Bulletin of Tokai Women's College, 15, 1995

Stimulus Valence and Mechanisms of Recognition Memory —An Analysis of Memory Performance and Eyeblink Activity—

Hideki Ohira

Abstract

The present research was conducted to examine the relative roles of recollection or intentional and controlled process and familiarity or automatic process in recognition memory of affectively positive and negative stimuli. Twenty subjects performed a memory task based on Jacoby's (1991) process dissociation procedure and their eyeblink activity was assessed as a secondary measure which should reflect inner cognitive processes. Results of memory performance indicated that the role of recollection was lower in recognition of affectively positive items than in recognition of affectively negative items. On the other hand, the role of familiarity was especially high in recognition of positive and high arousal items. In addition, the results of eyeblink activity suggested that the process of memory scanning should be performed longer and probably more repeatedly for the positive and high arousal items in a memory test stage.

Introduction

In recent years, a number of studies have been conducted on the relationship between affective or emotional factors and cognitive processes. One of the interesting phenomena about the relationship of emotion and cognition has been the valence based asymmetries of effects of affective stimuli on various cognitive performances (e.g., Taylor, 1991, for a review). In the present study, cognitive mechanisms during the performance of a recognition memory task of affective stimuli were examined. Ortony, Turner, and Antos (1983) reported that the recognition performance of affectively positive words was inferior to that of affectively negative words. They maintained that this result is a robust phenomenon and that a main cause of the inferiority of recognition of positive valenced stimuli is a large number of false alarm responses to filler items with positive valence. In a typical paradigm of recognition memory tests, subjects are given several items in an encoding period. Then, the "old" items which were presented in the previous encoding period and "new" or filler items which the subjects did not encounter in the encoding period are randomly given to the subjects in a latter test period. The subjects must judge each item as either "old" or "new." A false alarm is an example of an error response that they call new filler items "old." Ortony et al. (1983) repeatedly found a higher false alarm rate for positive filler items than for negative filler items.

Although their data were clear, they were not able to explain the finding and called it a "puzzle". Gardiner and Java (1990) suggested a possible solution for the puzzle based on their two process model of recognition memory. In their model, two components are involved in recognition memory, that is, a conscious, intentional, and attention-demanding process and an automatic, unintentional process. The former is called recollection and the latter is familiarity. Gardiner and Java (1990) interpreted the finding of Ortony et al. (1983) as showing higher involvement of familiarity and lower involvement of recollection in recognition of positive stimuli than in that of negative ones. They reasoned that familiarity automatically facilitates the possibility of the "old" responses to an item probably based on subjective experiences or frequencies of encountering it regardless of whether the item was presented or not in the previous encoding period. This process should increase the hit rate, the probability of correct answers to "old" items, however, at the same time it should increase the false alarms. On the other hand, the process of recollection should be more highly activated in recognition of affectively negatively valenced stimuli. It should make subjects judge each item more carefully resulting in a lower probability of false alarm. This remark is in line with Taylor's (1991) review which showed that negative stimuli often have a greater cognitive impact and activate more elaborated cognitive processes than positive stimuli.

One of the difficulties in this reasoning has been the lack of empirical evidence because degrees of involvement of familiarity and recollection have not been able to be examined separately in traditional paradigms of recognition memory. Usually familiarity and recollection work simultaneously and are contaminated in any memory task. Recently, a new paradigm for separate estimation of involvement of familiarity and recollection has been presented by Jacoby (1991), which is called the process dissociation procedure. The principle of this procedure is to compare memory performance in one test setting in which familiarity and recollection work in coordination or in the same direction (inclusion test) with that in another test setting in which the two components work antagonistically or in the opposite directions (exclusion test). For example, in an original version of the procedure (Jacoby, 1991, Experiment 3), the experiment involved three phases. Subjects were given two different lists of stimulus words in phase 1 (List A) and phase 2 (List B). Then, a recognition test with List A, List B, and filler items was performed in phase 3. In the inclusion condition, the subjects were required to call "old" to words both of List A and of List B and to call "new" to fillers. On the other hand, in the exclusion condition they had to call "old" only to List B words and to call "new" not only to fillers but also to List A items. A critical point was the comparison of memory performance of List A words between the inclusion condition and the exclusion condition.

