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The brain mechanism that reduces the vividness of negative imagery

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ABSTRACT

The present study attempts to locate brain regions that are related to vividness control, a hypothesized mechanism that reduces the vividness of negative imagery by controlling memory retrieval and emotion processing. The results showed that BOLD response in the left posterior cingulate gyrus in the negative imagery condition, in which activation of vividness control mechanisms was considered to be strong, was greater than that in the positive imagery condition, in which the activation of control mechanisms was considered to be weak. Moreover, the activation of this region negatively correlated with the subjective vividness of negative imagery. These results support the idea that the posterior cingulate gyrus may be involved in the suppression of imagery generation. Several previous studies have suggested that the posterior cingulate cortex is involved in both memory and emotion processing. Therefore, the current results indicate that the posterior cingulate gyrus may function as the vividness control mechanism.

1. Introduction

It is well known that mental imagery vividness varies depending on individual difference in imagery ability and on length of imagery generation time (Campos, Pérez-Fabello, & Gómez-Juncal, 2006; D'Angiulli & Reeves, 2002; Marks, 1973; Paivio, 1968). Furthermore, vividness varies according to what is to be imagined. For example, previous studies have indicated that vivid mental imagery of concrete things is easily formed (Benjafield & Muckenheim, 1989; Paivio, Yuille, & Madigan, 1968) and that the vividness is high for imagery of an object that is frequently used and/or encountered in daily life (Benjafield & Muckenheim, 1989; Desrochers & Thompson, 2009). Recently, it has been shown that mental imagery vividness varies according to emotional value even when there is no difference in the concreteness or in the frequency of experiencing the imagined objects. For example, Bywaters, Andrade, and Turpin (2004) showed that pleasant imagery was more vivid than unpleasant imagery. In their study, positive and negative imageries were selected from *specific events that the participants had experienced*. Therefore, there was no difference in the concreteness or experienced frequency of these events. In addition, Hertel and Parks (2002) showed that the imagery of negative words produced lower ratings of vividness than did positive and neutral words and that the vividness of the positive and the neutral imageries did not differ. In their experiment, noun phrases that had positive, neutral, and negative valences were produced by pairing a noun with an adjective and the participants were asked to generate the imagery. To prepare materials, all of which had similar concreteness and frequency of occurrence, the researchers produced noun phrases with the same noun but different adjectives to adjust the emotional

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values (e.g., cruise ship, cargo ship, sinking ship). The result of this experiment showed that the mental imagery vividness varied according to emotional value despite adjustment for the concreteness and frequency of occurrence of the imagery objects. These studies suggest that mental imagery vividness varies systematically within a person according to the emotional value of the imagery. Consequently, intra-individual variability in vividness is not produced randomly. Rather, it is likely caused by a mechanism that controls mental imagery vividness. The present study was conducted to uncover the neural correlates of this mechanism.

As mentioned above, some studies have suggested that the vividness of a mental image depends on its emotional value. How the emotional value of imagery is related to imagery vividness is one of the fundamental questions in imagery research that aims to understand what determines the vividness of mental imagery. Previous studies have suggested that vividness is determined by the amount of visual information that is included in an image (Cornoldi et al., 1991; Hishitani, Miyazaki, & Motoyama, 2011; Hishitani & Murakami, 1992). For example, Hishitani and Murakami (1992) showed that the mental images of vivid imagers contained many colors compared with those of non-vivid imagers. This evidence suggests that negative imagery contains less information than both neutral and positive imagery and that the former is vaguer than the latter.

It is unknown why more visual information is contained in positive images than in negative images. There are two possible explanations for this question. One explanation is that more information is stored in long term memory (LTM) for positive images than for negative images. An additional explanation is that the mechanisms that control the amount of information that is included in mental imagery recruit more information to generate positive imagery than negative imagery, creating a difference in vividness.

