博士論文

Measurement and Modification for Attentional Bias in Depression and Anxiety

（抑うつ及び不安における注意バイアスの測定と修正）

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Chapter 1: Introduction

1. Depression

Depression is one of the most common mental disorders worldwide and places a heavy burden on individuals and society. The total amount of disability caused by depressive disorders is so large that depression is estimated to carry a significant burden of disease (Ferrari et al., 2013). Moreover, depressive disorder is one of the most common causes of suicide. The estimated risk of suicide caused by depressive disorder varies in the literature; however, previous studies have reported that there is a strong relationship between depressive disorders and suicide attempts or suicidal ideation (e.g., Harris & Barraclough, 1997; Ferrari et al., 2013; Hawton, Comabella, Haw, & Saundes, 2013). Today, it is essential to explore ways to prevent and cure depression to reduce individuals' mental suffering and economic waste in society caused by depression.

Though depression has been a target of research for many years, it is still difficult to create a definition of depression that can gain universal consensus. Beck and Alford (2009) define depression in terms of a) sad or lonely mood, b) negative self-concept, c) feelings of guilt and self-punitive wishes, d) loss of motivation, e) change in activity. According to the diagnostic manual from the American Psychiatric Association (DSM-5, American Psychiatric Association, 2013), major depressive disorder, one of the depressive disorders, is diagnosed by 2 weeks of depressive episodes, which include depressed mood or loss of interest, and other depressive symptoms

The word "depression" indicates a variety of concepts. Depressive disorders are of course included in depression; however, depressive mood is also included in the broader sense of depression. Depressive mood is a discouraged, sad state of mood that varies widely in intensity. Depressive mood sometimes continues for only a short period, but it can continue for two weeks or more. When depressed mood arises in individuals, cognitive and somatic dysfunction such as anhedonia, suicidal ideation or sleep disturbance appear, known as depressive symptoms. A short period of depressed mood and co-occurrence of depressive symptoms are experienced even in the daily life of individuals without clinically diagnosed depression. Researchers pointed out that there is a similarity between depressive disorders and low or “blue” mood commonly experienced by healthy individuals (Wessman & Ricks, 1966). Moreover, there is some evidence to support the continuity between depressive disorders and depressed mood in normal mood swings by taxometric analysis (Hankin, Fraley, Lahey, & Waldman, 2005; Meehl, 1995). If both depressive disorders and light depressive mood experienced in daily life are on the same spectrum, there may be common underlying factors. Thus, it is also important to investigate depressive mood and depressive symptoms in daily experience to reveal the mechanism of depression and to develop effective intervention for depressive disorders. Based on these previous studies, I posit the continuity between diagnosed depressive disorders and self-reported depression in non-clinical individuals in this doctoral thesis.

2. Depressive cognition

What is the key factor of depression, and how depression can be treated? To answer this question, Beck (1967) noted the cognitive aspect of depression. Beck (1967) hypothesized that individuals with depression display a peculiar tendency in information processing, which is called depressive cognition. When the level of depression rises in individuals, characteristic latent beliefs, or depressive schema, are assumed to be activated. Once a depressive schema is activated, individuals process external and internal information in accordance with that depressive schema. A depressive schema contains negative beliefs about self, the world, and the future. Thus, individuals with higher levels of depression tend to process information in a more negative way than mentally healthy individuals. For example, individuals with depression would understand an ambiguous message in a letter as a rebuke for them since they have negative self-image in their depressive schema. Individuals with depression would feel hopeless when they made a mistake at work since they have negative beliefs about their future. In this way, once depressed, individuals maintain and strengthen their depressive mood via depressive cognitions, which leads to difficulty in recovery since they struggle to process positive aspects of life events because of selective processing of negative information.

This cognitive model of depression assumes that once a depressive schema is activated, individuals cannot easily recover from depression because of depressive cognitions. Moreover, if depressive cognitions are not modified, they tend to relapse into depression even after their depression is cured, and depression has a very high relapse rate. Conversely, if I can eliminate depressive cognitions, the depressive mood would no longer be maintained, and individuals would become able to process the positive aspects of information, reducing depression.

Thus, the main purpose of cognitive therapy for depression, a treatment based on the cognitive theory of depression, is to modify depressive cognitions. Researchers have investigated depressive cognition in detail, applying perspectives from cognitive psychology such as memory, interpretation, and attention (Wisco, 2009). Previous studies found negatively biased information processing in various aspects of cognitive functions. For example, previous studies have reported that there is a negative memory bias in depression: individuals with depression tend to memorize negative information more than neutral or positive information (e.g., Bradley & Mathews, 1988; Ingram, Smith, & Brehm, 1983), and they tend to remember negative autobiographic memory in their daily life (e.g., Rottenberg, Hildner, & Gotlib, 2006). Individuals with depression also tend to interpret neutral, ambiguous feedback as negative (Cane & Gotlib, 1985), which is called negative interpretation bias. Moreover, selective attention to negative stimuli in individuals with depression has been eagerly investigated in these decades (Peckham, Otto, & McHugh, 2010). The cognitive psychological approach for depression is not only based on the cognitive theory of Beck (1967), but also guided by the associative network theory of Bower (1981), who proposed a mood-congruent effect. The mood-congruent effect is a promotive effect on processing information, which has a congruent emotional valence with individuals’ mood. On the other hand, it is expected that information with emotional valence incongruent with individuals’ mood is difficult to process. From the perspective of associative network theory, it should be easier for individuals with elevated depressed mood to process information related to sad mood or loss than to process information related to positive or happy emotion, due to the mood-congruent effect. From this viewpoint, attentional bias seems to be a state-like information processing style, which appears when depressive mood arises, and disappear when depressive mood becomes low. In the present doctoral thesis, I generally treat cognitive bias as a state-like information processing style. However, there are evidences which showed negative cognitive bias in individuals recovered from depression (e.g., Joorman & Gotlib, 2007). Moreover, individuals can be trained to control their attention away from negative stimuli regardless of emotional change (e.g., Nishiguchi, Takano, & Tanno, 2015). Thus it seems that changes in attentional bias remains even after individuals' emotional state changed, when individuals were intensively habituated to attentional bias or trained to modify their attention.