In the inclusion condition, both conscious recollection of memory traces and automatic familiarity facilitate correct "old" responses to List A words. The subjects may answer based either on recollection, on familiarity, or on both. On the other hand, in the exclusion condition, the conscious recollection works to inhibit "old" responses to List A words because it is the demand of the task. However, in this condition, familiarity which lacks flexibility to change its own performance automatically facilitates generating such responses. Thus, an interference between recollection and familiarity will be evoked in the exclusion condition.

Jacoby (1991) represented performances of recollection and familiarity in these two different settings by using a pair of simple equations. Namely, the probability of responding with a studied word in the inclusion condition is the probability of recollection (R) plus the probability of the subject's automatic feeling of encountering when there is a failure of recollection, $A(1-R)$:

$$\text{Inclusion} = R + A(1-R).$$

For the exclusion test, a studied word will be called 'old' only when a word automatically recognized to be encountered and there is a failure to recollect that it was on the List A:

$$\text{Exclusion} = A(1-R).$$

Thus, the prabability of recollection and familiarity can be estimated by solving these equations:

$$R = \text{Inclusion} - \text{Exclusion}.$$
$$A = \text{Exclusion}/(1-R).$$

Although there is a controversy about the validity of this procedure (e.g., Graf & Komatsu, 1994; Curran & Hintzman, 1995), it is only one method which can examine the two processes of memory separately. The purpose of the present study is to examine affective positive-negative asymmetry effect of stimuli on characteristics of memory processes using the process dissociation procedure of Jacoby (1991).

Additionally, eyeblink activity was measured in this study as an index to assess the characteristics of cognitive processes. Psychophysiological studies have suggested that spontaneous eyeblink activity is related to various cognitive activity including attention, visual search, stimulus discrimination, or problem solving (Sterm, Walrath, & Goldstein, 1984, for a review). Generally, it has been maintained that when stimuli are presented intermittently, spontaneous eyeblinks are inhibited during stimulus processing and blinks occure frequently and suddenly after stimulus processing is completed (e.g., Fukuda & Matsunaga, 1983; Bauer, Strock, Goldstein, Stern, & Walrath, 1985; Goldstein, Walrath, Stern, & Strock, 1985, Fukuda, 1994). Also, it has been reported that these poststimulus eyeblinks are remarkedly increased by processing load (Fukuda & Matsunaga, 1983) and were delayed by processing time (Bauer, et al., 1985). Moreover, Ohira (1995) examined the eyeblink activity during a recognition memory task. He found that the frequency of eyeblinks decreased when subjects were studying items which were difficult to read and had high cognitive load in an encoding stage. On the other hand, characteristics of the eyeblink activity were totally different in a test stage. Frequency of the blinks was dependent on the subjects' responses to presented stimuli, namely, more blinks were evoked when the subjects responded "new" to an item than when they answered "old" to it. Ohira (1995) interpreted these results as indicating that spontaneous eyeblinks during a cognitive task may reflect updating of working memory or transportation of information between working memory and long-term memory. Based on these findings, and also in the present study, the eyeblink activity was examined during an encoding period and a recognition test period.

Method

Subjects.

Twenty female undergraduates (age range=20-22yr.) participated in the experiment individually. All of them were native Japanese speakers and had normal or corrected to normal vision.

Stimulus words.

A supplemental study was conducted to select stimulus words used in the experiment session. A set of 168 Japanese nouns which represented affective states was presented to 450 female undergraduates who rated them on 4 seven point scales, that is, valence, emotional impact, subjective frequency of usage, and subjective familiarity. A cluster analysis revealed four categories which were interpreted as positive-high arousal words, positive-low arousal words, negative-high arousal words, and negative-low arousal words. These results seem to indicate that there are at least two dimensions in a structure of affective words, that is, valence and arousal level. Thus, the arousal level of stimulus words was also manipulated as an independent variable. Twenty four words were randomly selected from each category respectively for stimulus words.

Design.

The design of the present experiment was 2 × 2 × 2 (test condition, inclusion vs. exclusion, as a between subject factor and stimulus valence, positive vs. negative, and stimulus arousal, high vs. low, as within subject factors).

Procedure.

Based on Jacoby's (1991, Experiment 3) procedure, the experiment involved three phases. In phase 1, the subjects were visually presented a list of 36 stimulus words which were randomly ordered. The list contained an equal number of items of the four categories, that is, positive-high arousal, positive-low arousal, negative-high arousal, and negative-low arousal. Each item was presented for 8 sec. through a slide projector with an electric shutter. The subjects performed an orienting task in which they rated the frequency with which each stimulus word is used in everyday life. They were not told about a subsequent memory test for the items. Further, their eyeblink responses and signals for identifying the onset of stimulus words were continuously recorded during the phase through a hidden video camera.

