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ERP로 확인되는 인지정보 처리에 대한 정서 점화효과

Affective Priming Effect on Cognitive Processes Reflected by Event-related Potentials

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요약

본 연구는 스트룹(Stroop)과제를 이용하여 정서가(affective valence)로 구성된 역하의 정서유발 점화자극이 인지과제 수행에 영향을 미치는지와 일반인에서도 정서장애 환자와 같은 지표가 나타나는지를 반응시간과 ERP(사건관련전위) 패턴으로 확인해 보고자 하였다. 측정된 데이터는 정서가(긍정 및 부정)와 일치여부로 수행되는 인지과제의 조합으로 제시되어 수집되었고, 전위변화의 특성인 진폭과 정점 잠복기를 기준으로 그 효과가 검증되었다. 먼저 반응시간 행동분석 결과, 중립 정서자극을 제외한 역하의 정서자극에 의해 목표과제의 반응을 촉진하는 결과를 확인할 수 있었다. 아울러 부가적으로 수집된 사건관련전위를 분석한 결과, 불일치 요인이 결합된 부정적 정서정보가 긍정적 정서정보에 비해 더 높은 음전위 및 지연된 잠복기를 보임으로써 표정과 관련된 정서유발-특정적인 N2효과를 확인하였다. 그리고 동일한 조건에서 긍정조건에 비해 유의한 차이의 양전위와 함께 더 짧은 잠복기를 보이는, 인지적 판단과정의 차이를 시사하는 P300의 효과도 관찰하였다. 이는 역하의 부정적 정서정보가 인지처리과정에서 자동적으로 억제되는 경향과 함께 해당 정서의 탐지를 가속시키는 한편, 주의자원의 적절한 재분배를 가능케 하여 목표자극의 반응을 촉진시킨 것으로 해석할 수 있으며, 기능적이고 인지적인 반응의 차이에서 역하효과를 비롯하여 과제 수행 정도에 영향을 끼치는 정서관련 재인과정의 중요성을 시사한다 할 수 있다.

■ 중심어 : | 정서점화 | 부적정서 | 역하자극 | 주의자원 | 사건관련전위 |

Abstract

This study was conducted to investigate whether Stroop-related cognitive task will be affected according to the preceding affective valence factored by matchedness in response time(RT) and whether facial recognition will be indexed by specific event-related potentials(ERPs) signature in normal person as in patients suffering from affective disorder. ERPs primed by subliminal(30ms) facial stimuli were recorded when presented with four pairs of affect(positive or negative) and cognitive task(matched or mismatched) to get ERP effects(N2 and P300) in terms of its amplitude and peak latency variations. Behavioral response analysis based on RTs confirmed that subliminal affective stimuli primed the target processing in all affective condition except for the neutral stimulus. Additional results for the ERPs performed in the negative affect with mismatched condition reached significance of emotional-face specificity named N2 showing more amplitude and delayed peak latency compared to the positive counterpart. Furthermore the condition shows more positive amplitude and earlier peak latency of P300 effect denoting cognitive closure than the corresponding positive affect condition. These results are suggested to reflect that negative affect stimulus in subliminal level is automatically inhibited such that this effect had influence on accelerating detection of the affect and facilitating response allowing adequate reallocation of attentional resources. The functional and cognitive significance with these findings was implied in terms of subliminal effect and affect-related recognition modulating the cognitive tasks.

■ keyword : | Affective Priming | Negative Affect | Subliminal Stimulation | Attentional Resource | ERPs |

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I. Introduction

Many recent studies have investigated the relationship between emotion and attention. Probably the biased attentional effect will be also one of many effects elicited by the emotional-related stimuli[1]. Abundant evidence supports the hypothesis of distinctive patterns of attentional response to emotionally negative stimuli in normal and anxious people[2][3]. While there are much more data of a relatively clear attentional response pattern to threatening stimuli in anxiety patients, the corresponding attentional pattern in normal participants has not been directly investigated.