Previous studies have not directly examined these hypotheses. However, certain evidence indicates that the first explanation might be inadequate. For example, Clark and Paivio (2004) reported that the noun frequency index that is assumed to show the frequency of observing a particular word in daily life, which is objectively estimated by summing the occurrences of each particular word token in large sets of written text (Desrochers & Thompson, 2009) was not related to emotional value. Furthermore, other studies (Benjafield & Muckenheim, 1989; Desrochers & Thompson, 2009; Gernsbacher, 1984) have demonstrated strong positive correlations between the noun frequency index and subjective word frequency, assessed by human judges by rating a large set of words on a 7-point Likert-like scale ranging between 1 (perceived rare words) and 7 (perceived common words). These findings suggest that the probability of contact with objectively estimated high frequency words is high, and that we encounter such words more frequently. Therefore, the noun frequency is an appropriate index for evaluating the frequency with which a particular noun is encountered, and therefore, an approximate index for evaluating the amount of information associated with a particular noun that is stored in LTM. Since, this index is not related to the emotional value of a noun, Clark and Paivio's finding implies that people do not necessarily store more information regarding positive, compared to negative events in LTM.

Additional research has suggested that more information may be stored for negative events than positive events. Öhman, Flykt, and Esteves (2001) found that negative events had a greater tendency to capture attention than other types of emotional events. They showed that their participants found fear-relevant pictures more quickly than fear-irrelevant pictures. They interpreted their result to mean that threatening stimuli, which are evolutionarily relevant, are effective in capturing attention. The act of quickly acquiring a large amount of information about negative events and storing it in LTM is an important survival strategy. Therefore, LTM may store more information about negative events than about other emotional events. Furthermore, Kensinger and Schacter (2006) showed that a negative event could be recalled marginally better than a positive event. However, the imagery of the negative and positive events were equally vivid. Their these findings suggest that although more information was retained about a negative event than a positive event in LTM, the negative imagery was comparably vivid to the positive event. Additionally, many previous studies have reported that recall or recognition tests for negative matters are better than those for neutral matters (Hamann, 2001; Hertel & Parks, 2002; Kensinger & Corkin, 2003; Kensinger, Groff-Eaton, & Schacter, 2006; Ochsner, 2000; Sommer, Gläscher, Moritz, & Büchel, 2008). Therefore, it seems unlikely that less information is stored in LTM about a negative matter than a neutral or positive matter. Nevertheless, negative imagery is vaguer than positive imagery (Bywaters et al., 2004; Hertel & Parks, 2002). It is conceivable that vividness is not necessarily influenced by the amount of information in LTM but must be controlled by a mechanism to adjust the amount of information that is included in mental imagery based on its emotional value.

One of the two hypothetical mechanisms that account for the relationship between emotional value and vividness of mental imagery has been rejected. The remaining hypothesis states that a mechanism controls the amount of retrieved information from LTM depending on emotional value. The mechanism was theoretically predicted by one of the present authors (Hishitani, 1993). However, it has not yet been examined experimentally. Therefore, the current study explores the neural bases that directly support the existence of the mechanism.

As stated above (Bywaters et al., 2004; Hertel & Parks, 2002), negative imagery is vaguer than positive and neutral imagery, and there is no difference in the vividness of positive and neutral imageries. These results show that the vividness control mechanism suppresses negative imagery. Therefore, this mechanism should function more actively in the generation of negative imagery than positive imagery. Thus, the current study focuses on areas in which a stronger blood oxygenation level dependent (BOLD) signal has been observed for negative imagery than for positive imagery. Furthermore, the mechanism is thought to decrease the amount of visual information that is included in mental imagery. If the amount of information decreases, mental imagery vividness is reduced (Cornoldi et al., 1991; Hishitani & Murakami, 1992; Hishitani et al., 2011). Therefore, activation of the mechanism should negatively correlate with mental imagery vividness. In other words, as the area becomes more active, the imagery should become less vivid. In the current study, we searched for the brain