In phase 2, another list of 36 items with the same characteristics (positive-high arousal, positive-low arousal, negative-high arousal, and negative-low arousal) as one in phase 1 was auditorily presented to the subjects. They were asked to repeat aloud each word presented with an inter stimulus interval of 8 sec. and asked to remember the item for a later memory test.

In phase 3, the subjects were given a recognition test. Each item seen in phase 1 and heard in phase 2 and a new list of 24 stimulus words (6 positive-high arousal, 6 positive -low arousal, 6 negative-high arousal, 6 negative-low arousal) as filler items were visually presented through the same device as phase 1 for 4 sec. respectively. The subjects in the inclusion test condition were instructed that any item encountered either in phase 1 or 2 was to be called "old" and filler items were to be called "new". On the other hand, in the exclusion test condition, the subjects were required to call "old" only for items that were heard in phase 2 and to call "new" not only for filler items but also for items seen in phase 1. Additionally, their eyeblink responses and the stimulus onset signals were recorded through the same video camera as in phase 1.

The experimental session lasted about 40 min. At the end of it, all of the subjects were fully debriefed and interviewed to check whether they had noticed the purposes of the experiment. It was revealed that no subject had been able to guess the correct purpose, thus all data of the twenty subjects were analyzed.

Results

Memory data.

Recall that in the exclusion condition the subejcts were required to ignore items encountered in phase 1. If an item in phase 1 was consciously recollected, it had to be called "new". Hence, a phase 1 item called "old" in the exclusion condition was an error and indicated that it was not consciously recollected and the recognition decision was based on item familiarity, an automatic process. On the other hand, an answer of "old" to a phase 1 item in the inclusion condition was right and both recollection, an intentional or controlled process and familiarity, an automatic process should be involved in the recognition decision. A basic idea of Jacoby's procedure is to compare the rate of the "old" responses for phase 1 items in both conditions. Based on this reasoning, Figure 1.

shows frequencies of judging phase 1 words as "old" as a function of test condition (inclusion vs. exclusion), stimulus valence (positive vs. negative), and stimulus arousal (high vs. low). In the exclusion condition, positive words were more likely to be called "old", indicating that they were not consciously recollected. This result suggests a low recollective component in the recognition of affectively positive items.

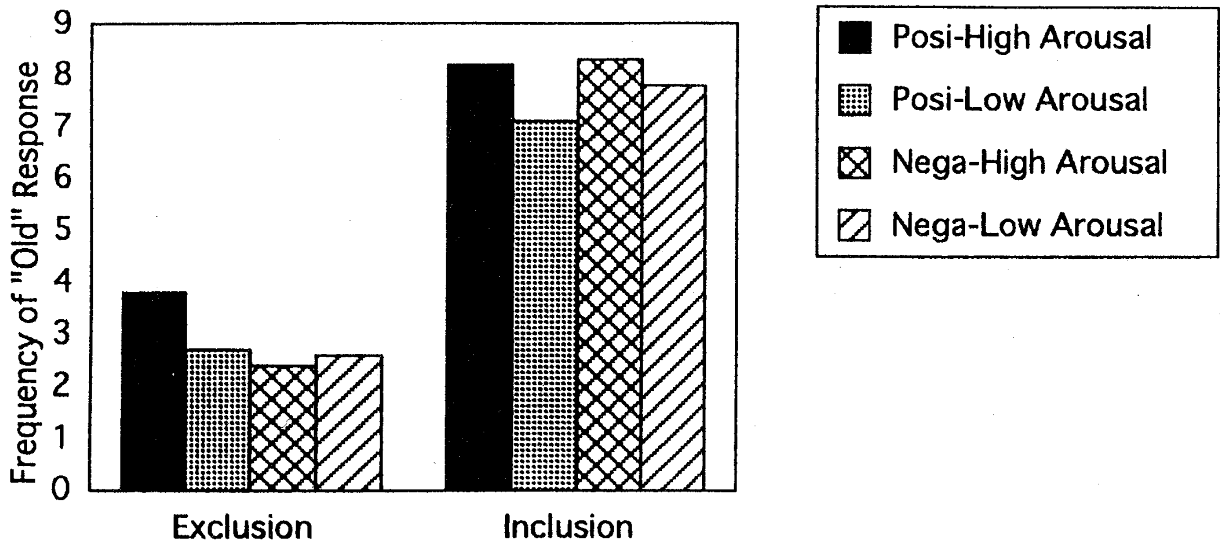

Figure 1. Mean frequency of judging phase 1 stimulus words as "old" as a function of test condition, stimulus valence, and stimulus arousal level.

