acquired using a 3.0T GE HD scanner (EPI, TR=2000ms, TE =30ms, flip angle =90 , matrix=64x64, FOV=220mm, slice thickness = 4 mm, no gap). A 3-D T1-weighted scan was obtained for structural reference. Image processing and statistical analyses for fMRI data were performed using the SPM8 on MATLAB. The pre-processed fMRI data were entered into first-level individual analysis in order to obtain parameter images for the contrasts of each condition. Second-level group analysis with one-way ANOVA (within subject) was then used to find the main effect of between contrast differences. The SPM{F}s were thresholded at P<0.01, false discovery rate (FDR)-corrected for multiple comparisons across the whole brain. In addition, post-hoc two sample t-test was performed for determination of difference between two conditions. The SPM{t}s were thresholded at P<0.01, using a Bonferroni adjusted alpha level of 0.0033, FDR-corrected for multiple comparisons across the whole brain. The result of the activation map was displayed by projection of an anatomically standardized mean T1 template. All statistical analyses of the behavioral data were performed using SPSS software.

Results and Discussion

The result of one-way ANOVA analysis for three conditions showed neural activation in the occipital lobe, dorsolateral prefrontal cortex, posterior parietal cortex, striatum, hippocampus, temporal gyrus, amygdala, calcarine, cuneus, precuneus, and cerebellum (Fig 2). Post-hoc two sample t-test was performed for further comparison between conditions. The comparison of text-congruous illustration > text-incongruous illustration showed activation in the dorsolateral prefrontal, posterior parietal cortices, striatum, and hippocampus in both hemispheres (Fig 3a), but there is no significant different in opposition. Comparison of text-congruous illustration > without illustration showed activation in the occipital lobe, dorsolateral prefrontal cortex, posterior parietal cortex, striatum, right hippocampus, right temporal gyrus, amygdala, calcarine, right cuneus, precuneus, and cerebellum (Fig 3b). In particular, most areas of the brain showed right dominant activation. In comparison of text-congruous illustration < without illustration, no significant activation was observed. Comparison of text-incongruous illustration > without illustration showed activation in the right occipital lobe, right calcarine, and right cerebellum (Fig 4a). Comparison of text-incongruous illustration < without illustration showed activation in the left occipital lobe, left calcarine, left cuneus, and left cerebellum (Fig 4b).

The activation of dorsolateral prefrontal and posterior parietal cortices seems to suggest that text-congruous illustrations tend to enhance the level of attention during text reading.[3] The activation of both dorsal and ventral areas in striatum showed that text-congruous illustrations may function as a cue predicting reward before reading text and may encourage enhancement of goal-directed reading by participants.[4] The activation in the hippocampus may motivate memorization and exploration of the text by participants.[5] Therefore, this study demonstrates that compared to text without illustrations, text-congruous illustrations induced stronger activation in the important brain areas in attention, motivation, and reward. However, text-incongruous illustrations hindered the neural processing of text and negatively affected reading comprehension. Finally, this result clearly show that textbooks should be included text-congruous illustrations to help reading comprehension, but text-incongruous illustrations may not help.

Reference

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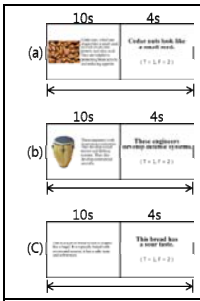

Figure 1. Passage examples, (a) text-congruous, (b) text-incongruous and (c) text only conditions.

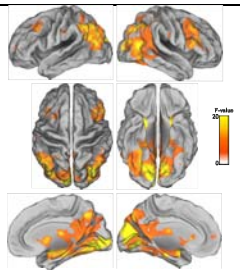

Figure 2. Significant brain activation differences on the whole-brain level revealed by the one-way within subject ANOVA with the condition. The SPM{F}s were thresholded at P<0.01, false discovery rate (FDR)-corrected for multiple comparisons across the whole brain for activation.

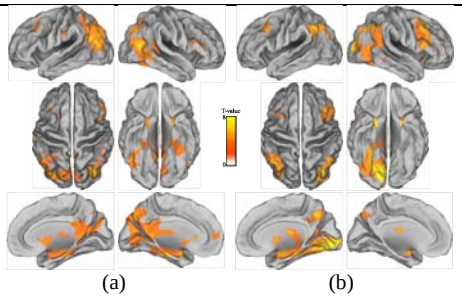

Figure 3. the whole-brain level revealed by the Post-hoc two sample t-test. The SPM{t}s were thresholded at P<0.01, FDR-corrected for multiple comparisons. (a) text-congruous illustration > text-incongruous illustration, (b) text-congruous illustration > without illustration.

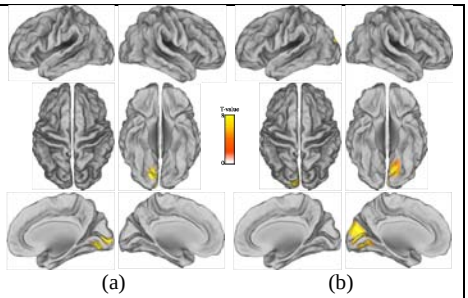

Figure 4. the whole-brain level revealed by the Post-hoc two sample t-test. The SPM{t}s were thresholded at P<0.01, FDR-corrected for multiple comparisons. (a) text-incongruous illustration > without illustration, (b) text-incongruous illustration < without illustration.