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Extraversion and Recognition for Emotional Words: Effects of Valence, Frequency, and Task-difficulty

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In this study, memory for emotional words was compared between extraverts and introverts, employing signal detection analysis to distinguish differences in discriminative memory and response bias. Subjects were presented with a study list of emotional words in an encoding session, followed by a recognition session. Effects of task difficulty were examined by varying the nature of the encoding task and the intervals between study and test. For an easy task, with a retention interval of 5 minutes (Study I), introverts exhibited better memory (i.e., higher d') than extraverts, particularly for low-frequency words, and response biases did not differ between these two groups. For a difficult task, with a one-month retention period (Study II), performance was poor overall, and only high-frequency words were remembered; also extraverts adopted a more liberal criterion for 'old' responses (i.e., more hits and more false alarms) for positive emotional-valence words. These results suggest that as task difficulty drives down performance, effects of internal control processes become more apparent, revealing differences in response biases for positive words between extraverts and introverts. These results show that extraversion can distort memory performance for words, depending on their emotional valence.

Key words : extraversion, recognition, emotion, word, response bias

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Introduction

The subject of this report is the effect of individual differences in extraversion on recognition memory for words, and, in particular, how these interact with the emotional valence of the stimuli, task difficulty (e.g., retention interval), and response biases.

Memory of events is improved when the emotional valence of the event is consistent with mood, an effect called 'mood-congruency' in memory network theory (Bower, 1981). According to the 'trait-congruency' hypothesis (B. P. Bradley & Mogg, 1994; Cantor & Mischel, 1977; Gomez, Gomez, & Cooper, 2002; Rusting, 1998), personality traits associated with positive or negative moods and affect promote selective processing of positive or negative emotional stimuli, respectively. Extraversion, the subject of this study, is a personality trait that is well known for positive affect (Costa & McCrae, 1980; Larsen & Ketelaar, 1989). Two different conceptual frameworks have been developed for understanding the interaction between extraversion and recognition memory. Gray (1970) proposed that extraversion is associated with sensitivity to positive reinforcement, and predicted that extraverts would have greater sensitivity to emotionally positive stimuli, an idea that has been expanded into the trait-congruency hypothesis (hereafter referred to as the 'reinforcement-sensitivity/trait-contingency hypothesis'). An alternative to these emotion-based explanations is Eysenck's general arousal hypothesis (Eysenck, 1967; Eysenck & Eysenck, 1967), in which extraversion is associated with a chronically low baseline arousal level, leading to the prediction that introverts should outperform extraverts on 'low stimulation' (i.e., relatively simple) tasks, where arousal level is optimal for them, whereas extraverts should outperform for 'high stimulation' (i.e., relatively difficult) tasks, where the arousal level of introverts may be higher than optimal. Of these two different approaches to understanding the effects of extraversion on learning, Eysenck's arousal hypothesis and the reinforcement-sensitivity/trait-congruent hypothesis, the latter has drawn more interest in recent years, because the former does not consider the emotional valence of the stimuli, whereas the latter's prediction that extraverts are especially sensitive to emotional valence or motivation has been supported by investigations of free-recall (Gomez et al., 2002; Rusting, 1999; Rusting & Larsen, 1998) and priming tasks (Robinson, Moeller, & Ode, 2010). Gillespie and Eysenck (1980). However, these studies of emotional valence did not address recognition memory, which is the focus of the present study.

Another issue is the nature of particular sensitivities of extraverts or introverts to emotional events, in particular, whether such sensitivities are related to memory capacity or response biases. Gillespie and Eysenck (1980) provided a precedent for identifying response biases with signal detection analysis when they reported that for an immediate recognition task utilizing digits, extraverts and introverts had equivalently sensitive memory, and that performance differences resulted from the introverts using more stringent response criteria. Although Gillespie and Eysenck did not examine emotional stimuli, subsequent studies have suggested an important role of response biases for these as well. Extraverts appear to experience positive events more strongly than introverts (Canli et al., 2001), but their tendency to recall positive life events more frequently than negative events has been argued to result from a bias in 'reporting', rather than better memory for positive events per se (Barrett, 1997). Consistent with this argument, the apparently better memory for emotional words relative to neutral words (Kensinger & Corkin, 2003) has been shown to reflect response biases, rather than differences in memory per se (Dougal & Rotello, 2007). This suggests that the high recall rate of positive words by extraverts observed by Rusting and Larsen (1998) may be associated with stronger reporting biases for positive events in free-recall tests. Such bias can be more easily quantitatively examined in recognition tests, such as those of the present study, because the bipartite recognition judgment ('old' or 'new') allows signal detection methods to be employed. In the current study, signal detection theory was utilized to distinguish response sensitivities related to memory capacity from those reflecting response biases.

When evaluating learning and memory in relationship to the hypotheses outlined above, it is important to consider various task factors that may impact performance (Corr, Pickering, & Gray, 1995; Hooker, Verosky, Miyakawa, Knight, & D'Esposito, 2008; Matthews & Gilliland, 1999; Zinbarg & Revelle, 1989). Task difficulty is obviously an important variable in memory studies, and one way of manipulating task difficulty is to vary the retention interval between study and test phases. Of the two independent processes, recollection and familiarity, on which recognition judgment is based (Tulving, 1985), longer retention intervals result in a larger contribution of the familiarity-based process than does the recollection-based process (Gardiner & Java, 1991). As outlined previously, task difficulty plays directly into the predictions of Eysenck's general arousal hypothesis (Eysenck, 1967; Eysenck & Eysenck, 1967) for non-emotional stimuli. In the present study, the inclusion of positive and negative valence stimuli was intended to evaluate these predictions for emotional stimuli, and also to examine their effects with respect to the reinforcement-sensitivity/trait-congruency hypothesis. A longer retention interval should make the recognition task more challenging and difficult, resulting in poor memory performance, as indicated by a greater false alarm rate or 'know' response rate (Yonelinas, 2002). In the present report, task difficulty was manipulated by using two retention intervals (several minutes for Study I versus one month for Study II), and by the presence (Study I) or absence (Study II) of study-test congruence.