To clarify this interpretation, a 3 factor (test condition as a between subject factor, valence and arousal as within subject factors) repeated measures analysis of variance (ANOVA) was conducted on the number of "old" judgements for items in phase 1. Unsurprisingly, there was a large main effect of test condition ($F(1, 18)=114.46$, $p<.001$) indicating that more "old" responses were evoked in the inclusion condition than in the exclusion condition. The main interest in the present study was a significant interaction between test condition and stimulus valence in the exclusion condition ($F(1, 18)=4.71$, $p<.05$), indicating that positive words were more likely to be called "old" than were negative ones. A comparable difference did not emerge in the inclusion condition ($F(1, 18)=1.84$, n.s.). These results supported the prediction that the role of recollection should be lower in recognition of positive stimuli than in recognition of negative stimuli. A main effect of stimulus arousal was also significant ($F(1, 18)=5.30$, $p<.05$). It means that high arousal words were more likely to be called "old" than low arousal words regardless of test condition and stimulus valence.

Figure 2. shows frequencies of "old" responses to phase 2 words. It should be noted that unlike a phase 1 word this type of response for a phase 2 word is a right answer both for the exclusion condition and for the inclusion condition. Thus, an "old" response to a phase 2 word means a "hit" in a traditional recognition memory paradigm. A three-way repeated measures ANOVA yielded no significant main effects and interactions ($F<1.0$).

Hence, it was indicated that the subjects both in the exclusion condition and in the inclusion condition responded to phase 2 words in the same way. Figure 3 shows frequencies of "old" responses to filler items. This type of response corresponds to a "false alarm" in a traditional recognition memory paradigm, because the filler items had not been given both to the subjects in the exclusion condition and to ones in the inclusion condition, and thus they should answer "new" to them. An ANOVA revealed a significant main effect of stimulus valence ($F(1, 18)=5.32$, $p<.01$) indicating that affectively positive filler items were more likely to be called "old" than affectively negative filler items were regardless of test condition and stimulus arousal.

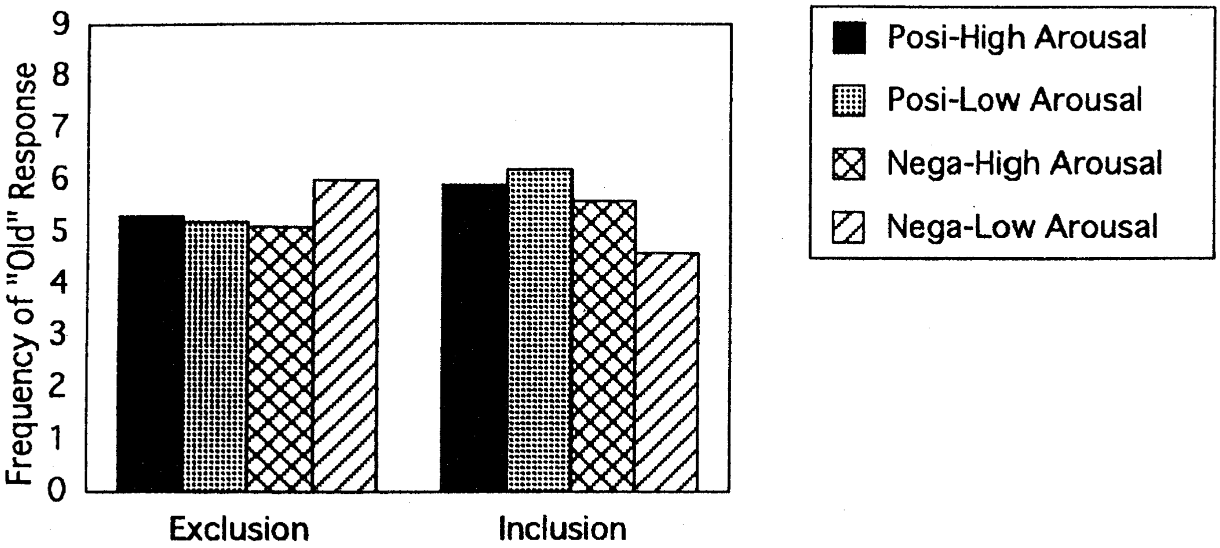

Figure 2. Mean frequency of judging phase 2 stimulus words as "old" as a function of test condition, stimulus valence, and stimulus arousal level.