Some studies have exhibited an interesting processing pattern with normal participants using a dot probe task developed to measure how clinically anxious individuals allocate their visual attentional resources when encountered emotional stimuli[4-6]. However this task asked participants to respond as quickly as possible to a probe that appears in one of two locations, occupied by two stimuli (one threatening vs. other neutral), providing only a snapshot of events that occur after the onset of a word stimulus pair usually presented for 500 msec[7][8]. Therefore it is unclear whether the dot probe task effect implicates attentional avoidance from threatening information or the capacity to disengage attention from threatening information in normal participants relatively to anxious people[9].

On the other hand, a study using a word stimulus expressing emotion showed that anxious patients and control participants depicted very different patterns of attention; anxious individuals responded more quickly to probes replaced with the threatening stimuli as compared to with the neutral stimuli, whereas normal individuals were faster to respond to probes replaced with neutral stimuli, in contrast to the threatening stimuli[10]. This suggests that, while anxious individuals orient attention towards the location at which a threat has occurred, normal participants orient their attention away from those locations. Similar results have also been reported in researches using the human threatening faces or threatening pictures as stimuli[11][12].

The experimental paradigm most frequently used to show attentional biases were almost affective Stroop task which asked them to name the colour of a word varied in emotional valence (negative, neutral, and positive). The results says consistently that words with threatening or negative meaning cause slower colour-naming latencies relative to matched neutral words in emotionally disturbed populations[13].

While as for normal participants, this bias generally appeared to have little effect except for a few studies. According to the related studies, they showed that affective information related processing in target task demand condition can be controlled; that is, although there is any specific pattern of attention to negative information in normal participants, strong perceptual input or compelling target-related processing can usually intercept the effects of task irrelevant, affective processing in ordinary affective Stroop task regardless of its emotional valence[1][13][14].

However, as mentioned shortly above there is also a study showing direct investigation for attentional biases in which automatic inhibition of affective processing coocurred in the case of negative stimulus in normal participants[15]. The study adopted a modified affective Stroop task providing affective information before the target stimuli to explore more directly emotional effects. This is why unpredictable emotional variance and sudden changes on environment surrounding individuals could cause the levels of performance of ongoing cognitive tasks for normal people as well as affective disturbed patients.

It seems like it happens all the time when we are facing turns to present, interviewing to the public, and hearing of harsh words and so on. Accordingly it is sufficiently meaningful to identify the processes of affective biases influencing the cognitive tasks as priming effects.

To avoid the interference effect between the stimuli, the present study also employed the strategy presenting the affective subliminal stimulus prior to the target not to compete directly with the task processing. This method ensures that the affective stimulus cannot be so easily overwhelmed by strong ongoing target processing.

If normal participants inhibit more easily negative information than positive or neutral information, the reaction times(RTs) in color naming task after negative information will be faster than after other affective informations. Furthermore the task permits us to measure the influence of emotion following the subsequent attention, as does the dot probe task. However, the task implicates only initial attention-orientedness and the avoidance of locations coocurring negative information not associated with the cognitive task. On the contrary, the present task adopting serial presentation between priming and target stimuli may reveal the modulation of attentional resources to the target stimulus with measures of RT after processing emotional contents.

Meanwhile, another index of psycho- physiological information concerning affective changes over autonomous nervous system has been used as a measure called event-related potentials(ERPs). ERPs are averaged potentials time-locked based on experimental condition and a specific scalp site across subjects' EEG (electro- encephalogram) within a predefined time period. Many affect-related ERP deflections or modulations called components for picture stimulus have been known in 3 divided time range, short(~200ms), middle(200~300ms), and long(300ms~) latency. First of all, we excluded all components (P1, N1 etc., see [Fig. 4]) within short latencies, that is why the components are known as physical or sensory processing within the visual cortex being irrelevant to cognitive demand. For this reason, the present study focussed our attention on the subsequent components occurring in middle and long latencies.