Today, the cognitive psychological approach has become a popular means by which to investigate depression, and depressive cognitive bias has also been reported in non-clinical samples with elevated depressed mood. To prevent the onset and relapse of depression, it is beneficial to investigate cognitive biases in non-clinical individuals with elevated depression levels and individuals with remitted depression.

3. Attentional bias in depression

As discussed above, various approaches can be used to examine the cognitive aspect of depression. Of these approaches, the investigation of depressive attentional bias has greatly progressed in the past two decades. Depressive attentional bias is a type of cognitive bias that was assumed to exist in individuals with depression based on the cognitive model. According to the cognitive model, it is expected that individuals with activated depressive schema would tend to attend to negative information selectively, and attention to positive information would be inhibited (Disner, Beevers, Haigh, & Beck, 2011). Previously, researchers examined depressive attentional bias using an emotional Stroop task, which measures the time to indicate color of emotional words. If individuals with depression attend to negative stimuli selectively, it should be more difficult to indicate the color of negative words than to indicate the color of neutral or positive words, since they spend more cognitive resources on the negative meaning of the word. Some studies reported significant attentional bias in depression with this emotional Stroop task (Gotlib & McCann, 1984; Klieger & Cordner, 1990); however, the effect was not robust, as other studies observed no significant emotional Stroop effect in individuals with depression (Hill & Knowles, 1991; Mogg, Bradley, & Williams 1993). In fact, a meta-analytic review by Peckham et al. (2010) revealed an only marginally significant effect of depressive attentional bias (d = 0.17) when the emotional Stroop paradigm was used for bias measure. In later studies on depressive attentional bias, the dot-probe task (Mathews, MacLeod & Tata, 1986) has been applied more often than the emotional Stroop task. The dot-probe task is a measure of selective attentional orienting in which paired emotional stimuli are presented at different locations. Then emotional stimuli disappear, and target stimuli appear at one of the places where emotional stimuli are presented. For example, when sad stimuli and neutral stimuli are presented at different locations at the same time, individuals with higher levels of depression should selectively allocate their attention at the place of sad stimuli but not attend to the location of neutral stimuli. Consequently, when a target appears in the place of sad stimuli, the response should be faster than when a target appears in the place of neutral stimuli. Conversely, when a target appears at a different location than the sad stimuli, the response should be slow in individuals with depression. Though early studies indicated that attentional bias in orienting appears only in anxiety but not in depression (Mathews et al., 1986; Mathews & MacLeod, 1994), this type of attentional bias has been repeatedly observed in other studies (e.g., Donaldson, Lam, & Mathews, 2007; Mathews, Ridgeway, & Williamson, 1996). A meta-analytic review by Peckham et al. (2010) also revealed a significant effect of depressive attentional bias in a dot-probe task (d = 0.52).

The dot-probe task is easy to modify, thus many modified versions of the dot-probe task have been applied in previous studies. Most often, stimuli presentation time has been manipulated to investigate the time-course of depressive attentional bias. Presentation time of emotional stimuli varied widely across the studies (14 ms to 1500 ms), and it is assumed that depressive attentional bias does not appear with a subliminal or very short presentation time of negative stimuli (Koster, De Raedt, Goeleven, Franck, & Crombez, 2005; Mogg & Bradley, 2005; Mogg, Bradley, & Williams, 1995). Often depressive attentional bias has been observed with presentation times of 1000 ms or more, but a meta-analysis by Peckham et al. (2010) revealed that 500 ms of stimuli presentation may be sufficient since there was no significant difference in effect size between studies with 1000 ms presentation and 500 ms presentation of depression-related stimuli. In addition, the type of emotional stimuli often varied across studies. The content-specificity hypothesis (Greenberg & Beck, 1989) predicts that attentional bias is only observed when the content of negative stimuli is related to sad mood or loss. However, content-specificity of depressive attentional bias is still not established since there is a possibility that socially threatening stimuli also cause depressive attentional bias. Wisco (2009) reviewed the results of studies on cognitive bias and argued that verbal stimuli are more valid for examining depressive attentional bias than pictorial stimuli; however, Peckham et al. (2010) reported that there is no significant difference in effect size of attentional bias between studies with verbal stimuli and pictorial stimuli.

Though studies with the dot-probe task have offered beneficial information, the dot-probe task has a limitation in measuring attentional orienting. According to Posner, Inhoff, Friedrich, and Cohen (1987), there are three processes in attentional orienting: shifting, engagement, and disengagement. However, the dot-probe task cannot discriminate attentional engagement from disengagement, as Fox, Russo, Bowles, & Dutton (2001) and Koster, Crombez, Verschuere, & De Houwer (2004) pointed out. Koster et al., (2005) applied an emotionally modified exogenous cueing task (Posner, 1980) and found depressive attentional bias in attentional disengagement, but not attentional engagement, and this result was replicated in individuals with clinical depression (Leyman, De Raedt, Schacht, & Koster, 2007). Koster, De Lyssnyder, Derakshan, and De Raedt (2011) related difficulty in attentional disengagement from negative stimuli to a ruminative response style, which is characterized by repetitive thinking about negative aspects of self or the negative mood itself (Nolen-hoeksema, 1991). Today, difficult attentional disengagement from negative stimuli is thought to be a key factor in negative attentional bias in depression.