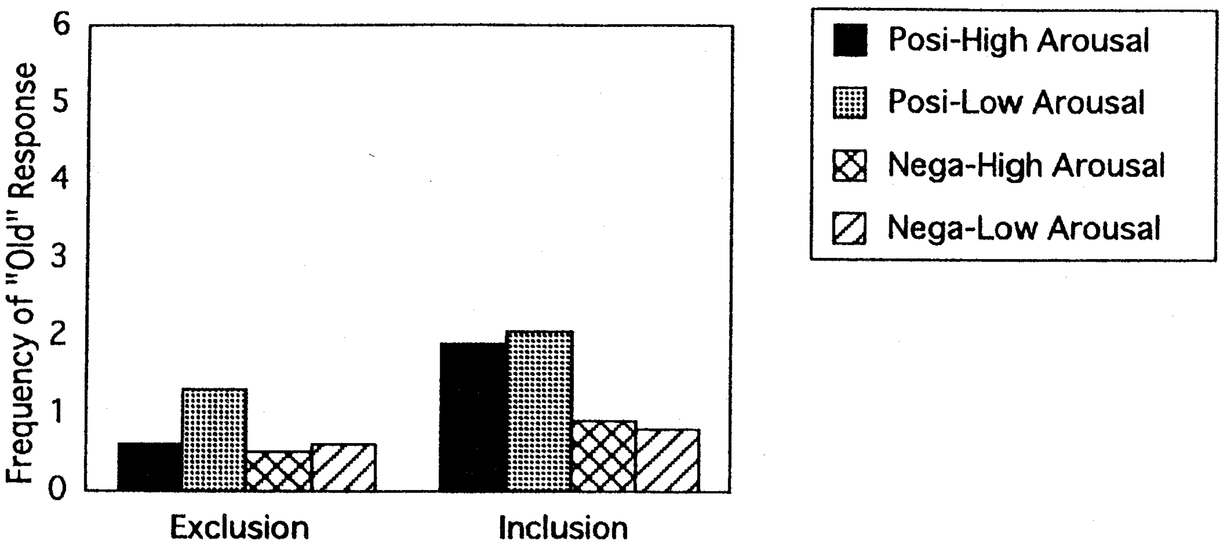

Figure 3. Mean frequency of judging filler words as "old" as a function of test condition, stimulus valence, and stimulus arousal level.

Using Jacoby's estimation procedure described in the introduction, probabilities that recognition decisions were based on recollection or familiarity were determined from the memory data for phase 1 words. These probabilities are shown in Table 1. Incidentally, because recollection and familiarity are assumed to be independent, their respective probabilities will not sum to 1.0; see Jacoby (1991). The estimated scores of recollection and familiarity were in line with the predictions in this study. Namely, the estimated probability of recollection was generally lower for the positive stimuli than for the negative stimuli. Additionally, the role of familiarity was higher for the positive stimuli, especially for the positive and high arousal stimuli.

Table 1 Estimated probabilities that recognition decisions were based on familiarity or recollection, based on Jacoby's (1991) estimation procedure.

	Familiarity		Recollection	
	Stimulus Valence		Stimulus Valence	
Stimulus Arousal	Positive	Negative	Positive	Negative
High	.82	.77	.49	.65
Low	.59	.69	.49	.58

Eyeblink data.

Two subjects were removed from the analysis of eyeblink data because of errors in the recording device. Using eyeblink data recorded in phase 1, a mean of eyeblink frequency during stimulus presentation (8 sec.) was determined for each experimental condition and shown in Figure 4. An ANOVA was conducted to log-transformed eyeblink data because of a high variance and a positive skewness in the data distribution. There were no significant main effects and interactions ($F<2.35$, $p>.15$), thus, no differences of the eyeblink activity were found in conditions in the encoding stage (phase 1). For the analysis of eyeblink activity during the stimulus presentation (4 sec.) in phase 3, the data were divided into two response categories; "old" and "new". Figure 5. shows a mean of eyeblink frequency in each condition. A four-way repeated measures ANOVA (test condition, stimulus valence, stimulus arousal, and response) revealed a complicated four way interaction ($F(1,16)=4.57$, $p<.05$). Tests of simple main effects ($p<.05$) showed that more eyeblinks were evoked when the subjects responded "old" than when they responded "new" only during presentation of positive and high arousal stimuli. However, it was indicated that "new" responses evoked more eyeblinks than "old" responses did during the other three categories of stimuli, that is, positive-low arousal, negative-high arousal, and negative-low arousal.