One of earlier components of ERPs related to the affective effect is an EPN (early posterior negativity) well-known as arousing stimuli for further processing within the 200-300ms latency, and another N2(2nd component of negativities) component elicited by stimulus valence such as unpleasant stimuli is also observed within the same latency reflecting the activity of stimulus discrimination and response execution stages range[16][17]. The next later component is known as P300 (positive peak occurring around 300ms poststimulus) denoting attentional memory storage events or mental resources allocation with regard to affective pictures engaged for target processing[18-20].

II. Methods

1. Participants and Materials

Fifteen healthy right-handed subjects in A University participated in this experiment. (10 females and 5 males). None of the subjects had neurological or systemic disease and all were confirmed to be right-handed by the right-hand assessment test. This study was approved by the ethics committee not fixed at our institution and a written informed consent was obtained from each subject. The mean age was 21 years old (range = 19 to 28 years old).

Meanwhile the color words were prepared in four

Korean words; blue[파랑], red[빨강], green[녹색], and yellow[노랑] and its respective color patch was also used. The words were presented in Gothic 48 bold black type on a white screen. The color patches were four squares (12 x 12 cm) painted blue, red, green, or yellow. In addition, the patches were divided into 2 types which are matched or mismatched the preceding colour words for cognitive matching task. Lastly, Intermediate 3 schematic faces depicting negative, positive, and neutral emotion face were given to serve as affective stimuli from the literature previously used[21]. Specifically, stimuli presented to the subjects were divided into 4 types of faces, i.e. 2 affective faces(positive and negative), 1 neutral face, and the last 1 blank face used only for evaluating each affective effect relevant to the face stimulus recognition.

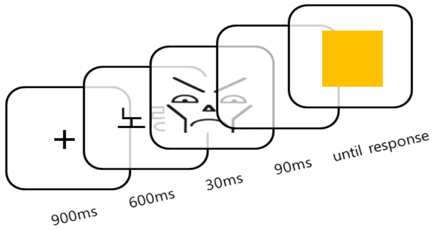

Fig. 1. Time-course model of each trial stimuli appeared in an experimental task

2. Procedures

Participants were instructed to name the colour of the last colour patch as quickly and accurately as possible for cognitive matching task. After training trials, the experimenter answered any participant questions and ensured that he or she had understood all instructions. Each trial started with a central fixation point (+) for 900 msec, which was replaced by a colour word for 600 msec. A schematic face composed of 3 faces was presented for 30 msec subliminally just before the onset of the blank screen of 90ms duration as a masking stimulus. Finally, the colour square appeared and disappeared when the participant uttered the first syllable of the colour word presented as target stimulus[Fig. 1]. Each series of trial stimuli was repeated successively five times, with the picture and text order counterbalanced to minimize the carry-over effect. As referred to the preceding section subjects' responses to the task were acquired in two ways: RTs for behavioral and electroencephalography (EEG) data corresponding to the trials.

On the one hand, EEG data were also acquired to examine the impact of primed affective stimuli prior to target processing and to find the neural correlates responsible for the emotional facilitation or inhibition. The EEG data was recorded from 32 sites on the scalp of the international 10-20 systems mounted on a Quick cap by Brain Vision system (ver. 4.2) at a sampling rate of 250Hz. A linked-mastoid reference attached behind both ears was used, and the electrode impedance was under 10 kΩ or less. A band-pass filter was 0.3 Hz and 70Hz(12dB/octave). The electrooculogram (EOG) artifact rejection criterion was set at + 50 uV and - 50 uV. The ERPs were extracted separately by each trial type from the EEG and sampled for 920ms from 120ms before the onset of the stimulus to 800ms after the onset. The mean amplitude and peak latency were used for the differences between the conditions. For statistical analysis, an ANOVA on the 2-way repeated measures was conducted and divided into the following variables: 2 affective face (positive, negative) X 2 matchedness (matched, mismatched).

