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The modulating effect of emotional valence on the speed of involuntary attentional capture*

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Emotional information can easily capture our attention compared to neutral information. Evidences suggest that the amount of induced attentional capture is correlated with arousal levels of processed information. On the other hand, the speed (onset latency) of attentional capture seems to be determined by the valence of the emotional information. In this study, the speed of attentional capture between equally high arousing positive and negative stimuli was compared by using the emotion-induced blindness (EIB) procedure, which is suited for measuring temporal changes in attentional effects. In Experiment 1, either a positive or negative word distractor was presented among a rapid stream of neutral words, and a to-be-reported target animal word followed 1, 2, 3, 4, 5, & 8 lags after distractor presentation. In Experiment 2, either a positive or negative distractor was presented among a rapid stream of opposite valence words. The overall results indicate that negative distractors induced a rapid attentional capture response occurring at lags 2 to 4, while positive distractors induced a late attentional capture response, which gradually increased and peaked at lag 5. In conclusion, the emotional valence of distractors determines the speed of attentional capture when compared emotional distractors have similar arousal levels.

Key words : attentional capture, emotion, valence, arousal, emotion induced blindness

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Emotional events are special and they involuntarily capture our attention over other information. This mechanism of emotional attentional capture may guide our behavior to be more adaptive and increase our chance of survival. In fact, different aspects of emotional information can cause varying effects on how emotional objects and events capture our attention.

Emotional information can be broken down into two separate sub-dimensions called valence and arousal (Bradley & Lang, 1994; Mehrabian & Russel, 1974; Osgood, 1952; Osgood, Suci, & Tannenbaum, 1957). Valence represents the positive and negative polarities of emotion and arousal represents the intensity of the emotional experience. Rating valence and arousal of emotional information is particularly beneficial because virtually all types of stimuli can be universally quantified and compared.

Initially, valence was thought to drive attentional capture. Scientists argued that negative emotion generates stronger responses than the positive emotion: an idea called *negativity bias* (Rozin & Royzman, 2001; Taylor, 1991). To test how negative stimuli capture attention, Pratto and John (1991) proposed two accounts: 1) the *categorical negativity* account, which suggests that once a stimulus is evaluated as negative in any degree, it attracts attention in an all-or-none fashion, and 2) the *evolutionary threat* account, which claims that only the negative stimuli directly related to physical threat, such as spiders, snakes, guns, or sharp metallic objects, capture attention.

Later, it was discovered that positive stimuli (e.g., erotic stimuli) can also attract attention just as much as or more than negative stimuli, thus providing a counter evidence against the two accounts (Anderson, 2005; Buodo, Sarlo, & Palomba, 2002; Keil & Ihssen, 2004; Most, Smith, Cooter, Levy, & Zald, 2007). These findings lead to a hypothesis that arousal levels, instead of valence, is related to the intensity of attentional capture (Schimmack & Derryberry, 2005). This hypothesis has been supported by numerous studies that used procedures such as attentional blink and emotion-induced blindness (e.g., Anderson, 2005; Anderson & Phelps, 2001; Arnell, Killman, & Fijavz, 2007; Ciesielski, Armstrong, Zald, & Olatunji, 2010; Fox, 2005; Keil & Ihssen, 2004; Maratos, Mogg, & Bradley, 2008; Mathewson, Arnell, & Mansfield, 2008; Most, Chun, Widders, & Zald, 2005; Most et al., 2007).

Still, there is a possibility is that valence is responsible for the speed (onset latency) of attentional attraction. In other words, it is feasible that there is a negativity bias in the speed of attentional capture. Data from visual search paradigms suggests that search for negative stimuli is significantly more efficient than neutral (Yiend, 2010). For example, Öhman, Flykt, and Esteves (2001) discovered that searching for negative stimuli in a visual array was quicker than searching for a non-negative stimulus. Also, event-related potential studies revealed that emotional information enhances early perceptual processes which can influence the speed of attentional capture. The P1, an early occipital visual component with a latency of 117ms (Smith, Cacioppo, Larson & Chartrand, 2003), and the early posterior negativity (EPN) component occurring at 200ms (Schupp, Öhman, Junghöfer, Weike, Stockburger, & Hamm, 2004) was augmented when negative stimuli were presented. In contrast, there are evidences of enhanced processing of positive information in later stages. The P400, a posterior component occurring at 400ms was augmented after presentation of positive stimuli (Carretie, Hinojosa, & Mercado, 2006).

The differences in the capture speed between positive and negative may arise from functional differences. The suggested primary function of positive emotion is the broadening of action-thought repertoires and the building of personal resources (Fredrickson, 1998, 2001; Fredrickson & Branigan, 2005). In other words, positive emotion promotes widening in the range of thoughts and actions of an individual, which helps build the necessary personal resources such as physical skills, health, friendship, social support networks, knowledge, creativity and more, for long-term survival. On the other hand, the primary function of negative valence seems to be the adaptation to imminent emergency situations. Quickly allocating attention to the source of threat and engaging in rapid responses would have increased the chances of survival. Taylor (1991) described the negative responses to have a pattern of *mobilization-minimization*. He described that negative emotional responses are initially 'mobilized' more rapidly than the positive. Also it is quickly minimized afterwards to restore the bodily functions to a normal state. Otherwise, prolonged negative emotional responses can be counter adaptive. Long-term fixation on negative emotions is characteristic of emotional disorders such as PTSD, anxiety disorder, depression and more (American Psychiatric Association, 2013).