Another factor that may affect recognition memory is word frequency. Low-frequency words are better recognized than high-frequency words, whereas high-frequency words are better recalled than low-frequency words (Gorman, 1961; MacLeod & Kampe, 1996). The superiority of low-frequency words in recognition has been shown to be associated with the recollection process, because low-frequency words have higher discriminability than high-frequency words (Guttentag & Carroll, 1997). The high-frequency word superiority usually observed in free recall has been attributed to the benefit that familiarity confers on reconstruction processing. (Glanzer & Bowles, 1976; Kinoshita, 1955). Emotional words of both high and low frequency, were included in the present study in order to evaluate the relative contributions of recollection- and familiarity-based processes to recognition.

Finally, confidence judgments were obtained following recognition judgments, because overconfidence has been shown to characterize extraversion (Kim & Sohn, 2006; Schaefer, Williams, Goodie, & Campbell, 2004). This provided an opportunity to determine if the overconfidence of extraversion would be reflected in error monitoring or response biases, and if it would interact with task difficulty.

Study I

In Study I the influence of extraversion on memory was evaluated via a recognition test with a short retention period and a retrieval phase whose context was identical to that of the encoding phase. For this easy recognition task, different patterns of results are predicted by the two major views of extraversion.

The original account of extraversion, which is based on arousal level (Eysenck, 1967), holds that low extraversion/high introversion is associated with high baseline arousal, and predicts that this condition is optimal for tasks with easy or moderate level difficulty. This prediction is based on the well-known inverted-U relationship between arousal level and task performance - i.e., performance is poor for very low or very high arousal levels, and is optimal at an intermediate level (Yerkes & Dodson, 1908). Consistent with this view, for relatively simple conditions introverts show greater accuracy in fear conditioning and more stringent response biases in recognition than extraverts (Gillespie & Eysenck, 1980; Hooker et al., 2008; Matthews & Gilliland, 1999). In contrast, the reinforcement-sensitivity/trait-congruency hypothesis, for which extraverts are viewed to be more sensitive to positive emotional stimuli (Gray, 1970; Rusting, 1998), better memory for positive words is predicted to be associated with extraversion, regardless of task difficulty. Thus for Study I, the arousal hypothesis predicts better memory performance (high memory accuracy and/or stringent response bias) for individuals low in extraversion, whereas the reinforcement-sensitivity/trait-congruent hypothesis predicts better memory performance for these individual only for positive-valence words.

In addition, it was expected that accuracy of recognition would be high (regardless of degree of extraversion), not only because the retention interval was short, but also because deep encoding was encouraged with an emotional-valence categorization task. For this easy recognition test, it was anticipated that low-frequency words would be better recognized than high-frequency words because of their greater discriminability (Glanzer & Bowles, 1976; Kinoshita, 1955), reflecting the contribution of the recollection process for recognition judgments when the memory trace is strong (Glanzer & Adams, 1985; Glanzer & Bowles, 1976; Guttentag & Carroll, 1997).

Methods

Participants and personality inventory

Forty-three university students (12 male, 31 female; mean age 20.23, range = 18~29), who were all Korean native speakers, volunteered in return for course credit. All gave informed consent before the study and were debriefed afterwards. The research was performed in accordance with the Declaration of Helsinki.

Extraversion scores were obtained for a Korean translation of the NEO-Personality Inventory-R (Costa & McCrae, 1992) administered after the session.

The median E-score across all participants was 146 (mean = 151.3). The median-split of E-scores defined high-extraversion (E+; n = 21, mean = 168.6, range = 150~193) and low-extraversion (E-; n = 22, mean = 134.5, range = 113~146) groups. Mean E-scores of E+ and E- groups were significantly different ($p < .0001$).

Word lists

One hundred sixty emotional two-syllable Korean abstract nouns were selected from the Korean word-frequency database based on 5,500,000 words (Kang & Kim, 2004), categorized for emotional valence independently by three raters, and randomly divided into two 80-word lists. Word frequencies were obtained from the database, with low-frequency words having a frequency less than 290, and high-frequency words having a frequency greater than 310 and less than 3600. Each word list had equal proportions of four word categories: negative high-frequency (NH), negative low-frequency (NL), positive high-frequency (PH), and positive low-frequency (PL). Each category consisted of equal numbers of old words (targets) and new words (lures), and the new and old words were counterbalanced across participations. The average word-frequency for the negative words was 605.9 (range = 4~3397), and that for the positive words was 677.0 (range = 1~3589). One of the word lists used is presented in the Appendix as an example.

Encoding and recognition tasks

E-prime (E-studio, Version 2.0, Psychological Software Tools, Inc., Pittsburgh, PA) was used to present stimuli and collect data. Participants were informed that a recognition test would follow the study phase. During encoding, a set of 80 words (20 for each word type) was used as a study list. Each word was displayed in white font (Batang 50 point: 1000-ms ITI) on computer screen for 2000 ms, during which time participants made a categorical judgment (positive or negative) of its semantic valence with a key press. The inter-trial interval (ITI) was 100 msec, during which a crosshair was presented on the center of display. Immediately after the encoding phase, a series of two-digit computations (50 addition problems) was given as an interference task (duration of problem display = 4000 ms, duration of answer display = 1500 ms, ITI = 500 ms, total length of task = 5 min).