III. Results

1. Behavioral and ERPs Measures

This study aimed to identify whether

Stroop-related cognition tasks will be affected by the stimulus with emotional valence. Behavioral response analysis based on RTs confirmed that rapid affective-schematic face recognition shown for 30ms and the following masking of 90ms primed the target processing in negative and positive valence but the neutral one.

The main effects of affective face were significant, irrespective of matching between colour word and colour square *($F_{2,42}$=4.50, $p<.05$)*. Further comparison of post-hoc for emotional face conditions revealed the significant difference between negative and neutral or positive stimuli *($ts(28) > 2.78$, $ps< .01$)* based on the RT data shown in [Table 1].

Table 1. Mean reaction times and error rate for each emotional face recognition

Face type	reaction times	% error
	M (SD)	%
blank	383.2(25.17)	0.02
neutral	382.1(25.26)	0.03
positive	377.5(24.68)	0.08
negative	368.3(25.89)	0.07

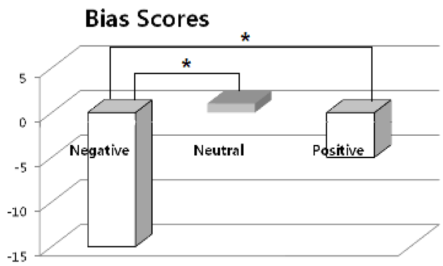

Fig. 2. Bias scores of attention according to the each emotional valence: facilitation (-) and inhibition (+) effect for emotional valence. * denotes significant difference of priming submitted to one-sample t-tests at the p 〈 .05.

In addition, facilitation and interference effect were calculated by subtracting the mean RT on blank face trials from the mean RT on each affective face(positive & negative) trials in which the positive(+) value indicates the corresponding face-inducing slowing effect, negative(-) value the speeding effect as shown in [Fig. 2].

On the other hand, ERP data acquisition designed to be 4 [affect(2) x matchedness(2)] conditions are as follows; ERP data used for analysis are extracted from positive affect matched or mismatched, and negative affect matched or mismatched. Together with the ERP data, two- way repeated measures ANOVA using 2 factors was performed to get a differential response pattern according to the factors.

First of all, [Fig. 3] shows the grand averages obtained from each ERP subtracting baseline amplitude at centro-parietal areas(C3/4, P3/4/7/8). As appeared in the grand averaged ERPs, all the conditions across bilateral hemisphere revealed N2 and the following P300 deflection other than preceding components([Fig. 3], N1 and P1, see [Fig. 4]. The mean amplitudes and latencies for the N2 and P300 components were selected for the following statistical analysis.

The first component of interest, N2(180-220ms peak amplitudes between mismatch conditions shown in negative affect condition marked more negative voltages compared to the corresponding positive affect condition mainly at left scalp sites(C3, P3, and P7). Mean latencies between matched conditions revealed the negative affect reached faster than the positive affect with mismatched conditions reversed as appeared in [Fig. 3] & [Table 2][Table 3]. The following component P300(between 260 and 300 msec) occurring at negative affect stimuli were identified to be more positive(+) and faster latencies at only mismatched condition mainly over right centro-parietal areas as depicted in [Fig. 3] & [Table 4][Table 5].

Table 2. Mean amplitude(uV) and SDs of N2 at left(C3, P3, P7) centro-parietal region (C at C3: cental site, P at P3,P7: parietal site)

site	Positive affect		Negative affect	
	matched	mismatched	matched	mismatched
C3	−1.45 (0.83)	−1.56 (1.03)	−1.33 (0.88)	−3.13 (1.76)
P3	−3.08 (1.75)	−3.12 (1.83)	−2.57 (1.45)	−4.04 (2.12)
P7	−2.31 (1.09)	−2.47 (1.58)	−2.37 (0.97)	−5.56 (3.07)

Table 3. Mean latencies(ms) and SDs of N2 at left centro-parietal region

site	Positive affect		Negative affect	
	matched	mismatched	matched	mismatched
C3	196(24.2)	201(22.8)	148(20.9)	231(33.9)
P3	186(20.3)	192(19.2)	163(19.6)	195(25.8)
P7	192(21.5)	200(21.4)	192(22.5)	230(30.7)

In contrast, N2 and the following P300 component in matched condition show little difference in the mean amplitudes and latencies between positive and negative affect condition except for the latencies of N2 at bilateral centro-parietal areas.