4. Attentional bias in anxiety

Though the main theme of this doctoral thesis is attentional bias in depression, attentional bias is also an important factor in anxiety. A.T. Beck, who proposed the cognitive theory of depression (Beck, 1967) also theorized a cognitive model of anxiety (Beck, 1976). The cognitive theory of attention assumes the existence of an anxiety schema, which guides individuals to selectively attend to threatening information, which is an attentional bias in anxiety. This hypothesis was examined by a number of research groups, and the existence of attentional bias in anxiety has been mostly supported, as the meta-analysis by Bar-Haim, Lamy, Pergamin-Hight, Bakermans-Kranenburg, and IJzendoorn (2007) showed. However, contrary to depressive attentional bias, which is often observed in later stages of attentional process, it is still difficult to determine what process is biased in attentional bias in anxiety. For example, some groups have proposed that attentional bias in anxiety affects the early process of attentional orienting, such as the early stage of detecting engagement (e.g., Mogg, Bradley, Miles, & Dixon, 2004; Williams, Mathews, & MacLeod, 1996). In particular, Mogg et al. (2004) argued that individuals with anxiety quickly attend to threatening information in the early stage of orienting, but they later avoid processing threatening stimuli. This hypothesis is called the vigilance-avoidance hypothesis. On the other hand, other researchers have reported difficulty with disengagement from negative stimuli in anxiety, which is a dysfunction in the later process of attentional orienting (Fox et al., 2001; Fox, Russo, & Dutton, 2002; Koster et al., 2004). Though there is disagreement, a meta-analysis by Bar-Haim et al. (2007) revealed that there was a significant effect of attentional bias in anxiety with both long and short stimuli presentation. This result means that attentional bias in anxiety may occur both in earlier and later processes of attention. Today, although there is room for further investigation of mechanisms, it is widely agreed that attentional bias in anxiety plays an important role in etiology and maintenance of anxiety (e.g., Eysenck, Derakshan, Santos, & Calvo, 2007; Williams, Watts, MacLeod, & Mathews, 1988).

5. Attentional bias modification

The cognitive theory of depression predicts that depressive attentional bias maintains and strengthens depressive mood. Not only have studies reported a correlation between negative emotionality and attentional bias, but there are also some studies which reported that attentional bias predicted future increase in negative mood (e.g., Beevers & Carver, 2003; MacLeod & Hagan, 1992). Koster et al. (2011) hypothesized that attentional bias and increased depressive mood interact and reinforce each other to make a negative loop. Individuals with increased depressive mood attend to negative information more strongly, and a stronger negative attentional bias leads to a stronger depressive mood. A similar negative interaction is also assumed in the relationship between anxiety and attentional bias to threatening stimuli (Van Bockstaele et al., 2014).

If attentional bias to negative stimuli is critical in the maintenance and reinforcement of depression and anxiety, it should be effective to intervene in the attentional bias itself. MacLeod, Rutherford, Campbell, Ebsworthy, and Holker (2002) conducted the first study that directly tested this hypothesis. MacLeod et al. (2002) tried to promote disengagement of attention from negative stimuli by a modified dot-probe task. In a normal dot-probe task, a target has equal probability of appearing at the location of emotional stimuli or neutral stimuli. However, MacLeod et al. (2002) almost always presented targets at the opposite location from negative stimuli to decrease participants’ attention to the location of negative stimuli. This training procedure is called attentional bias modification (ABM), and later studies reported a significant modification effect on negative attentional bias and negative emotionality (e.g., Amir, Beard, Burns, & Bomyea, 2009; Schmidt, Richey, Buckner, & Timpano, 2009).

A number of ABM studies have been conducted over the years, and there are some reports from meta-analysis on the effect of ABM (Hakamata et al., 2010; Hallion & Ruscio, 2011; Mogoase, David & Koster, 2014). The results may be disappointing for researchers of attentional bias in depression and anxiety. Though Hakamata et al. (2010) reported a significant effect of ABM on depression (g = .85) and anxiety (g = .61), later meta-analytic review did not find a significant alleviation effect on depression or anxiety. Hallion and Ruscio (2011) found a significant but small effect of cognitive bias modification (including ABM and modification of interpretation bias) on anxiety (g = .13) and an insignificant effect on depression (g = .06). Mogoase et al. (2014) also reported similar results that indicated a significant small effect of ABM on anxiety (g = .26) and an insignificant effect on depression (g = -.11). These results show that ABM has very limited therapeutic effect and that it is still premature to apply it for clinical purposes (Mogoase et al.). Thus, it is necessary to clarify the mechanism of effect in ABM and to develop a more efficient training procedure that would have a substantial effect on negative cognitions in depression and anxiety.

6. The overview of the doctoral thesis

As discussed above, negative attentional bias in depression and anxiety is assumed to be a key factor in the maintenance and reinforcement of negative emotion, and it seems promising to apply ABM in clinical situations. However, some important problems remain unsolved. First, current literature on negative attentional bias has mostly focused on examination of attentional bias in orienting, such as attentional disengagement. For example, there are possible biased aspects of attention such as attentional blink (Koster, De Raedt, Verschuere, Tibboel, & De Jong, 2009) or attentional window, but there is a very limited amount of research that has investigated these aspects of attention. More specifically, it is assumed that there can be attentional bias in regard to attentional window (Wells & Matthews, 1994), but there is no example of direct examination. Thus, it is problematic that the current literature ignores the attentional window and most of the attentional bias studies are devoted to the investigation of orienting.

The second concern is the inefficiency of the current ABM. Though attentional bias was successfully modified in previous research (Hakamata et al., 2010), previous ABM has required either a large number of training sessions over time or a massive amount of training trials in one day. It is difficult for individuals with clinical depression or anxiety to complete ABM procedures, which require so much effort. Thus, I have to develop more efficient training that needs less effort in order to apply ABM for therapeutic use. Moreover, in connection with the first problem, ABM is developed based only on previous studies on attentional orienting bias since there is insufficient literature on other aspects of attentional bias in depression and anxiety. Thus, it is possible that previous ABM has ignored critical aspects of attentional bias, or only observed superficial change in task performance on attentional orienting.