In summary, it is possible that the speed (onset latency) of attentional capture is determined by valence. To verify this, the speed of capture was compared across two experiments by presenting negative and positive words with similar arousal ratings using the *emotion-induced blindness* procedure (EIB; Most et al., 2005), also known as emotional attentional blink (McHugo, Olatunji, & Zald, 2013). EIB was adopted because it is specialized in measuring the time-course of distractor processing. In a typical

EIB procedure, an emotional distractor is presented among a rapid stream of filler objects that visually mask previous objects. Meanwhile, participants perform a task regarding a target stimulus presented at several different *lags* (number of positions after the emotional distractor). If the distractor successfully captures attention, target processing at temporally closer lags are prevented, resulting in emotion-induced blindness. The EIB procedure has consistently produced meaningful results across different types of stimuli such as emotional pictures (e.g., Most et al., 2007), words (e.g., Arnell et al., 2007; Barnard, Ramponi, Battye & Mackintosh, 2005; Barnard, Scott, Taylor, May, & Knightley, 2004), and faces (e.g., Maratos, 2011; Srivastava & Srinivasan, 2010; Stein, Zwickel, Ritter, Kitzmantel, & Schneider, 2009).

A significant advantage of EIB is its temporal resolution of measurement. Given the duration of each lag is 100ms, performance can be measured every 100ms after distractor presentation. Compared to procedures previously used for studying emotion-attention interactions such as backward masking (e.g., Pessoa, Japee, & Ungerleider, 2005), dot probe task (e.g., MacLeod, Mathews, & Tata, 1986), emotional Stroop (Williams, Mathews, & Macleod, 1996), and visual search (Öhman et al., 2001), it is much easier to observe the temporal changes in emotional information processing.

The EIB phenomenon can be explained with a two-stage bottleneck model which was proposed to explain the *attentional blink* (AB). AB is similar to EIB, but involves the presentation of two targets instead of one distractor and one target (Chun & Potter, 1995; Raymond, Shapiro, & Arnell., 1992). According to the model, all stimulus items in the rapid serial visual presentation (RSVP) first undergo a stage of perceptual and semantic processing that occurs in parallel. After presentation, representations of the stimuli compete to enter the second stage of a limited-capacity central bottleneck related to conscious awareness. Chun and Potter (1995) explain that when the representation of the first target enters the second stage, it depletes the capacity limited attentional resources causing an attentional blink that prevents the subsequent target from reaching awareness.

Despite the resemblance, AB and EIB paradigms are different in two major ways. First, AB involves a top-down process because active searching of the first target causes the blindness, while EIB involves a bottom-up process because involuntary attraction of attention causes the blindness. Another difference is that AB occurs even if the targets appear at different locations, which implies an overlap in a central resource (Jiang & Chun, 2001), but EIB does not occur if the distractor and target are presented at different locations. It has been suggested, that EIB stems from a perceptual competition between distractor and target representations that occur in stage 1 (Most & Wang, 2011; Wang, Kennedy, & Most, 2012).

The perceptual competition in stage 1 can also account for the attentional capture speed differences between positive and negative information. In accordance with the mobilization-minimization pattern, negative representations may recruit more perceptual resources increasing the level of competence, thus reaching the second stage earlier. If negative information reaches stage 2 early, central resources necessary for target processing will deplete earlier and EIB will be observed in earlier lags. However, if positive representations do not increase perceptual competition, central resources will deplete slowly and EIB latency will be pushed back to later lags.

Experiment 1

The main purpose of Experiment 1 was to compare the time-course of attentional capture or simply EIB, induced by positive and negative distractor words, to determine whether valence modulates the speed of EIB. A positive or negative distractor word was presented among filler stimuli, and a target word followed distractor presentation at six different lags (1, 2, 3, 4, 5 & 8). Random category neutral words were presented as fillers which reduced confounding factors of contrast between distractor and fillers, compared to when numbers, symbols, or pseudo-words are presented as fillers. Lags 1-5 were intended to measure the onset of attentional capture while lag 8 was intended to measure whether distractor processing would persist until 800ms after presentation. Emotional distractors were compared in a between-subject manner, thus the emotional effect was referenced to two separate baselines for each experimental group, in which neutral words were presented instead of emotional distractors.

If valence determines the speed of attentional capture, EIB of positive and negative distractors would start and peak at different lags, and negative responses will likely be faster than the positive. If the capture speed is determined by other factors such as arousal, differences in EIB latency will not be significant. Also it is important to note that since arousal is related to the intensity of attentional capture, positive and negative distractors with same arousal levels will induce similar sizes of EIB.

Method

Participants Thirty-six undergraduate participants from Korea University were recruited via the Internet and were paid 7,000 KRW for participation. Participants were aged between 18 and 27 (M = 21.72, SD = 2.29) years. All participants were native Korean speakers and were reported to have normal or corrected-to-normal visual acuity. None reported of having any history of clinical emotional disorders. Participants were divided into two experimental groups (positive vs. negative distractor groups) both similar in age, $t(34) = 1.48$, $p = .15$, $d = 0.51$, and gender ratio (positive: 9 male, 9 female; negative: 8 male, 10 female) for between-subject comparison.