The self-paced recognition test, which was administered approximately 5 minutes after the study phase, was composed of two 80-word blocks (40 old and 40 new words). A test word was displayed (maximum = 4000 ms), and participants made an old/new decision. After the recognition response (500-ms ISI) the words 'Confident' and 'Not Confident', were shown on either side of the display, and a confidence judgment was made by choosing one of these.

Data analysis

Hit, Correct Rejection (CR), Miss, and False Alarm (FA) rates were analyzed across word lists, as was *accuracy* (Hit - FA). The *confidence rate* is the fraction of trials given a 'confident' judgment for each type of response (e.g., *sure-Hit* and *sure-CR, sure-Miss* and *sure-FA*).

The d' and C statistics of signal detection theory were estimated following Stanislaw and Todorov (1999). The d' statistic is a measure of sensitivity, the ability to discriminate old words from new. *C* is a measure of bias toward reporting or denying the presence of a target; negative values indicate bias toward 'old' responses, and positive toward 'new' responses.

A two-way ANOVA (valence and frequency) was performed to reveal the effects of valence and word-frequency for all participants. Then, the extraversion effect was investigated by performing a correlation analysis (Pearson's *r*) with extraversion score (E-score) for each word type and the overall average for all word types. Lastly, a three-way ANOVA (valence, frequency, and group) was employed as a complementary method to reveal interactions between extraversion and word types, where the effect of extraversion on other factors was tested with median-split groups (version 18, SPSS, 2009).

Results

Encoding

Judgments of valence were in good agreement with nominal valences of target words: the fraction of judgments congruent with the list valence was .95 overall (for individual lists, NH = .91, NL = .95, PH = .98, PL = .98); there was no extraversion effect on valence judgments. There was no significant correlation between E-score and the mean RT of each word type or the overall RT across the four words types. However, a significant two-way interaction of group and frequency ($p < .05$) revealed that the E+ group was faster in making categorical judgments for high-frequency (810 ms) than for low-frequency words (855 ms), whereas the categorization speed of the E- group was unaffected by the word-frequency (high = 837 ms, low = 830 ms).

Recognition

Discriminative memory and response bias. For all participants, accuracy was better for low-frequency words (high = .58, low = .69, $p < .0001$) but there was no difference between positive and negative words, confirming the expected superiority low-frequency effect. Signal detection analysis confirmed that, overall, discrimination was better for low-frequency than high-frequency words ($d' = 2.24$ for low; 1.85 for high, $p < .0001$). The response bias was liberal for high-frequency relative to low-frequency words ($C = -.25$ for high, .08 for low, $p < .0001$) and liberal for positive relative to negative words ($C = -.20$ for positive, .03 for negative, $p < .001$).

E-score were negatively correlated with accuracy for PL words ($r = -.32$, $p < .05$).

There was a trend of negative correlation between E-score and overall accuracy (r = -.29, $p < .10$). An ANOVA yielded a significant group effect: The E+ group performed less accurately than the E- group (.59 for E+, .68 for E-, $p < .05$). Low extraversion was associated with high memory discriminability: The extraversion (E-score) was inversely correlated with the grand average d' (r = -.36, $p < .05$). Among individual word types, a negative correlation was found for positive low-frequency words (for PL, r = -.37, $p < .05$; for NL, r = -29, $p < .10$). As shown by Fig. 1a, the E+ group showed poorer discrimination between targets and foils (for average across word lists, d' = 1.86 for E+; 2.23 for E-, $p < .01$). There was no significant E-score correlation or group difference in the measure of response bias, C (Fig. 1b).

Response type. There was a trend for a group difference in FA response rate (E+ = .23, E- = .18, $p < .10$), even though there was no group difference for Hit rate (E+ = .83, E- = .86, *ns*). No group difference or extraversion-associated correlation was found for recognition RT.

Confidence ratings. Overall, the sure-Hit rate (grand average = .75) was greater for positive words (positive = .77, negative = .72, $p < .005$), and the unsure-Hit rate (grand average = .10) was greater for high-frequency words (high = .12, low = .08, $p < .001$).

Extraversion was associated with a greater rate of 'confident' judgments only after the recognition-error responses (i.e., FA and Miss). For example, there was a positive correlation between E-score and the overall average sure-FA rate (r = +.35, $p < .05$). The average sure-FA rate was higher for the E+ than E- group (.12 vs. .08, $p < .05$). For individual lists, there were positive correlations between E-score and overall sure-Miss rate (r = +.40, $p < .01$), and between E-score and sure-Miss rate for NH words (r = +.32, $p < .05$). The overall average of sure-Miss rate was greater for the

E+ than E- group (.09 vs. .05; $p < .005$). There were no extraversion effects for sure-Hit rates or sure-CR rates. There was no extraversion-associated difference in confidence RT.