To address these issues, four experiments were conducted in this doctoral thesis. In Experiment 1 and Experiment 2, I investigated attentional bias in depression and anxiety using a digit-parity task, a measure of attentional window. Attention to negative stimuli was measured in Experiment 1, while attention to positive stimuli was tested in Experiment 2. Experiment 3 and Experiment 4 were conducted to develop more efficient ABM. I tried to develop more effective ABM in short-term training and examined if the effect of ABM transferred to other measures of attentional orienting. ABM to increase attention to positive stimuli was developed in Experiment 4, while most of the previous ABM and the ABM in Experiment 3 have focused on decreasing attention to negative information.

Chapter 2. Measurement of attentional bias in the attentional window

Experiment 1-1

1. Introduction

Previous studies have developed the ABM program to decrease negative attentional bias; however, in order to clarify the ABM mechanism, there remains an issue to address. In previous ABM studies, they often used dot-probe task to measure attentional bias. Although previous ABM procedure was able to decrease attentional bias in dot-probe task, task is a measurement for attentional orienting (Posner, 1980). Indeed, many extant attentional bias studies of depression and anxiety have used dot-probe or exogenous cueing tasks (Koster et al., 2005; Posner, 1980) which measure attentional orienting. As current ABM procedures have been developed based on studies that have only examined attentional orienting, extant ABM research has ignored other aspects of spatial attention. Although some ABM studies have successfully modified emotional states using attentional training, others have failed to observe significant effects of ABM on emotion. I speculate that there is an unidentified aspect of attentional bias that importantly affects the maintenance of emotional disturbance, which previous ABM procedures have not successfully modified.

It thus remains unclear from what viewpoint I should investigate spatial attentional bias. Theoretically, it has been assumed that the spatial e

.xtent of attentional distribution, termed the “attentional spotlight” or “attentional window” (Belopolsky & Theeuwes, 2010; Belopolsky, Zwaan, Theeuwes, & Kramer, 2007; Jonides & Yantis, 1988; Theeuwes, 1991), may also be affected by mood disturbances like depression and anxiety (Wells & Matthews, 1994). It is assumed that individuals who are interested in a spatial location or who concentrate their attention on a stimulus have a narrower attentional window and process information in the attentional window more finely (Castiello & Umiltà, 1990; Eriksen & St. James, 1986; Eriksen & Yeh, 1985; Jonides, 1983; Maringelli & Umiltà, 1998; Theeuwes, 2004; Turatto et al., 2000) . By contrast, if attention is not concentrated, the attentional window will be wider but information in the window will not be deeply processed (Williams, Watts, MacLeod, & Mathews, 1988). Individuals with higher levels of depression or anxiety are assumed to selectively allocate their attention to negative stimuli (i.e. attentional bias); it is therefore expected that individuals with depression or anxiety will exhibit concentrated, narrowed attentional windows when negative stimuli are presented (Wells & Matthews, 1994). Practically no previous research has measured the extent of the attentional window when negative stimuli are presented to individuals with mood disturbances.

Experiment 1 therefore aimed to measure the attentional window when negative stimuli are presented. I used an emotionally modified digit-parity task (Aquino & Arnell, 2007; Fernandes, Koji, Dixon, & Aquino, 2011; Wolford & Morrison, 1980) to measure the spatial extent of the attentional window. In this task, emotional stimuli are centrally presented first; digit pairs then appear flanking the central stimulus. There are two types of trials: distant trials and near trials, according to the digit's distance from the central stimulus. It is assumed that if attention is concentrated on the central emotional stimulus, the attentional window will be narrowed and it will become difficult to respond in distant trials. By contrast, it is assumed that no large difference in difficulty will be observed between responses in distant trials and in near trials if attention is unfocused and widely distributed. Sad and neutral faces were used as emotional stimuli in this experiment. As the first focus of this doctoral thesis is on attentional bias in depression, sad stimuli (which previous studies have found to be related to cognitive bias in individuals with higher levels of depression; Hankin, Gibb, Abela, & Flory, 2010; Joormann, Talbot, & Gotlib, 2007) were employed. Presentation time of emotional stimuli in Experiment 1 was 1,000ms, which is relatively long, as it has often been reported that depressive attentional bias is observed when negative stimuli are presented for longer times, as depressive attentional bias requires deeper processing of emotional stimuli (Mogg & Bradley, 2005; Wisco, 2009). It is expected that participants with higher levels of depression will narrow their attentional window when negative stimuli are presented; hence, responses in distant trials are expected to be slower when sad stimuli are presented than when neutral stimuli are presented. By contrast, in near trials, participants may make quick responses regardless of the size of their attentional window; therefore, their response times are expected not to differ greatly between trials with sad faces and trials with neutral faces. Additionally, extant research suggests that individuals with higher trait anxiety will also react to negative stimuli. I therefore conducted two steps of analysis. In the first step, participants were divided into a high and a low depression group, and these two groups were compared. In the next step, participants were divided into a high and a low trait anxiety group, and these two groups were likewise compared.

2. Method

2.1. Participants

Thirty-two (22 females and 10 males; age 18–21 years, M = 18.93) who completed the present experiment were analyzed in the Experiment 1-1. These volunteer participants were recruited from introductory psychology classes at the University of Tokyo.