Apparatus The experiment was conducted in a dark sound proof chamber with a Pentium R Dual Core PC with 2GB memory. The attached CRT monitor was 17-inches in size and had a resolution of 1024*768 and a refresh rate of 85 Hz. Responses were collected with a standard keyboard. Stimuli presentation and response collection were controlled by E-Prime 2.0 Professional software (Psychology Software Tools, Pittsburgh, PA).

Stimuli Stimulus words were always presented at the center of the monitor in Courier New font, size 18, which was viewed from a distance of 60cm and at a visual angle of 1.43°. Unlike the English alphabet, the written length of each syllable is always identical in the Korean character system.

Four hundred forty-six random two-syllable Korean words were rated by a separate group of sixteen participants in terms of affective valence and arousal prior to the experiment for stimulus selection. These participants were students of Korea University, aged between 20 and 30, who participated for partial course credit. Each criterion was measured with 9 point scales of self-assessment manikins (Bradley & Lang, 1994). For valence, scores lower than 5 represent negative valence and higher scores represent positive. For arousal, lower scores represent low arousal levels and higher scores represent high arousal levels. Stimuli used for both Experiments 1 and 2 were selected from this pool of affectively rated word stimuli. For Experiment 1, one hundred fifty-eight words with neutral valence (M = 5.23, SD = .58) and mid-level arousal (M = 4.66, SD = .60) were chosen as fillers (see Table 1). Thirty-two words of negative valence (M = 2.31, SD = .72) and high arousal (M = 7.41, SD = .63) were used as critical negative distractors. Thirty-two words of positive valence (M = 7.11, SD = .78) and high arousal (M = 7.51, SD = .71) were chosen as critical positive distractors. The neutral filler words and negative distractor words both statistically differed in terms of both valence, $t(188) = 24.92$, $p < .05$, $d = 3.63$, and arousal $t(188) = -24.34$, p

Table 1. Mean valence and arousal of selected positive-negative-neural stimuli and independent T-Test results for Experiment 1.

Stimuli Type	N	Valence		Arousal		Independent T-Test		
		M	SD	M	SD	Positive	Negative	Neutral
Positive	32	7.11	0.78	7.51	0.71	-	V* A	V* A*
Negative	32	2.31	0.72	7.41	0.63	V* A	-	V* A*
Neutral	158	5.23	0.58	4.66	0.60	V* A*	V* A*	-

Note. * $p<.05$

$< .05$, $d = -3.55$. Neutral fillers also statistically differed from positive distractors in terms of valence, $t(38.23) = -12.92$, $p < .05$, $d = -4.18$, and arousal, $t(188) = -24.42$, $p < .05$, $d = -3.56$. The positive and negative distractors were different in terms of valence, $t(62) = -25.56$, $p < .05$, $d = -6.49$, but were similar in arousal, $t(62) = 0.013$, $p = .99$, $d < .01$. At last, thirty-four animal words of random species were selected as target stimuli.

Word frequency of the emotional distractors were measured and analyzed because words with low frequency are usually associated with longer visual fixation (e.g., Johnson, Thompson, & Frincke, 1960; Solomon & Postman, 1952) and longer naming and lexical decision latencies (e.g., Besner & McCann, 1987). Word frequency estimates for the distractors were found using the corpus provided by KKMA (Lee, Yeon, Hwang, & Lee, 2010). Negative distractors ($M = 743.59$) were less frequent in the corpus than the positive ($M = 1639.25$). The frequency of neutral fillers was in between the two distractor types ($M = 1284.19$). When the word frequency was correlated with target accuracy for each word, no significant relationship was observed, $r(64) = .18$, $p = .08$. Furthermore, we sorted positive and negative words according to word frequency and divided them into more and less frequent groups. Paired t-test comparison of the accuracy between two groups did not reveal a significant difference, $t(31) = -0.65$, $p = 0.26$, $d = -0.24$.

Procedure To prevent emotional interference, participants were divided into two groups for between-subject comparison. Each group carried

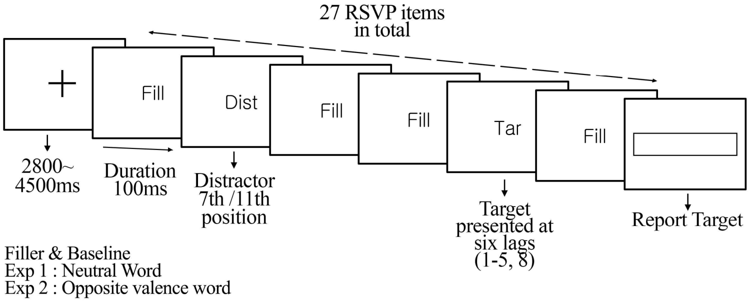

Figure 1. Schematic representation of the experimental procedure. In Experiment 1, negative, positive, or neutral word distractors were presented among an RSVP of neutral word fillers. In experiment 2, negative or positive distractors were presented among opposite valence fillers.

out baseline (neutral word) and emotional (positive or negative word) trials.

At the beginning of each trial, a fixation cross appeared at the center of the screen for a random interval between 2,800ms to 4,500ms. An RSVP of twenty-seven words followed after. Each word lasted for 100ms. A critical distractor randomly appeared at the seventh or eleventh position to reduce effects of expectation. A target animal word randomly appeared at lags 1, 2, 3, 4, 5 and 8. For baseline, neutral words were presented instead of emotional words. At the end of each trial, a small typing box appeared where participants reported the target word.