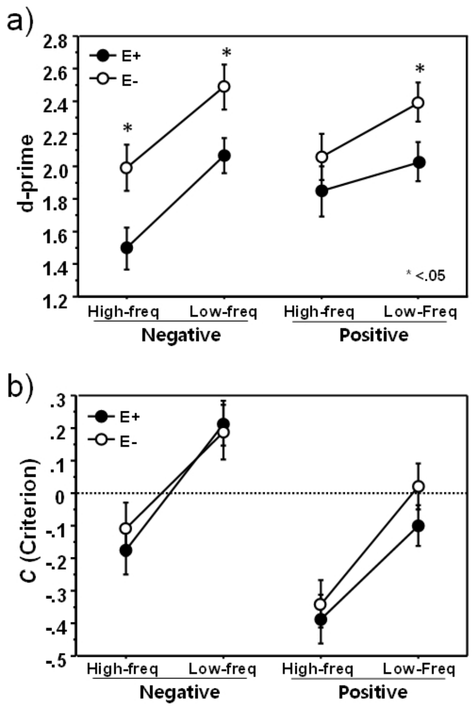

Figure 1. Results of signal detection analysis for Study I. (a) Interactions of *d'* with word frequency for negative- and positive-valence words, plotted separately for E+ and E- groups. Higher values of *d'* indicate better recognition memory. (b) Interactions of *C* with word frequency for negative- and positive-valence words, plotted separately for E+ and E- groups. More negative values of *C* indicate a bias toward responding 'old', whereas more positive values indicate a bias toward responding 'new'.

Discussion

Both accuracy and memory discrimination index d' indicate that extraverts' recognition memory was poorer than introverts'. There was no evidence that extraverts had better memory for positive-valence words than introverts; there was even a significant negative correlation between E-score and memory discrimination d' for positive low-frequency words (PL). These results are inconsistent with expectations from the reinforcement-sensitivity/trait-congruency hypothesis, which predicts that extraverts should have better memory for positive-valence events. The arousal-based hypothesis (Gillespie & Eysenck, 1980; Hooker et al., 2008; Matthews & Gilliland, 1999) was partially supported in that introverts outperformed extraverts in this easy recognition task. However, the introverts showed greater d', not *C*, relative to the extraverts, which is inconsistent with Gillespie & Eysenck's (1980) report that introverts show a more stringent response criteria than extraverts. In contrast to the overall better memory accuracy of introverts, differences in degree of extraversion did not result in systematic differences in response bias or memory accuracy for positive words in this relatively easy recognition test.

Although group analyses did not result in significant difference in discrimination specific to valence, the correlation analysis revealed that extraverts were at a considerable disadvantage for positive low-frequency (PL) words, probably due to difficulty in discriminating PL targets from PL foils. The extraverts' higher sure-Miss rates for NH words suggests poor encoding of negative-valence words, consistent with reports that extraverts avoid paying attention to emotionally negative events (Amin, Constable, & Canli, 2004; Derryberry & Reed, 1994).

The overconfidence of extraverts was apparent in their higher 'confident' response rates following error recognition (FA and Miss), suggesting that error-associated metacognition processing (Nelson & Narens, 1990) may be especially compromised by overconfidence in extraverts.

Study Ⅱ

The purpose of this study was to evaluate the influence of extraversion on a difficult recognition task that was expected to result in poorer memory than Study I. Three variations in experimental procedures that differed from Study I were introduced. First, participants examined the lists in the process of completing an emotional rating of the words, but were not told of a subsequent recognition test. This had a dual purpose: promoting deep encoding by requiring semantic level processing, and providing finer measures (on one-to-five scales) of subjective valence and arousal. Second, the contexts of encoding and recognition phases were not matched: The study task was given in a paper-and-pencil group session, whereas the recognition test was administered via an individual computer session as in Study I. Finally, and perhaps most importantly, a much longer delay between study and test phases was introduced, with participants re-recruited for the unforeseen recognition test approximately one month after encoding.

Methods

Participants and personality inventory

The Self-Assessment Manikin (SAM) task (M. M. Bradley & Lang, 1994) was administered to 36 individuals recruited from the campus community with monetary incentives. One month later, 32 participants (4 male, 28 female; mean age 22.3, range = 20~35) from the original cohort were re-recruited for a memory study with monetary incentives, without being informed of its relationship to the previous SAM session. All were Korean native speakers, and all gave informed consent for the SAM session and again for the recognition session. Upon completion of the second study, participants were debriefed on the purpose of the investigation. The research was performed in accordance with the Declaration of Helsinki.

The NEO-PI-R inventory was administered after completion of the SAM session. The median E-score was 150 (mean = 152). Data from only those who participated in both the SAM session and the subsequent recognition test (N = 32) are included in this report. As in Study I, the E+ and E- groups were defined based on the median-split. The average E-score of the E+ group (n =16; mean = 171.3; range = 152~200) was greater ($p < .0001$) than that of the E- group (n=16; mean = 132.8; range = 109~148).

Encoding and recognition tasks

One of the 80-word lists from Study I was used for the SAM encoding session, and the other for distractors in the recognition session. During the SAM task, each word was rated on a five-point scale for valence (most positive = 1; most negative = 5) and arousal (highest = 1; least =5). The valence and arousal ratings obtained from the first 36 participants who participated the encoding phase of Study II, including those who didn't participate the final recognition test, are listed in the Appendix. The recognition test was administered individually using procedures identical to Study I.

Results

Encoding task

As expected, SAM valence ratings were in excellent agreement with assignment of words to the negative and positive lists (negative = 4.2, positive = 1.6, $p < .0001$). Negative words were given higher arousal rating than the positive words (negative = 2.2, positive = 2.8, $p < .0001$). High-frequency words were rated more positive in valence (high = 2.8, low = 3.1, $p < .0001$) and higher in arousal (high = 2.4, low = 2.6, $p < .0001$). Extraversion had no effect on valence ratings, but high extraversion was associated with greater arousal ratings only for the positive words (all positive words, $r = -.39$, $p < .05$; PH, $r = -.43$, $p < .05$; PL, $r = -.38$, $p < .05$; NH, $r = -.07$, NL, $r = -.12$). This was supported by a significant difference in the arousal rating between E+ group and E- group for the positive words only (PH, E+ = 2.4, E- = 2.7, $p < .05$; PL, E+ = 3.0, E- = 3.2, $p < .05$; NH, E+ = 2.2, E- = 2.3, $p > .30$; NL E+ = 2.1, E- = 2.3, $p > .10$).