2.2. Materials and Tasks

2.2.1. Questionnaire Depression was measured using the Japanese version of the Center for Epidemiological Studies Depression scale (CES-D; Radloff, 1977; Shima, Shikano, Kitamura, & Asai, 1985). The CES-D is a self-report questionnaire composed of 20 items (e.g. “I think my life had been a failure.”) Participants rate how often they experienced the feeling described in each item in the past week; responses used a 4–point Likert scale (0 = *not at all* or *for less than one day,* 3 = *for 5 to 7 days*). Additionally, trait anxiety was measured using the Japanese version of the Trait form of the State-Trait Anxiety Inventory (STAI-T; Shimizu & Imae, 1981; Spielberger, Gorsuch, & Lushene, 1970). The STAI-T is also a self-report questionnaire; it is composed of 20 items (e.g., “I worry too much over something that really doesn’t matter.”) that examine how participants ordinarily feel; responses used a 4–point Likert scale (1 = *almost never,* 4 = *almost always*).

2.2.2. Facial stimuli I selected eight sad facial stimuli as negative emotional stimuli from the face set developed by Ekman and Friesen (1976). Eight neutral faces were selected from the

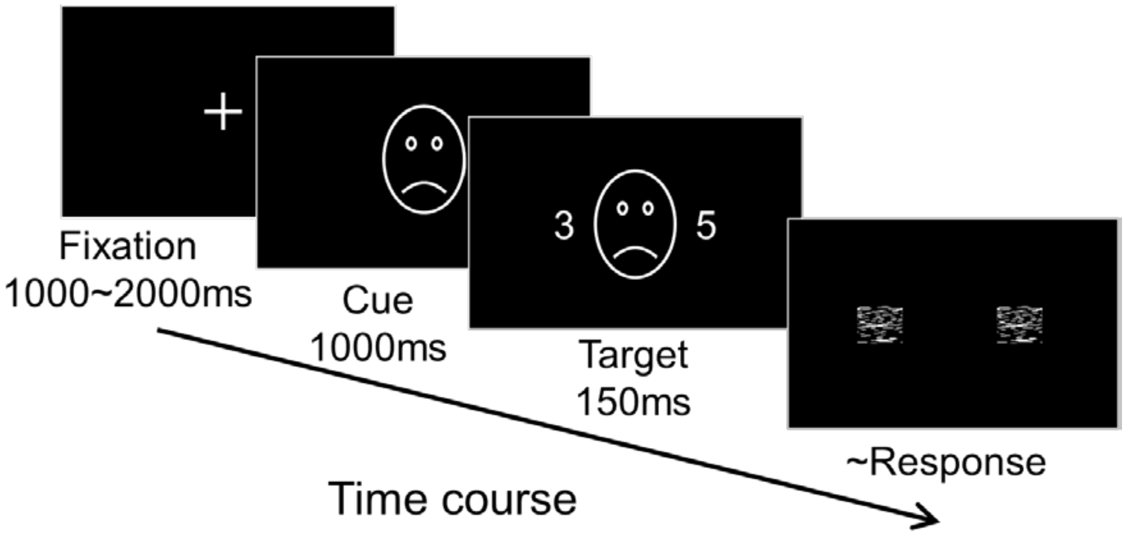

Figure 2-1. Procedure of digit-parity task in Experiment 1-1.

same face set.

2.2.3. Digit parity task An emotionally modified digit-parity task (Figure 2-1; Aquino & Arnell, 2007; Fernandes et al., 2011; Wolford & Morrison, 1980) was used. The task was programmed and administered using E-prime 2.0 (Psychology Software Tools Inc., Pittsburg, PA). Each trial of the task began with the presentation of a central fixation cross (1° in width, 1° in height); presentation time of the fixation cross randomly varied between 1000ms and 2000ms. Subsequently, neutral or positive facial stimuli (2° in width, 2.5° in height) were presented at the center of screen, replacing the fixation cross. One thousand ms after the facial stimuli appeared, target digits (approximately 0.3° in width, 0.5° in height; only 2, 3, 5, and 8 were used as target stimuli following Aquino & Arnell (2007)) appeared to the left and right of the face for 150ms. Target digits appeared at a distance of 1.5° (near trials) or 3° (distant trials) from the center of the facial stimuli, referring to the previous experiment setting (Aquino & Arnell; Fernandes et al.). Target digits were then replaced with mask stimuli (1° in width, 1° in height). Participants were asked if the target digits were matched (both odd, or both even) or mismatched (one odd and one even); responses were made by pressing a key. Masks were presented until participants responded. When participants responded, the trial was finished and the next trial immediately began.

The digit-parity task consisted of 64 near trials and 64 distant trials. Sad faces were presented in half of each trial type; neutral faces were presented in the other half. Additionally, target digits were matched in half of each trial type and mismatched in the other half. Trials were presented in random order and separated into two blocks, with a break in between.

A bias index for each participant was calculated as an index of attentional avoidance of happy faces observed in the digit-parity task. This index was computed as follows: (average RTs on trials including sad faces) minus (average RTs on trials including neutral faces). Positive bias index values indicate slower responses when sad faces were presented than when neutral faces were presented. In contrast, negative values indicate that presentation of sad faces accelerated responses, compared with neutral faces.

2.3. Procedure

Participants were individually invited to the laboratory; their first task was to answer the questionnaire. Participants then performed the digit-parity task in a dark room. Using a chin rest, viewing distance from the computer screen (I used an 85Hz, 17-inch monitor; Sony CPD-E230) was fixed at 60cm. After completing the task, participants were debriefed and paid a monetary reward according to their participation time.

3. Results

3.1. Analysis with depression as a group factor

Participants were divided into a high depression group and a low depression group according to their CES-D scores. The overall average CES-D score among participants was 12.96; hence, participants with CES-D scores over 13 were distributed into the high depression group and others were distributed into the low depression group (Table 2-1). Bias index values for each condition are presented in Figure 2-2. A mixed design 2 × 2 ANOVA was conducted with depression (high, low) as the between-subject factor, distance (near, distant) as the within-subject factor, and bias index value as the dependent variable. Interaction between depression and distance was not significant ($F(1, 30) = 3.03$, $p > .05$, $\eta_p^2 = .09$); no significant main effect was detected for depression and distance ($p > .10$).