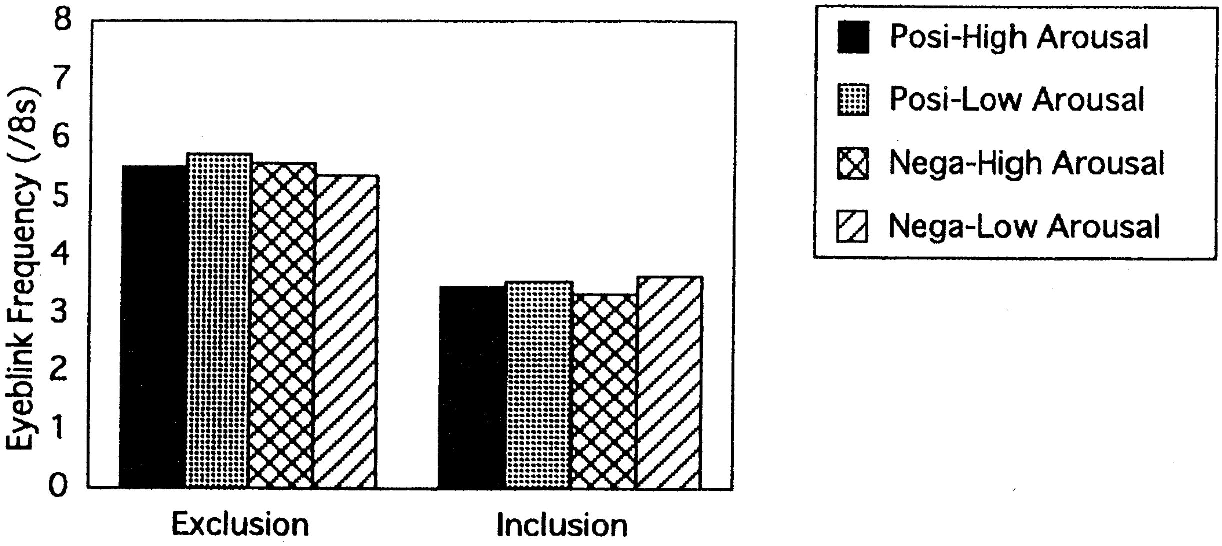

Figure 4. Mean frequency of eyeblinks occured during stimulus presentation in phase 1 as a function of test condition, stimulus valence, and stimulus arousal level.