Two-way repeated-measures ANOVA unfolded that the main effect of the affective stimuli face reached significance at amplitudes and latencies of N2 in the time window at left hemisphere ($F_{1,14} > 4.73$, $p < .05$). respectively. The other main effect of the matchedness was also significant at amplitudes and latencies($F_{1,14} > 6.91$, $p < .05$.) The interaction effect did not reach the significant level, $F_{1,14} < 2.1$. The next P300 component produced main effects of affective stimuli and matchedness, ($F_{1,14} = 5.82$, $p < .05$; $F_{1,14} = 4.94$, $p < .05$ respectively) for the amplitudes of the ERPs. The other main effects for the latencies of ERPs are also significant ($F_{1,14} = 10.38$, $p < .01$; $F_{1,14} = 9.57$, $p < .01$ respectively with interaction effect not significant($F_{1,14} < 1.2$).

Table 4. Mean amplitude(uV) and SDs of P300 at right (C4, P4, P8) centro-parietal region

site	Positive affect		Negative affect	
	matched	mismatched	matched	mismatched
C4	1.12 (0.67)	0.83 (0.59)	1.13 (0.83)	2.12 (1.56)
P4	3.01 (1.58)	2.07 (1.42)	3.21 (1.79)	3.08 (2.05)
P8	4.28 (2.74)	2.33 (1.49)	4.32 (2.54)	4.26 (2.88)

Table 5. Mean latencies(ms) and SDs of P300 at right centro-parietal region

site	Positive affect		Negative affect	
	matched	mismatched	matched	mismatched
C4	265(37.6)	288(42.7)	266(35.4)	264(38.7)
P4	264(39.2)	289(43.3)	262(31.2)	265(37.4)
P8	264(40.8)	289(45.8)	263(34.4)	268(37.7)

These results ensured that channel-wise ERP difference and scalp topographical maps of negative affect mismatched subtracting positive affect mismatched condition after the target presentation showing lateralizaion over left temporo-parietal distribution of N2, over the opposite region of P300 as shown in [Fig. 4].

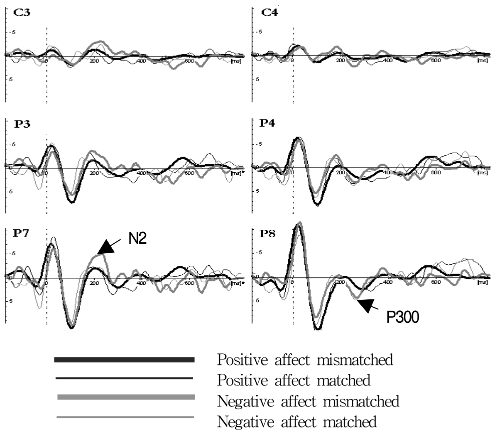

Fig. 3. Grand average ERPs over centro-parietal sites with levels of valence overlaid; the tick of horizontal axis is time in 200ms, that of vertical axis is amplitude in 1uV, negative is up.