3.2. Analysis with anxiety as a group factor

I subsequently conducted an ANOVA using trait anxiety (measured using the STAI-T) as an independent variable, as anxiety may also cause attentional bias towards negative stimuli. In this analysis, I divided participants into a high anxiety group and a low anxiety group according to their STAI-T score (Table 2-2). The overall average STAI-T score was 46.94; hence, participants with STAI-T scores of 47 or above were distributed into the high anxiety group, and others were distributed into the low anxiety group. A mixed design 2 × 2 ANOVA was conducted with trait anxiety

Table 2-1

Descriptive statistics of each group divided by CES-D score in Experiment 1-1.

Group	High Depression	Low Depression
n	15	17
Age	18.66	19.17
Gender(F/M)	8/7	14/3
CES-D *M*(*SD*)	19.66(6.54)	7.05(3.80)

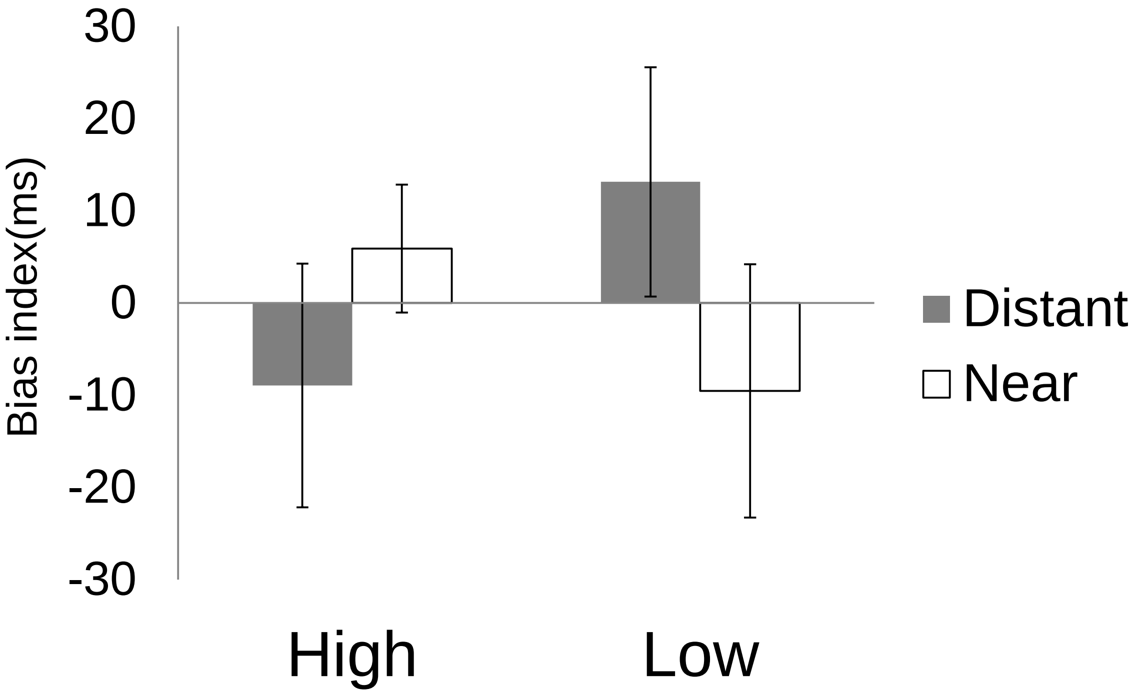

Figure 2-2. Bias index for each condition in Experiment 1-1. High indicates high depression group and Low indicates low depression group. Error bars indicate standard error.

Table 2-2

Descriptive statistics of each group divided by STAI-T score in Experiment 1-1.

Group	High Anxiety	Low Anxiety
n	17	15
Age	19.00	18.86
Gender(F/M)	11/6	11/4
STAI-T *M*(*SD*)	52.64(3.97)	40.46(5.49)

(high, low) as the between-subject factor, and distance (near, distant) as the within-subject factor (Figure 2-3). The results identified a significant two-way interaction between anxiety and distance ($F(1, 30) = 7.30$, $p < .05$, $\eta_p^2 = .20$). This two-way interaction was further analyzed using Bonferroni corrected *t*-tests. The results indicated that bias index values were significantly lower in the low anxiety group ($M = -20.13$) than in the high anxiety group ($M = 13.42$) in near trials ($t(30) = 2.24$, $p < .05$, $d = 0.79$). Moreover, bias index values were significantly higher in distant trials ($M = 14.09$) than in near trials ($M = -20.13$) in the low anxiety group only ($t(14) = 2.21$, $p < .05$, $d = 0.76$). Individuals with lower trait anxiety thus exhibited a narrower attentional window when negative stimuli were presented, whereas the attentional window of individuals with higher anxiety was relatively unaffected by negative stimuli.

4. Discussion

In Experiment 1-1, I measured the extent of the attentional window in individuals with higher levels of depression and trait anxiety on presentation of sad facial stimuli. Although I expected to observe a narrower attentional window in individuals with higher depression when sad faces were presented, analysis of Experiment 1-1’s results did not suggest that depression significantly affected participants’ attentional window. Although the results of extant research using attentional orienting tasks indicate the presence of attentional bias to negative stimuli in depression, I did not observe a narrowed attentional window or concentrated attention. As it is assumed that attentional orienting and focusing of the attentional window operate independently, it is unsurprising that attentional bias was observed only in attentional orienting and not in the attentional window.