Recognition test

Discriminative memory and response biases. Accuracy for recognition, which was unaffected by extraversion, was very low (.10), although accuracy for high-frequency words was significantly greater than low-frequency words (high = .20, low = .01, $p < .0001$; NH = .16, PH = .23; NL = -.02, PL = .03). The poor performance in Study II relative to Study I demonstrates that, as expected, the longer retention period and lack of situational congruence between encoding and testing phases in Study II resulted in a substantially more difficult task.

Overall, performance as shown by signal detection analysis was quite poor due to low recognition discrimination, and was subject to responses biases. Discrimination, as measured by d', was influenced by valence (positive = .45, negative = .24, $p < .05$), as well as frequency (high = .66, low = .03, $p < .0001$). However, extraversion did not affect discrimination (Fig. 2a).

The *C* statistic revealed a bias toward responding 'old' that was stronger for high-frequency words ($C = -.54$ for high, $C = -.29$ for low, $p < .0001$). There was no word-frequency difference in response bias in relationship with extraversion. However, there was an extraversion-associated difference in response bias between positive and negative words: Greater extraversion was associated with a higher response bias for the positive words only, as indicated by negative correlations between E-score and *C* for the positive words (PH, $r = -.45$, $p < .05$; PL, $r = -.43$, $p < .05$). Group comparison analysis with ANOVA resulted in a two-way interaction of group and valence ($p < .05$): The response bias was greater for positive than negative words in E+ group, whereas it was greater for negative than positive words in the E- group (See Fig. 2b; for E+, $C = -.60$ for positive, $C = -.46$ for negative; for E-, $C = -.23$ for positive, $C = -.36$ for negative).

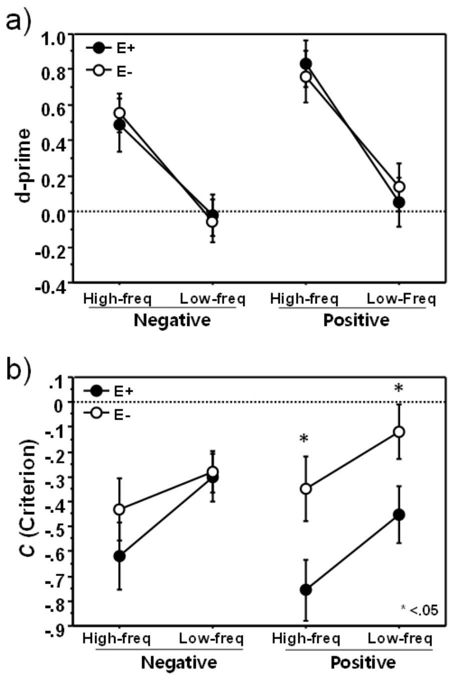

Figure 2. Results of signal detection analyses for Study II: (a) *d´* statistic; (b) *C* statistic. All conventions are identical to those of Fig. 1.

Response Type. There was a positive correlation with E-score for positive words, both in Hit rate (PH: $r = +.46$, $p < .01$; PL: $r = +.36$, $p < .05$) and FA rate (for PH, $r = +.39$, $p < .05$; for PL, $r = +.37$, $p < .05$). These correlations are supported by trends ($p < .10$) of two-way interactions between group and valence, both for Hit and FA rates.

Confidence Ratings. Overall, sure-Hit rate (grand average = .51) was influenced by word-frequency, with greater sure-Hit for high-frequency than low-frequency words (high = .59, low = .44, $p < .0001$). Unsure-Hit rate (grand average = .19) was affected both by valence and frequency, as indicated by a two-way interaction of valence and frequency (NH = .20, NL = .19, PH = .16, PL = .22, $p < .05$).

As the trait-congruent and reinforcement-sensitivity hypotheses predicted, the extraverts were more likely to be confident in 'old' recognition judgment for old positive words, that is, for Hit and FA (sure-Hit rate for PH, $r = +.35$, $p < .05$; sure-Hit for PL, $r = +.38$, $p < .05$; sure-FA rate for PH, $r = +.43$, $p < .05$; sure-FA for PL, $r = +.37$, $p < .05$). The sure-FA rate for positive-valence words was greater for the E+ group (.45) than the E- group (.37), while the sure-FA rates for negative-valence words did not differ between two groups (E+ =.45, E- = .43), as indicated by a two-way interaction between valence and group ($p < .05$). Extraverts were also less likely to be confident in their erroneous recognition judgments of 'new' for the old positive high-frequency words (sure-Miss rate for PH, $r = -.39$, $p < .05$). There was a statistical trend ($p < .10$) of two-way interaction of group and valence: The E+ group was more overconfident in their Miss responses (i.e., sure-Miss) for negative old words than positive old words, whereas the E- group did not show any difference between the two word types (for E+, positive =.10; negative = .16; for E-, positive = .13; negative = .14).

Reaction time. A negative correlation between E-score and RT was found for FA responses for PL words (r = -.47, $p < .01$), as well as for Hit responses for PH words (r = -.43, $p < .05$). No extraversion-associated RT difference was observed for 'confident' responses. For RT, a trend for a group difference was found. The RT difference in FA response was only indicated by a trend for a group difference (E+ = 1353 ms, E- = 1537 ms, $p < .10$).