Participants were instructed to type in the target animal word and press enter. They were encouraged to press space and enter when target detection failed, and also were advised to watch out for typing errors. When participants pressed enter without any input, the response box reappeared to prevent accidental trial skipping. Participants carried out twelve practice trials and two-hundred sixteen main trials in total. A 30 second break was given every forty trials.

Results

Misspelled responses of target animal words were corrected for accurate data analysis. The possibility of an experimenter bias during this process was minimal because the target animal words were easy and common enough to tell apart despite the typing errors. Mean accuracy was calculated with the corrected data for the four distractor variables (negative-distractor, negative-baseline, positive-distractor, and positive-baseline: separate baseline for each group for intergroup baseline performance comparison) and six lags.

First, a two-way ANOVA was conducted for performance accuracy of the positive and negative distractors without baselines as a between-subject variable and lag (1-5, & 8) as a within-subject variable (see Figure 2). The distractor main effect was not statistically significant, $F(1, 45) < 1.0$. There was no difference in performance accuracy between positive and negative distractor types. The effect of lag did reach statistical significance, $F(5, 45) = 3.27$, $p < .05$, $MSe = 0.03$, $\eta_p^2 = .09$ which suggests performance accuracy was influenced by lag. The interaction between distractor and lag was significant, $F(5, 45) = 2.38$, $p < .05$, $MSe = 0.02$, $\eta_p^2 = .07$. Performance accuracy across different lags was statistically different for the two distractor types. In addition, the effect of lag was analyzed separately for positive and negative distractors one-way ANOVA and Tukey's post-hoc analyses. The effect of lag was significant when the distractors were negative, $F(5, 22) = 4.20$, $p < .05$, $MSe = 0.05$, $\eta_p^2 = .20$. Post-hoc analysis revealed significant performance deficits at lags 2 and 3. The effect of lag did not reach significance when the distractors were positive, $F(5, 22) < 1.0$. Performance accuracy did not differ across lags when positive distractors were presented.

To remove confounding group characteristics, the mean accuracy of both distractor types was subtracted from each corresponding baseline accuracy (see Figure 3). Two-way ANOVA for distractor types and six lags (1-5, & 8) were conducted with the subtracted data. There was no two-way interaction, $F(5, 45) = 1.91$, $p = .09$, $MSe = 0.03$, $\eta_p^2 = .05$. The distractor

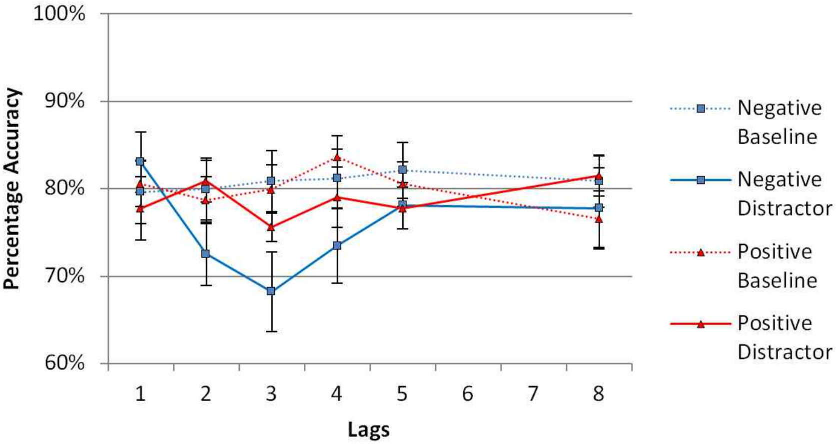

Figure 2. Percentage accuracy of Experiment 1 as a function of distractor types and lags (1-5, 8) before subtracting positive and negative distractor accuracy from baseline accuracy.

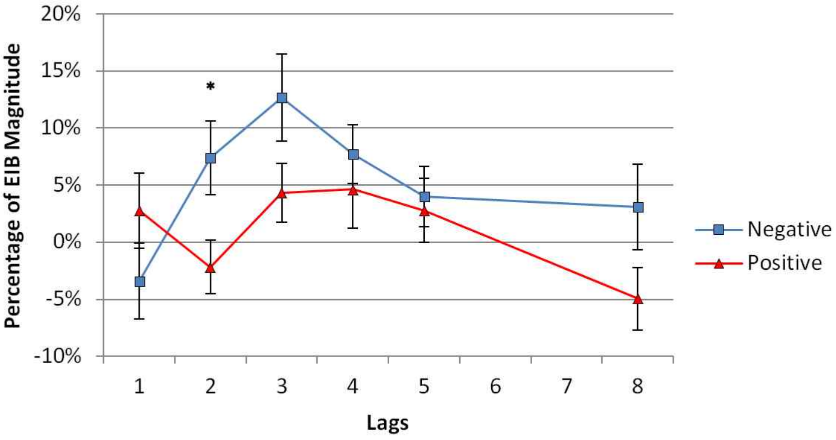

Figure 3. EIB percentage of Experiment 1 as a function of distractor types and lags (1-5, 8), acquired by subtracting positive and negative distractor accuracy from baseline accuracy. Note. * $p < .05$

main effect was significant, $F(1, 45) = 4.70$, $p < .05$, $MSe = 0.09$, $\eta_p^2 = .12$. Performance was significantly more impaired when the distractor was negative than when the distractor was positive. The effect of lag also reached significance, $F(5, 45) = 2.86$, $p < .05$, $MSe = 0.05$, $\eta_p^2 = .08$. Performance of the two distractor did show EIB across six lags. A t-test between distractors types at individual lags revealed a significant difference at lag 2, $t(34) = 2.39$, $p < .05$, $d = 0.82$.