In contrast, trait anxiety was found to affect the attentional window in an unexpected way: only individuals with lower trait anxiety exhibited a narrowed attentional window when sad faces were presented. This result implies that individuals with higher trait anxiety did not change the size of their attentional window depending on the emotional valence of facial stimuli, whereas individuals with lower anxiety concentrated their attention more when sad stimuli were presented than when

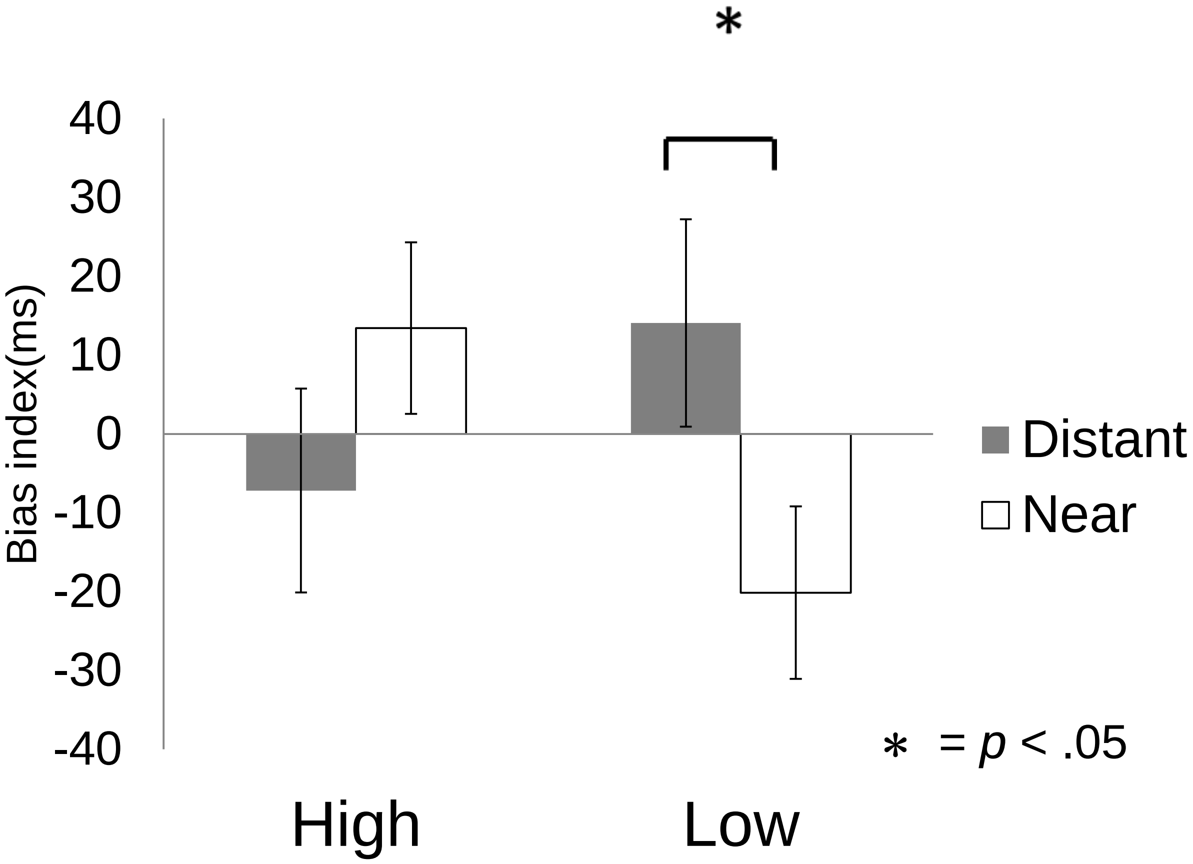

Figure 2-3. Bias index for each condition in Experiment 1-1. High indicates high anxiety group and Low indicates low anxiety group here. Error bars indicate standard error.

neutral stimuli were presented. It is natural that non-anxious individuals should concentrate their attention on sad faces, since previous research using the flanker task (Fenske & Eastwood, 2003) indicates that negative facial stimuli may narrow the attentional window. Thus, the results of the low anxiety group in the present experiment may be interpreted as a successful observation of the narrowed attentional window caused by the sad emotional valence of the facial stimuli themselves.

It remains unclear why the attentional window was unaffected by the emotional valence of stimuli in the high anxiety group. It is possible that the attentional window changes over time. For example, some previous studies of attentional orienting have observed fast attentional engagement of negative stimuli in earlier stages of attentional orientation, and attentional avoidance of negative stimuli in later stages. Based on these results, Mogg & Bradley (2004) proposed the vigilance-avoidance hypothesis: individuals with anxiety initially find and attend to negative stimuli faster than non-anxious individuals do, but anxious individuals later avoid negative stimuli in order to avoid processing them further. If the similar change over time happened in the attentional window, negative attentional bias may be observed when stimulus presentation times are shorter. To examine this possibility, Experiment 1-2 and Experiment 1-3 were conducted with altered stimulus presentation times.

Experiment 1-2

1. Introduction

In Experiment 1-2, I used the same digit-parity task as was used in Experiment 1-1. The only change was that the emotional stimuli presentation time was modified from 1000 ms to 500 ms. Presenting facial stimuli for 500 ms is assumed to be long enough for the attentional bias in anxiety to be observed, according to the results of previous studies employing the attentional orienting task (Mogg & Bradley, 2004). The purpose of Experiment 1-2 is to test the hypothesis that individuals with anxiety did not show focused attention to the sad stimuli in Experiment 1-1, but they may attend to negative stimuli when negative stimuli are presented for shorter periods of time.

2. Method

2.1. Participants

A total of 41 university student volunteers (16 females and 25 males; ages ranging from 18 to 21, M = 19.15) participated in and completed the present experiment.