Discussion

In Study II, relative to Study I, generally poor recognition memory and strong response biases were found, confirming initial expectations for the greater memory demand of this study. The difficulty in recognition memory for low-frequency words observed both in extraverts and introverts indicates that the recollection process associated with the low-frequency superiority in recognition deteriorated rapidly with retention delay (Yonelinas, 2002).

There was no indication of extraversion-associated differences in memory discriminability (measured by d') , and there was a greater response bias (measured by C) for positive words in individuals with higher extraversion. These results are partially consistent with the predictions of the arousal hypothesis. As in Gillespie and Eysenck's (1980) study using a recognition memory test of digits (i.e., an easy task), there was no group difference for memory accuracy, but introverts used a more stringent response criterion (i.e., less response bias). The current findings, however, are inconsistent with the arousal-based hypothesis of extraversion in the following sense: The greater response biases of extraverts, was specific to positive, but not negative words, and the introverts use of a more stringent criterion was observed in this relatively difficult recognition task, rather than the easier task in Study I, where the arousal level should have been more optimal for introverts. Instead, the response bias specific to positive words in extraverts is consistent with the view of extraversion as being sensitive to emotionally positive events (Gray, 1970; Rusting & Larsen, 1998). The extraverts' recognition bias toward emotionally positive words (i.e., reporting new positive words as old) suggests that all positive words, both old and new, evoked particularly strong familiarity in extraverts, resulting in their overconfidence in 'old' responses to all positive words (i.e., Hit and FA).

The extraverts' more liberal criterion for positive-valence, but not for negative-valence words, is contradictory to the view that individual differences in response bias for recognition are trait-like, persistent predispositions of the individual (Kantner & Lindsay, 2012). For example, there was no evidence of greater overconfidence in the recognition of extraverts for the low-frequency negative-valence words. One possible explanation for this result is that both high-frequency and positive-valence contributed to a sense of familiarity for the extraverts after the long retention delay, whereas only high-frequency contributed to familiarity for the introverts.

In general, high-arousal events are believed to lead to better memory due to increased attention during encoding (Dolcos, Iordan, & Dolcos, 2011; Easterbrook, 1959; Sharot & Phelps, 2004), but the results of Study II do not support this view. For example, negative words were rated as higher in arousal than positive words during encoding ($p < .0001$) in all participants, but the recognition for negative-valence words was low both in extraverts and introverts. Extraverts gave higher arousal ratings both for positive and negative words than introverts during encoding, but there was no difference between extraverts and introverts in memory discrimination (d') of either word type. The extraverts' higher arousal ratings for positive words, however, may explain their difficulty in discriminating old from new positive words, both of which could have evoked higher arousal during recognition.

General Discussion

The arousal hypothesis of extraversion, in which the key difference between extraverts and introverts is the baseline arousal level, predicts that introverts should be superior to extraverts in performance of easy tasks (Eysenck, 1967). This prediction was supported by Study I, where for a relatively easy task introverts' recognition performance was superior, with higher memory discrimination and better post-error monitoring, regardless of valence. These results do not conform to predictions based on the reinforcement-sensitivity/trait-congruency hypothesis of extraversion, in which extraverts are viewed as being sensitive to emotionally positive events (Gray, 1970; Rusting & Larsen, 1998), in that no advantage in memory discriminability for emotional positive words or differences in response bias were associated with extraversion. The reinforcement-sensitivity/trait-congruency hypothesis was partially supported by Study II, where extraversion was associated with greater sensitivity to emotionally positive words. However, this sensitivity was in the form of a greater response bias toward recognition of positive words, with the absence of higher memory accuracy. This result is entirely consistent with the conclusion that emotional words appear well-remembered relative to neutral words (Kensinger & Corkin, 2003) because of response biases, rather than because of differences in memory per se (Dougal & Rotello, 2007). Given that positive words were rated as more arousing by extraverts, it is likely that the bias-related interaction between extraversion and word valence of Study II occurred because positive/arousing words resulted in greater feelings of familiarity. This resulted in a recognition bias only when the task was relatively difficult, so that the recognition judgment was more likely to be based on familiarity, and thus was not observed in Study I, where recognition was more likely based on recollection.

Findings related to word frequency support the above conclusions. The greater contribution of familiarity-based relative to recollection-based processes has been associated with weaker memory, as opposed to the low-frequency word superiority effect being viewed as reflecting a greater contribution of recollection (Glanzer & Adams, 1985; Glanzer & Bowles, 1976; Guttentag & Carroll, 1997). Study I revealed a typical low-frequency word superiority effect, whereas in Study II, high-frequency words were better recognized in both high- and low-extraversion individuals, suggesting that recognition after the unusually long retention period was based on familiarity rather than recollection. Old low-frequency words (targets) were not differentiated from new low-frequency words (lures) when recognition judgments were made mainly with the familiarity-based process.

This investigation was not designed to resolve disputes over whether ‘Remember’ (i.e., sure-Hit) and ‘Know’ (i.e., unsure-Hit) responses depend on separate recollection and familiarity processes, respectively (Dewhurst, Holmes, Brandt, & Dean, 2006; Eldridge, Sarfatti, & Knowlton, 2002; Gardiner, 1988; Tulving, 1985). Extraversion did not substantially influence either sure-Hit or unsure-Hit rates. Nevertheless, other aspects of the results can be related to these issues. The greater rate of unsure-Hit responses for high-frequency relative to low-frequency words in Study I is consistent with Know responses being associated with familiarity-based recognition. However, the greater sure-Hit rate for high-frequency relative to low-frequency words in Study II suggests that familiarity-based recognition becomes the main strategy, even for Remember responses when the recollection process is virtually unavailable due to a long retention period. Thus, whether familiarity-based recognition is linked to Know or Remember responses appears to depend on the circumstances of the particular task, and in this case, probably on the decay of memory over a long delay period between encoding and recognition.