Discussion

Contrary to our prediction, positive distractors failed to induce an EIB effect therefore it was not possible to compare the speed of attentional capture. One possibility of the absence of EIB for the positive distractors could be the lack of control for the anxiety level between the experimental groups. The anxiety level of individuals is known to create attentional biases towards threatening stimuli (e.g., Mathews & MacLeod, 1994). People with clinical anxiety or sub-clinical high-trait anxiety levels are known to be more likely to pay attention to threatening words (Barnard et al., 2005; Broadbent & Broadbent, 1988; MacLeod, et al., 1986). People with low-trait anxiety are not as responsive towards threatening words and sometimes they tend to show reverse effects, suggestive of avoidance (Macleod & Mathews, 1988; Mogg, Bradley, & Hollowell, 1994). It is possible that the positive distractor group had significantly lower anxiety levels thus nullifying any EIB effects.

The second possibility is that participants may have perceived positive stimuli to be less salient compared to negative words due to positively biased neutral fillers. Although, the valence of neutral words significantly differed from positive and negative ones, the neutral-positive mean difference (1.88) is smaller than the neutral-negative difference (2.92). Positive distractors may have appeared less salient compared to negative distractors. Experiment 2 was conducted with possible solutions to these two issues.

Experiment 2

The main purpose of Experiment 2 was same as Experiment 1, which was to compare the time-courses of EIB induced by positive and negative distractors. In addition, issues regarding state-trait anxiety and distractor saliency were addressed by applying two key aspects. First, the Korean version of Spielberger *state-trait anxiety inventory* (STAI: Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was administered to compare anxiety levels of experimental groups (see Methods, Participants section). Second, neutral fillers were substituted with opposite (to the distractor) valence words. When a positive distractor was presented, negative words were presented as fillers, and vice versa. As an advantage, the mean valence difference of positive and negative distractors between distractor and baseline becomes equal which prevents a saliency bias toward a particular valence.

The predictions are also similar to Experiment 1. If emotional valence influences the speed of attentional capture, negative distractors would likely cause EIB at faster lags than the positive ones.

Method

Participants Forty-three undergraduate students enrolled in *Understanding Psychology* at Korea University and recruited via the Internet participated in partial fulfillment of a course requirement or for monetary reward of 7,000 KRW. Data of seven participants were discarded because of outlying trait STAI scores (less than 27 and more than 62 raw scores, or less than -2 or above 2 z-scores) and performance error (less than 50% performance accuracy). Participants with outlying trait STAI scores were removed so that experimental groups can represent a population with typical vulnerability towards psychopathology (Yiend, 2010). Participants were aged between 18 and 35 years (*M* = 21.69, *SD* = 3.81). All participants were native Korean speakers and had normal or corrected-to-normal visual acuity. None reported of having any history of clinical emotional disorder. Participants were divided into two experimental groups (positive vs. negative distractor groups) of eighteen, both matched in age, $t(34) = 0.28$, $p = .78$, $d = 0.10$, and gender ratio (8 male, 10 female for both groups) for between-subject comparison. Before the experiment, participants filled out an STAI questionnaire for measuring trait and state anxiety. The average state, $t(27.43) = 1.19$, $p = .25$, $d = 0.45$, and trait, $t(34) = 1.40$, $p = .17$, $d = 0.48$, STAI scores were not significantly different between two groups.

Stimuli Word stimuli were selected from the same pool of affectively rated words that stimuli from Experiment 1 were chosen from. Forty-three positive words with positive valence ($M = 7.08$, $SD = .63$) and high arousal ($M = 7.59$, $SD = .55$) levels were chosen as well as forty-three negative words with negative valence ($M = 2.29$, $SD = .55$) and high arousal ($M = 7.58$, $SD = .47$) levels (see Table 2). The arousal levels were not significantly different, $t(84) = -0.04$, $p = .97$, $d = -0.01$, while valence levels were, $t(84) = -37.60$, $p < .05$, $d = -8.20$. Target words were the same thirty-four animal words from Experiment 1. The word frequency of negative distractors were less frequent in the corpus than the frequency of positive distractors ($M = 903.42$ and $M = 1737.56$, respectively). There was no significant correlation between word frequency and accuracy, $r(86) = -0.99$, $p = .18$. Furthermore, we sorted positive and negative words according to word frequency and divided them into more and less frequent groups. Paired t-test comparison of the accuracy between two groups did not reveal a significant difference, $t(43) = 1.54$, $p = .07$, $d = 0.47$.

Procedure The design was identical to Experiment 1. The procedure was also identical to Experiment 1 with one exception: the valence of fillers were not neutral but were opposite to the distractor. When the distractor was positive, fillers were negative, and when the distractor

Table 2. Mean valence and arousal of selected positive-negative stimuli and independent T-Test results for Experiment 2.

Stimuli Type	N	Valence		Arousal		Independent T-Test
		M	SD	M	SD	
Positive	43	7.08	0.63	7.59	0.55	V*
Negative	43	2.29	0.55	7.58	0.47	A

Note. * $p<.05$

was negative fillers were positive. Also the baseline word for positive distractors was negative and the baseline word for negative distractors was positive.