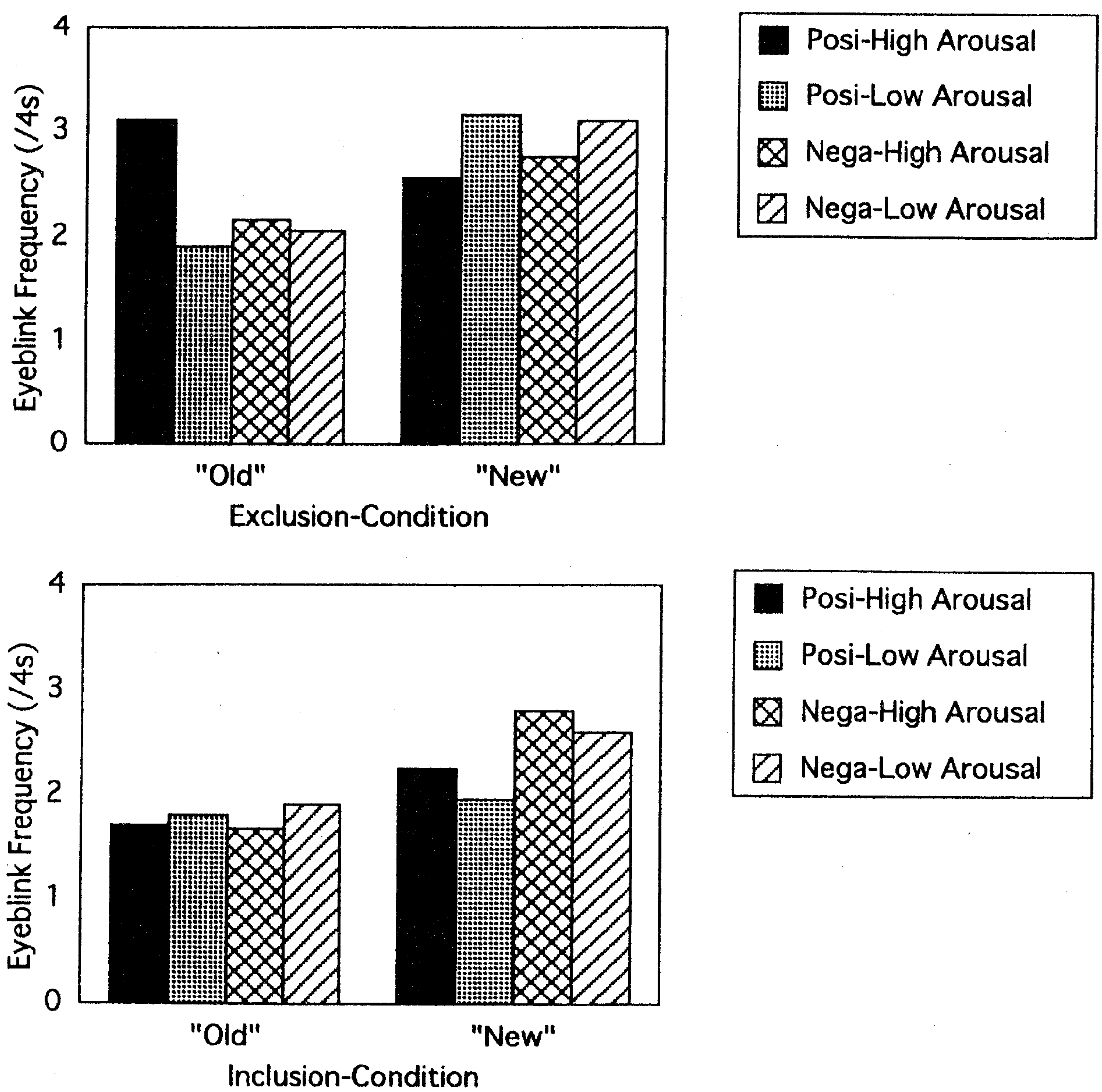

Figure 5. Mean frequency of eyeblinks occured during stimulus presentation in phase 3 as a function of test condition, stimulus valence, stimulus arousal level, and response.

Discussion

In the interpretation of the present results, it is important that affectively positive filler items evoked more false alarms than affectively negative filler items did. This is a precise replication of the finding of Ortony et al. (1983). Thus, the present experiment seems valid for the assessment of the explanatory principle of such an affective asymmetry effect of stimuli in recognition memory. Furthermore, there was no difference in the memory performance of stimulus words presented in phase 2 between the inclusion condition and the exclusion condition. This shows that the hit rate of such stimuli was identical between the two groups and that the subjects in both groups used the same criteria of judgement during the test phase (phase 3). Therefore, this finding permits a direct comparison of memory performance of stimulus words given in phase 1.

Results Concerning the memory data of phase 1 stimuli clearly supported the predictions described in the introduction. Positive stimuli evoked more "old" responses to phase 1 words which contradicted the demanded task than negative stimuli did in the exclusion condition, whereas there was no such difference in the inclusion condition. The estimated probability of familiarity also showed the dominance of automatic familiarity in processing the positive stimuli. As predicted, the estimated probability of recollection indicated a reversed pattern between the positive stimuli and the negative ones, that is, there was a high involvement of recollection in processing of the negative stimuli. These results suggest that affectively negative stimuli should activate intentional and elaborated cognitive processing. On the other hand, it seems that affectively positive stimuli should decrease the intentional processing and make individuals adopt relatively automatic and unintentional processing. This seems compatible with some formulations about affective asymmetry in cognition and social cognition (e.g., Schwartz & Clore, 1988; Taylor, 1991; Forgas, 1991).

The eyeblink activity seems to have provided some implications about inner cognitive activity during the performauce of the task. During the encoding of stimulus items in phase 1, there was no difference in the eyeblink activity in each experimental condition. Following the finding of Ohira (1995) that task difficulty, cognitive load, and the amount of attention allocated to stimulus processing should influence frequency of blinks during stimulus presentation, the present result suggested that the valence and arousal level of stimuli made no substantial difference in the cognitive activity for processing them. Thus, the two components, recollection and familiarity may be affected by stimulus valence or stimulus arousal level not in the encoding stage of memory but rather in the retrieval stage.