The purpose of this study was to understand a personality trait’s effect on memory in terms of individual differences in a normal, healthy population. Keeping this in mind, a couple of methodological issues deserve discussion. First, even though extraversion's effect on memory has often been examined through the induction of positive affect (Lucas & Baird, 2004), mood induction is not commonly used in investigations of recognition memory. Second, a medial-split group comparison was used in the current studies along with regression analysis, rather than comparing subgroups at the opposite ends of the extraversion-introversion scale (e.g., the upper and lower 30%). Such extremes of extraversion trait may be associated with various pathologies such as alcohol abuse (Anderson, Schweinsburg, Paulus, Brown, & Tapert, 2005), depression (Clark, Watson, & Mineka, 1994), cardiovascular reactivity (Jonassaint et al., 2009), or vulnerability to changes in attention or vigilance following sleep deprivation (Killgore, Richards, Killgore, Kamimori, & Balkin, 2007). Furthermore, such an analysis is impractical with the moderate sample sizes (n = 30∼ 40) of the present study, which would result in comparing groups of 10 or so individuals.

Summary and Conclusions

These results may have resolved a long-standing issue over the effects of extraversion on memory, giving partial support to both Gillespie and Eysenck (1980) conclusion that introverts utilize a more stringent recognition criteria, and the reinforcement-sensitivity/trait-congruency prediction that extraverts have better memory for positive events. It turns out that whether extraverts show a less stringent response criterion, or a response bias only specific to positive events, can be greatly influenced by the strength of memory trace at the time of retrieval. When the memory trace is strong and discriminative, as in the higher accuracy of low-frequency words in Study I, introverts have greater memory accuracy for materials of all types than extraverts, who, additionally, suffer from overconfidence. When the memory trace is weak and non-discriminative overall, familiar and positive events are recognized better by both introverts and extraverts, but the extraverts' were unable to differentiate targets from lures because their trait-consistent words (*i.e.,* positive words) seemed all too familiar.

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(요 약)

외향성과 정서단어의 재인 기억: 정서가, 빈도, 과제 난이도 효과

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본 연구는 외향성이라는 성격 특성에 따른 정서적 단어의 기억 수행의 차이를 연구하기 위해, 신호 탐지 분석법을 적용하여 기억 변별력과 재인 반응 편향을 분석하였다. 참여자들은 부호화 시에 제시되는 정서 단어에 대하여 정서 범주 판단과제를 수행하고, 이어서 재인 검사를 받았다. 또한 단어 재인에 미치는 과제의 난이도와 성격의 상호작용 조사하기 위해, 부호화와 인출 사이의 기간을 달리한 두 개의 실험이 수행되었다. 파지 지연기간이 짧은(5분) 저난이도 과제(Study I)에서는 특히 저빈도 단어에 대해, 외향성이 낮은 사람일수록 더 좋은 기억 수행(높은 d')을 보였으며, 재인 반응 편향에는 외향성에 따른 차이가 없었다. 특히, 외향성이 높을수록 오류 재인 후에 과신하는 경향이 높았다. 파지기간이 긴(한 달) 고난이도 과제(Study II)의 경우, 기억 수행은 외향성에 따른 차이가 없이 전반적으로 저조하였으나, 고빈도-긍정 단어에서만 외향성이 높은 개인일수록 훨씬 자유로운 반응 준거(높은 적중률과 높은 오경보율)를 적용하는 재인 수행의 특성을 보이는 것이 관찰되었으며, 이런 긍정 단어에 대한 자신의 재인에 과신하는 경향도 높았다. 본 결과는 기억 수행이 저조해질 때, 외향성이 높은 개인들이 내적 통제 과정에 더 취약해 지며, 이런 성격차이는 긍정단어의 기억의 재인 준거나 재인 반응에 대한 확신에 영향을 미칠 수 있음을 보인다. 즉 기억의 흔적이 약할 때, 외향성이 높은 개인들은 긍정적 정서가의 단어에 특정적으로 기억 보고와 확신 편향을 보일 수 있음을 시사한다.

주제어 : 외향성, 재인, 정서, 단어, 반응편향

Appendix

One of two word lists used in Study I and Study Ⅱ. Valence and arousal ratings were obtained from a different cohort of participants (N = 36).

A. Negative High-frequency Words

word	frequency	valence	(SD)	arousal	(SD)
반대	1402	3.78	(0.5921)	2.66	(0.8905)
범죄	853	4.62	(0.5097)	1.92	(1.0118)
부담	938	3.99	(0.7373)	2.29	(1.1179)
부정	466	4.20	(0.6881)	2.65	(1.1415)
부족	1038	4.05	(0.5221)	2.83	(1.0284)
부패	347	4.44	(0.6726)	2.34	(1.1643)
불만	492	4.38	(0.6688)	2.63	(1.0248)
불법	543	4.05	(0.6104)	2.67	(1.1159)
불안	902	4.34	(0.5639)	1.96	(0.7532)
비극	590	4.62	(0.5097)	2.18	(1.3264)
비리	422	4.44	(0.583)	2.40	(1.236)
비밀	685	3.15	(0.6543)	3.01	(1.1752)
비판	1564	3.83	(0.7795)	2.20	(0.7896)
욕망	545	3.05	(1.0235)	2.10	(0.9761)
우려	846	3.88	(0.7565)	2.70	(1.0178)
위기	732	4.26	(0.6136)	1.87	(0.9221)
위반	552	3.87	(0.5704)	2.44	(0.9165)
위험	947	4.37	(0.6803)	1.50	(0.866)
잘못	610	3.95	(0.65)	2.32	(0.9066)
충격	650	4.42	(0.6315)	1.60	(0.7435)