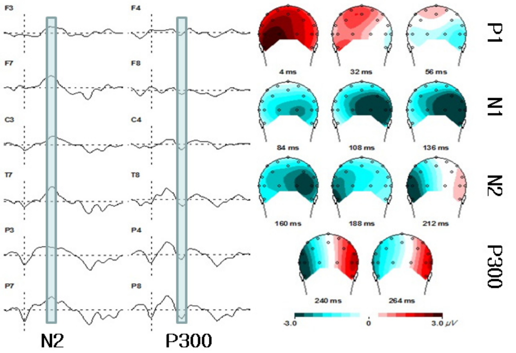

Fig. 4. Channel-wise ERP difference and scalp wave map corresponding to N2 and P300 of negative affect mismatched minus positive affect mismatched after target presentation; P1-N1: early components not addressed here.

IV. Discussion

The present study adopted a modified Stroop-task presented with the word and color patch split to assess affect priming effects for match and mismatch cognitive task. As shown in the grand averaged ERPs, all the conditions revealed N2 and the following P300 deflection except for other components to be analysed later.

As described in the preceding section, in early time windows called N2, priming stimuli related to the positive affect did not influenced the degree or speed of emotional face detection regardless of machedness. However when presented with the negative affect as priming stimuli, matched conditions accelerated the speed of detection of the emotional face relative to the positive affect condition at posterior left hemisphere. In contrast, when mismatched condition followed the negative affect the index related to face specificity marked more negativity recognizing the deviation stimuli(negative emotional face) but delayed the time for detection of the affect stimuli.

The following time windows named P300 indicated that negative affect as priming stimuli seemed not to be different from the positive affect in degree and the point of occurrence at the matched condition. However when negative affect followed by mismatch condition, the index saying cognitive decision or closure marked more positive(+) amplitudes and faster latencies mainly at right hemisphere as appeared in [Table 4][Table 5].

Putting it all together, in the view of emotional processing, tasks being lack of cognitive load could speed up the detection of negative affect, but when presented with tasks burdened from the mismatch responses between stimuli to be processed, the detection of the negative affect came to be slower, which could bring the delay of evading response or behavior. While In terms of task-related cognitive processing, the tasks with cognitive load to be mismatched influenced obviously the degree and speed of the tasks, as a result mismatch conditions could facilitate the response behavior under the priming stimulus of negative affect.

In sum, we can infer the two effect of the negative affect priming through the results mentioned above. Firstly the N2 effect being likely to reflect face recognition or detection in this study shows that negative affect marked more negative deflection (EPN; early posterior negativity) at left dominant hemisphere (at P3, P4, P7)[22]. it suggests that emotional face specificity for facial expression occur mainly in left dominance.

Secondly, P300 effect by negative affect can be seen to process target stimulus by allocating the attentional resources, in which matched condition in reality shows no bias of attention evidenced from nearly similar mean amplitude. Whereas mismatched condition reveals faster and more positive peak response (C4, P4, P8, and P3, P7 as well) by relatively more allocation of attentional capacity. Especially latency effect identified as faster peak latencies seems to be reflected on accelerating response speed of target by inhibition of negative affect input as confirmed in [Fig. 2]. The results may also imply that patients suffering from anxiety or panic disorder used to avoid hatred stimulus that fast even in normal people aroused by negative affect or something. Moreover some indices in this finding could play part in using and investigating apparatus related to measuring the degree of disability as well in gathering data to correctly respond to given stimulus of threatening objects to normal person. That's why the patients and normals surrounded by negative affect stimuli are likely to reach the high level of emotional expression not to be controlled.

Finally, it should be noted that negative potential distributed by N2 appears to index more negativity mainly in left scalp region if given the mismatching stimulus together with attentional negative affect, and positive distribution on P300 seems to recruit mainly right scalp region to facilitate the process of target stimuli[23]. However it remains not clear as to what kind of affect mechanism could cause this cognitive facilitation effect and what cognitive processing influences these N2 and P300 ERP effects in reverse[24][25].

In conclusion, these results support the view that negative affect stimulus is automatically inhibited even in subliminal level in normal subjects. Additionally this inhibition mechanism seemed to increase the speed of processing related to target stimulus by means of redistributing and condensing the attentional resources.

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