In phase 3, the blink activity was strongly determined by response patterns to stimuli. Generally, when a subject recognized a test item as a new filler frequency of blinks was increased compared to when they judged it as an old one. Although there is no direct evidence, this result can probably be interpreted by assuming that updating the working memory facilitates the occurauce of blinks. When a subject judges a word "new", he or she must scan all of his or her memory traces related to the encoding phases in long-term memory. In this situation the scanning of memory and transportation of information to working memory should require a large amount of updating of the working memory. On the other hand, when he or she answers "old", the scanning can be cancelled at the time a memory trace of the studied item is accessed. Thus, the scanning time should be shorter and the amount of updating of the working memory should be smaller compared to the "new" answer. This difference in degree of working memory updating might affect the eyeblink frequency.

Only for affectively positive and high arousal stimulus words which were estimated to be the most strongly influenced by automatic familiarity, was the relationship between the eyeblink activity and response pattern reversed. Namely, an "old" response evoked more blinks than a "new" response. If the reasoning described above is correct, more memory scanning was conducted for the "old" responses than for the "new" responses. This might reflect a kind of cognitive rumination, that is, repeated scanning for a missing memory trace in long-term memory. Specifically, in the exclusion condition, the subjects should respond "new" to a phase 1 word if she can intentionally access its memory trace. An "old" response should be generated only when she cannot access it but the familiarity of the test stimulus is relatively high. The cognitive rumination or repeated memory scanning is a process that the subject cannot cancel even when she fails to access it because of high familiarity and nas to repeat the scanning again. Sometimes these processes might make errors and generate "old" responses.

Although these interpretations might be speculative, the eyeblink activity seems to become a potentially useful index to assess characteristics of cognitive processing. Further research should be conducted to examine psychological and physiological mechanisms and how stimulus valence or stimulus arousal level affects the blink activity in detail. Additionally, the relationship between the performances of other behavioral measures such as reaction time to test stimuli and that of eyeblink activity in recognition memory tasks should be examined.

Acknowledgment

The author wishes to thank Dr. Ward M. Winton of University of St. Thomas (U. S. A.) for theoretical and technical advice, Makiko Oyama and Hiroko Higuchi for their assistance in data collection, and Mr. Joseph Stavoy for his suggestions for the early draft. A part of this research was presented in the Inaugural Conference of the Asian Association of Social Psychology in Hong Kong (1995. June).

References

Bauer,L.O., Strock,B.D., Goldstein,R., Stern,J.A., & Walrath,L.C. (1985). Auditory discrimination and the eyeblink. *Psychophysiology*, *22*, 636-641.

Curran,T., & Hintzman,D.L. (1995). Violations of the independence assumption in process dissociation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 531-547.

Forgas,J.P. (1991). Affect and person perception. In J. P. Forgas (Ed.), *Emotion and social judgments*. Pergamon: Oxford. Pp. 263-298.

Fukuda,K. (1994). Analysis of eyeblink activity during discriminative tasks. *Perceptual and Motor Skills*, *79*, 1599-1608.

Fukuda,K., & Matsunaga,K. (1983). Changes in blink rate during signal discrimination task. *Japanese Psychological Research*, *25*, 140-146.

Gardiner,J.M., & Java,R.I. (1990). Recollective experience in word and nonword recognition. *Memory and Cognition*, *18*, 23-30.

Goldstein,R., Walrath,L.C., Stern,J.A., & Strock,B.D. (1985). Blink activity in a discrimination task as a function of stimulus modality and schedule of presentation. *Psychophysiology*, *22*, 629-635.

Graf,P., & Komatsu,S. (1994). Process dissociation procedure: Handle with caution! *European Journal of Cognitive Psychology*, *6*, 113-129.

Jacoby,L.L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language*, *30*, 513-541.

Ohira,H. (1995). [Recognition memory and the eyeblink.] Presentation Paper in 59th Annual Meeting of Japanese Association of Psychology (in Japanese).

Ortony,A., Turner,T.J., & Antos,S.J. (1983). A puzzle about affect and recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *9*, 725-729.

Schwartz,N., & Clore,G.L. (1988). How do I feel about it?: The informative function of affective states. In K.Fiedler & J.P.Forgas (Eds.), *Affect, cognition, and social behavior*. Hogrefe: Toronto. Pp. 44-62.

Stern,J.A., Walrath,L.C., & Goldstein,R. (1984). The endogenous eyeblink. *Psychophysiology*, *21*, 22-33.

Taylor,S.E. (1991). Asymmetrical effects of positive and negative events: The mobilization-minimization hypothesis. *Psychological Bulletin*, *110*, 67-85.