Results

Typing errors were corrected before calculating mean accuracy. A two-way ANOVA was conducted for two distractor types (positive vs. negative) as between-subject variables, and six lags (1-5, 8) as within-subject variables (see Figure 4). The main effect of distractor reached significance, $F(1, 45) = 6.67$, $p < .05$, $MSe = 0.25$, $\eta_p^2 = 0.16$. Tukey's post-hoc analysis revealed that performance accuracy of positive distractors were lower than the accuracy of negative distractors. The main effect of lag also was significant, $F(5, 45) = 9.41$, $p < .05$, $MSe = 0.07$, $\eta_p^2 = 0.22$. Post-hoc revealed that overall performance was significantly more impaired at lags 2 to 5 compared to lags 1 and 8. Two-way interaction between distractor and lag was not significant, $F(5, 25) < 1$.

The mean accuracy of both distractor types was subtracted from each corresponding baseline accuracy to remove confounding group characteristics as in Experiment 1. The subtracted data were also analyzed with two-way ANOVA (see Figure 5). The distractor main effect was not significant, $F(1, 45) = 1.93$, $p = 0.17$, $MSe = 0.03$, $\eta_p^2 = 0.05$. Distractor valence did not influence the overall magnitude of performance deficit across six lags. The main effect of lag was significant, $F(5, 45) = 8.88$, $p < .05$, $MSe = 0.09$, $\eta_p^2 = 0.21$. Tukey's post-hoc analysis suggests performance was significantly more impaired at lags 2 to 5. The

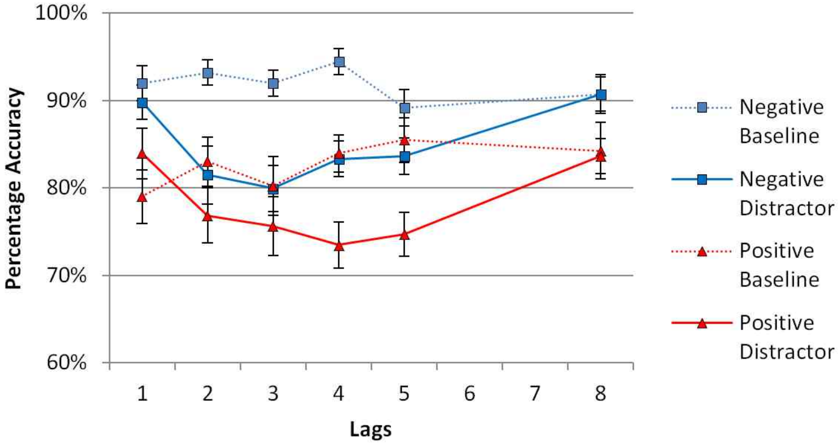

Figure 4. Percentage accuracy of Experiment 2 as a function of distractor type and lag (1-5, 8) before subtracting positive and negative distractor accuracy from baseline accuracy.

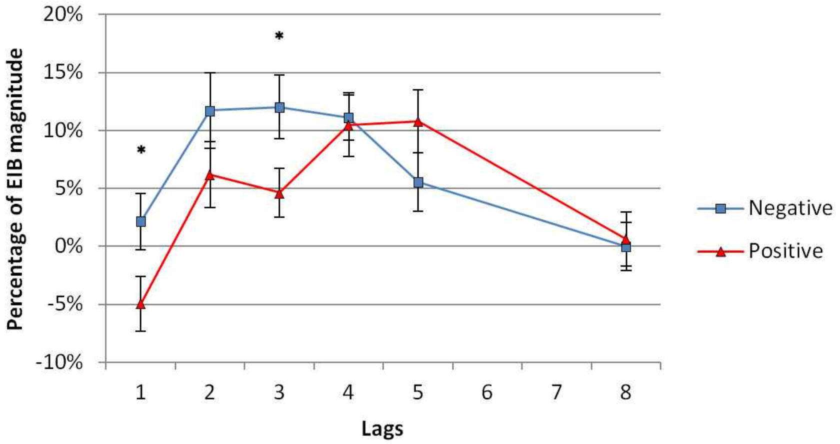

Figure 5. EIB percentage of Experiment 2 as a function of distractor type and lag (1–5, 8) acquired by subtracting positive and negative distractor accuracy from baseline accuracy. Note. * $p〈.05$

two-way interaction nearly approached significance, $F(5, 45) = 2.20$, $p = 0.06$, $MSe = 0.02$, $\eta_p^2 = 0.06$. It is highly probable that distractor types influenced the time-course of EIB across lags. Separate one-way ANOVA for each distractor was conducted for closer examination. For the positive distractor type, main effect of lag reached significance, $F(5, 22) = 6.25$, $p < .01$, $MSe = 0.07$, $\eta^2 = 0.22$. Tukey's post-hoc analysis indicates performance was most impaired at lag 5 ($p < .05$). Main lag effect for negative distractors was also significant, $F(5, 22) = 4.82$, $p < .01$, $MSe = 0.05$, $\eta^2 = 0.25$, and post-hoc suggests performance at lags 2 to 4 were significantly more impaired than the rest ($p < .05$). A t-test between distractors types at individual lags revealed a significant difference at lag 1, $t(34) = -2.09$, $p < .05$, $d = -0.72$, and lag 3, $t(34) = -2.14$, $p < .05$, $d = -0.73$.