Average Frequency (756±SD 70.5)

Average Valence (4.08±SD 0.43) (Valence 1: positive/happy ~ 5: negative/unhappy)

Average Arousal (2.31±SD 0.41) (Arousal 1: high arousal ~ 5: low arousal

B. Negative Low-frequency Words

word	frequency	valence	(SD)	arousal	(SD)
무식	82	4.15	(0.6249)	2.59	(1.1231)
박해	42	4.22	(0.8143)	2.28	(1.194)
반역	29	4.02	(0.7327)	2.10	(1.0852)
변태	42	4.49	(0.7026)	2.11	(1.1539)
불륜	49	4.49	(0.647)	1.99	(1.1095)
불응	33	4.01	(0.6566)	2.89	(1.1097)
불효	21	4.38	(0.5218)	2.44	(1.2)
비련	4	4.32	(0.589)	2.78	(1.1014)
외설	25	4.07	(0.7871)	2.51	(1.1645)
우롱	28	4.42	(0.7898)	2.18	(0.8197)
윤락	29	4.07	(0.8983)	2.51	(1.1858)
잔혹	57	4.61	(0.5757)	1.65	(0.8533)
추태	32	4.45	(0.7229)	2.12	(0.9472)
탐닉	22	3.61	(0.9321)	2.37	(1.1237)
텃세	9	4.28	(0.5596)	2.48	(1.0365)
테러	115	4.70	(0.4593)	1.60	(1.062)
트집	43	4.15	(0.5728)	2.63	(1.0126)
파멸	84	4.74	(0.5259)	1.98	(1.3036)
파산	59	4.61	(0.5064)	2.04	(1.2569)
패배	283	4.45	(0.5788)	2.23	(1.1942)

Average Frequency (54±SD 13.4)

Average Valence (4.31±SD 0.28) (Valence 1: positive/happy ~ 5: negative/unhappy)

Average Arousal (2.77±SD 0.34) (Arousal 1: high arousal ~ 5: low arousal)

C. Positive High-frequency Words

word	frequency	valence	(SD)	arousal	(SD)
가족	1803	1.60	(0.6729)	3.07	(1.1432)
감동	518	1.54	(0.5171)	2.13	(0.9619)
감사	311	1.52	(0.622)	3.10	(0.9501)
건강	1166	1.85	(0.7685)	2.94	(1.1629)
관심	2314	1.77	(0.5926)	2.79	(1.0123)
기쁨	473	1.23	(0.4198)	2.23	(0.8595)
노력	1885	1.89	(0.7787)	2.55	(0.9138)
도움	946	1.98	(0.6016)	3.31	(0.8207)
발전	2660	1.66	(0.5296)	2.65	(0.9762)
사랑	3589	1.21	(0.4327)	2.28	(0.994)
용기	497	1.65	(0.7004)	2.12	(0.8275)
웃음	916	1.29	(0.474)	2.49	(1.1645)
자유	2598	1.55	(0.669)	2.34	(1.126)
지지	607	1.81	(0.6603)	2.81	(1.145)
창조	1269	1.81	(0.7148)	2.46	(1.0271)
최고	1141	1.20	(0.3853)	2.05	(1.005)
평화	1018	1.54	(0.6363)	3.39	(1.2526)
해방	1219	1.50	(0.559)	2.29	(1.2195)
행복	1005	1.18	(0.3833)	2.52	(1.1289)
희망	912	1.31	(0.4858)	2.83	(1.0223)

Average Frequency (1342 ±SD 194.7)

Average Valence (1.55±SD 0.25) (Valence 1: positive/happy ~ 5: negative/unhappy)

Average Arousal (2.62±SD 0.40) (Arousal 1: high arousal ~ 5: low arousal)

D. Positive Low-frequency Words

word	frequency	valence	(SD)	arousal	(SD)
경축	23	1.60	(0.6444)	2.74	(1.0555)
관대	2	1.95	(0.6305)	3.74	(0.8301)
권장	89	2.55	(0.5895)	3.51	(0.8022)
귀감	17	1.92	(0.6605)	3.09	(0.8434)
근면	60	1.88	(0.6203)	3.32	(0.9271)
능동	150	1.98	(0.7155)	2.71	(0.9012)
덕망	20	1.83	(0.598)	3.29	(0.873)
보은	20	2.02	(0.5118)	3.37	(0.7828)
열의	38	1.65	(0.6349)	2.12	(0.9272)
온정	18	1.73	(0.5373)	3.48	(1.0425)
우애	42	1.76	(0.5015)	3.00	(0.8139)
원만	1	1.93	(0.676)	3.63	(0.8443)
청결	40	1.90	(0.6821)	3.28	(0.9621)
충만	76	1.79	(0.5698)	3.13	(1.2043)
충실	232	1.81	(0.6213)	3.32	(0.8423)
친애	11	1.39	(0.5305)	3.39	(0.9521)
친화	24	1.66	(0.5055)	3.28	(0.9086)
쾌거	11	1.39	(0.5647)	2.05	(1.0356)
화목	45	1.44	(0.5499)	3.02	(1.0663)
환대	12	1.85	(0.5505)	2.92	(0.8359)

Average Frequency (47±SD 12.6)

Average Valence (1.80±SD 0.26) (Valence 1: positive/happy ~ 5: negative/unhappy)

Average Arousal (3.12±SD 0.44) (Arousal 1: high arousal ~ 5: low arousal)