Discussion

Unlike Experiment 1, positive distractors did induce an EIB effect as predicted (see Figure 5). This result is consistent with the assumption that emotional distractors with same arousal levels would induce similar amounts of attentional capture. More importantly, nearly significant speed difference of capture was observed when between-group confounds were removed. For negative distractors, EIB latency began at an early stage of lag 2 and diminished after lag 4. In contrast, EIB began slower and peaked at lag 5 for positive distractors.

General Discussion

This study mainly observed how positive and negative emotional words impact the time-course of attentional capture process. The main prediction was that valence is responsible for modulating the speed of attentional capture under the assumption that similar levels of arousal induce similar intensity of capture. A comprehensive interpretation of the current results indicates it is highly probable that the speed of attentional capture is modulated by emotional valence. Consistent with our predictions, capture began earlier for negative distractors than positive distractors. EIB latency for the negative emotional distractor peaked and diminished at earlier lags compared to that of the positive (see Figure 5).

These results are compatible with both explanations that attribute the cause of blindness to the second stage source depletion, or the first stage perceptual competition. Jiang and Chun (2001) explains that AB occurs because target representation enters the capacity limited second stage and depletes the resources required for processing another target. However, Most, Wang and colleagues (2011, 2012) discovered that blindness caused by emotional distractors are spatially localized while non-emotional distractors are not. They suggested that the source of emotion-induced blindness has a different mechanism from the source of non-emotional blindness which is the perceptual competition between distractor and target stimuli. However, this study was not intended to observed spatial localization thus the observed speed differences of attentional capture could be explained by either the different speed of the second stage resource depletion or the first stage perceptual competition.

The current study disambiguate the role of valence and arousal, and gives more insight into what properties of emotional stimuli influence different aspects of attention. Although the role of arousal is relatively well known, the role of valence independent from arousal has not been tested thoroughly. In fact, many previous studies that report differences in emotional responses between valences did not take valence and arousal into consideration (Maratos, 2011; Öhman et al., 2001) or did not control the stimulus affective dimensions systematically enough (Anderson, 2005; Arnell et al., 2007; Barnard et al., 2005; Keil & Ihssen, 2004). In other words, stimuli of different valences were compared even though arousal levels were not matching. In this study, an impartial comparison of negative and positive valences was possible due to matching the arousal levels of distractors which enables us to conclude that differences in the time-course of EIB is due to valence and not arousal.

Distractor Saliency

Some variants of the AB or EIB procedure highlight or discriminate targets and distractors from fillers using physical features (e.g., color, scrambled pictures, orientation, configuration; Anderson, 2005; Anderson & Phelps, 2001; Eo, Joo, & Chong, 2013; Maratos, 2011; Most et al., 2005, 2007; Stein et al., 2009) or semanticity (e.g. false-font, symbols, & numbers; Huang, Baddeley, Young, 2008; Stein, Zwickel, Kitzmantel, Ritter & Schneider, 2010) in order to control the saliency between stimulus items. In this study, all items in the RSVP were meaningful words, For example, highlighting a distractor word in red presented among a stream of word fillers increases the chance of and the intensity of the attention capture. Also, presenting a word stimuli among a stream of pseudo-word, non-word or even non-character symbols also increases the saliency of the distractor. However, the use of such extraneous methods to increase distractor saliency also confounds the results. It becomes harder to determine exactly how much the critical characteristics of the distractor has contributed to capturing attention (Barnard et al., 2005). In this study therefore, all items in the RSVP were meaningful words which guaranteed that the emotional meaning of the distractor is responsible for EIB responses.

Other than the efforts to reduce extraneous distractor saliency by using meaningful words, another method was used to increase distractor saliency which did not introduce any other confounding factors of saliency. In Experiment 2, the neutral stimuli were completely excluded and fillers were substituted with the opposite valence distractors so that saliency of emotional distractors is mutually referenced and remains constant across the RSVP. Mutual referencing of valences dramatically increased the saliency of distractors because positive-negative valence difference is much greater than either positive-neutral or negative-neutral valence difference. In elaboration, the use of neutral words which had a valence rating in between the ratings of positive and negative distractor words as fillers introduced a reference point that halves the saliency compared to when the distractors are mutually referenced.

In addition, by using neutral words as fillers, achieving identical levels of difference for both negative-neutral and positive-neutral valence intervals during stimulus selection becomes an issue. It is possible that positive or negative biasing of neutral words can skew the results of the current study. Actually, an perfectly impartial group of neutral stimuli is hard to select and in practice we did observe asymmetrical rating differences in Experiment 1 (see Table 1). In fact, the valence of neutral fillers were slightly positive which could have attenuated the saliency of the positive distractor and lead to the failure of inducing an EIB response.

State-Trait Anxiety

It is imperative that the anxiety level of participant groups is matched when comparing positive and negative stimuli in a between-subject design because participants with high trait and state anxieties are known to be more sensitive towards emotional contents (Arend & Botella, 2002; Barnard et al., 2005; Broadbent & Broadbent, 1988; Yiend, 2010). Therefore, it is possible that the difference in anxiety level between the two groups influenced the results of Experiment 1, since anxiety was not measured. Specifically, if the negative distractor group had high trait anxiety and the positive group had low trait anxiety, the negative group would induce EIB while the positive group would not as in Experiment 1. A negative group with high anxiety would have shown an exaggerated EIB response to the emotional distractors while a positive group with low anxiety would have shown a smaller EIB response. In addition, despite the fact that participants denied having clinical record of affective disability, other sub-clinical tendencies may have caused a decreased sensitivity towards the positive distractors. For example, anxiety and depression frequently co-occur (Persons, Roberts, & Zalecki, 2003) and markedly diminished interest or pleasure in all or almost all activities is a characteristic symptom of depression (American Psychiatric Association, 2013). It is possibly beneficial for future studies that compare negative and positive stimuli, to consider the influence of depression as well as anxiety.

Spatiotemporal Localization

Most and Wang (2011) suggest that blindness caused by emotional stimuli are spatially localized while that of non-emotional stimuli are not. In their Experiment 4, They presented a negative distractor photo and a target landscape photo in two streams of neutral photos. The distractor and target photos were either presented in the same stream or the opposite stream while participants report the orientation of the target photo. They discovered that EIB occurred when targets appeared at the same stream but not when they appeared at a different stream. In Experiments 1, 2 and 3, non-emotional letters, digits and photos, defined as targets and distractors in terms of color, were presented in two separate streams of filler stimuli as well. In contrary to Experiment 4, blindness occurred regardless of the stream where targets and distractors were presented. Researchers concluded that emotion-induced blindness is localized and reflects a perceptual competition in Stage 1. However, conclusion of Most and Wang (2011) is based on results produced by negative stimuli. It is possible that emotion-induced blindness is not spatially localized when positive stimuli are presented.

In fact, spatial localization can be accounted by a size change in the attentional scope. Eriksen and James (1986) suggested that attention behaves as a 'zoom lens' which constantly controls the size of scope of attention. In relation to emotion, being in positive states of emotion is known to broaden the scope of attention (Derryberry & Tucker, 1994; Rowe, Hirsh, & Anderson, 2007). Inversely, being in negative states of emotion, narrows the scope of attention which is sometime called "weapon focus" (Derryberry & Tucker, 1994; Easterbrook, 1959). If this is true, positive distractors could induce EIB responses even though the target is presented in a different stream of stimuli because there will be a wider scope of attention. In reverse, negative distractors will cause the attentional scope to narrow and target processing at a different stream will not be prevented. The viability of this hypothesis will have to be answered through further research.

According to the zoom lens theory, there is a trade-off between the size of the attended spatial region and visual processing resolution (Castiello & Umilta, 1990, Eriksen & James, 1986; Eriksen & Yeh, 1985; Müller, Bartelt, Donner, Villringer, & Brandt, 2003). When the scope increases, the processing resolution decreases for a fixed area of visual field, and vice versa. The trade-off is observable in Experiment 2 where an unexpected additive baseline shift in EIB between the two distractor types was observed (see figure 4). In Experiment 2, each experimental group was exposed to the absolute majority of either positive or negative filler words. It is possible that the positive group (negative fillers) would eventually enter a more negative emotional state in which the scope of attention narrows and increases the processing resolution. In turn, increased resolution increases the possibility of task-irrelevant fillers capturing attention. In reverse, the negative group (positive fillers) would enter a more positive or at least neutral state relative to the positive group. The scope of attention would broaden and resolution would decrease which would also decrease the possibility of positive fillers from capturing attention. However, variation in processing resolution would have minimal influence of the processing of distractors words because any confounding factors that contributed to the baseline shifting was removed from the results by subtracting distractor accuracy from baseline.

In conclusion, the present study compared the ability of emotional valence to capture voluntary attention by presenting positive and negative emotional distractors with an EIB procedure. The major finding is that given the same level of arousal, emotional valence seems to alter the latency of EIB onset. However, there are many ways to classify types of emotion or emotional information, thus a consensus has yet to been reached on how they influence our attentional system. This study provides a valuable additional piece of evidence for deepening the comprehensive understanding of complex human emotion.

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정서적 가치의 비자발적 주의획득 속도조절 효과

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정서적 정보는 정서 중립적 정보에 비해 비자발적 주의를 쉽게 획득한다. 기존 연구에 의하면 유발된 주의획득의 정도는 정서적 정보의 각성도와 상관이 있다고 한다. 한편, 다른 근거에 의하면 주의획득의 유발속도는 정서적 정보의 긍정적 혹은 부정적인 정서적 가치에 의해 결정된다고 한다. 본 연구에서는 비슷한 각성수준의 긍정 및 부정적 정서자극이 유발하는 주의획득속도를 비교하였다. 이를 위해 시간에 따른 주의효과의 변화를 측정할 수 있는 주의유발맹(EIB) 실험법을 본 연구 전반에 사용하였다. 실험1에서는 중립단어가 빠르게 제시되는 가운데 긍정적, 부정적 단어 방해물을 제시하였다. 방해물 제시 이후 1-5, 8번째 자리에 보고해야하는 동물 단어 목표물을 제시하였다. 실험 2에서는 긍정 및 부정적 방해물들의 제시가 반대의 정서적 가치를 지닌 단어들이 제시되는 가운데 이루어졌다. 결과적으로 부정적 방해물은 2번째부터 4번째 자리 사이에서 빠른 주의획득 효과를 유발하였고, 긍정적 방해물은 서서히 증가하다가 5번째 자리에서 최고점을 찍는 느린 주의획득 효과를 유발하였다. 따라서 정서적 방해물들의 각성도가 비슷하다면 정서적 가치에 의해 주의획득의 유발속도가 조절된다고 결론지을 수 있다.

주제어 : 주의획득, 정서, 정서적 가치, 각성도, 정서유발맹(EIB)