2.2. Materials and Tasks

In Experiment 1-2, I used the same questionnaires (CES-D and STAI-T) and the same digit-parity task as was used in Experiment 1-1, with the above-noted alteration.

3. Results

Using the same method as was used in Experiment 1-1, I divided the participants into the high and low anxiety groups, according to their STAI-T scores (Table 2-3). The overall average STAI-T score was 48.02; thus, participants with STAI-T scores of 49 points or above were allocated to the high anxiety group, while the rest were included in the low anxiety group. A mixed design 2 × 2 ANOVA, in which trait anxiety (high, low) as a between-subject factor and distance (near, distant) as a within-subject factor showed a significant main effect of distance ($F(1, 39) = 4.48$, $p < .05$, $\eta_p^2 = .10$); while, the interaction was not significant ($F(1, 39) = 1.59$, $p > .10$, η_p^2 = 04; Figure 2-4).

Table 2-3

Descriptive statistics of each group divided by STAI-T score in Experiment 1-2.

Group	High Anxiety	Low Anxiety
n	19	22
Age	18.66	19.17
Gender(F/M)	8/11	8/14
STAI-T *M*(*SD*)	56.21(3.75)	40.95(7.02)

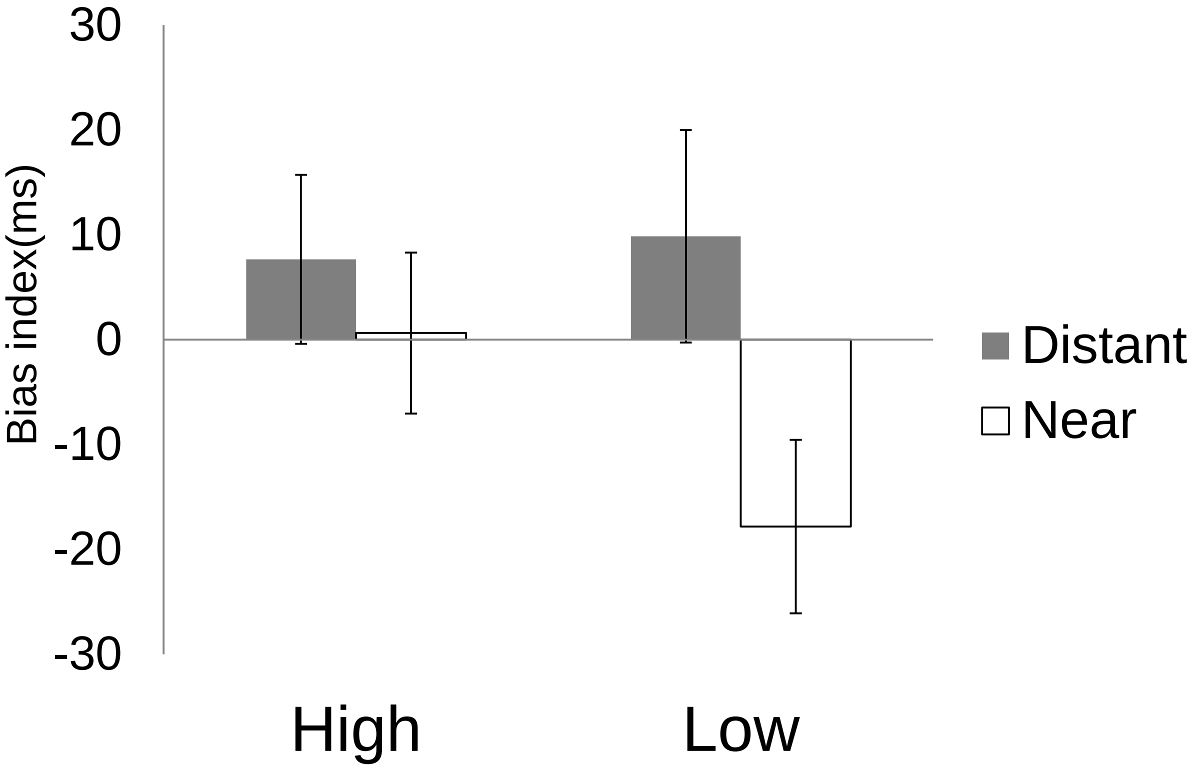

Figure 2-4. Bias index for each condition in Experiment 1-2. High indicates high anxiety group and Low indicates low anxiety group here. Error bars indicate standard error.

The results indicate that response time was significantly delayed when sad stimuli were presented compared to when neutral stimuli were presented in the distant trials (*M* = 8.84), as opposed to the near trials (*M* = -9.27) regardless of participants' trait anxiety levels.

4. Discussion

In Experiment 1-2, no significant interaction between anxiety and distance was found. The main effect of anxiety was also not significant; however, the main effect of distance was significant. These results imply that sad stimuli have the ability to make the attentional window narrower, but the level of trait anxiety was not significantly related to this effect. As previously reported by Fenske and Eastwood (2003), the negative facial stimuli themselves possibly narrow the attentional window. Overall, I found a narrowed attentional window when sad stimuli were presented, but trait anxiety did not affect the extent of this window. On the other hand, Experiment 1-1 showed attentional narrowing only in the low anxiety group. Though the mechanism explaining this difference has not yet been confirmed, my expectation that the attentional window would change with time was supported.

Experiment 1-3

1. Introduction

Although some studies have observed attentional bias in anxiety with a brief presentation of negative stimuli (e.g., Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006; Mogg, Bradley, Williams, & Mathews, 1993), Cisler and Koster (2010) found that highly threatening stimuli are required to observe an attentional bias in the early stages of orienting. Sad stimuli, which are not highly threatening, are used in the present experiment; thus, it is not likely that the attentional bias would be observed in the present setting with its brief presentation of emotional stimuli. However, the attentional window can be narrowed with only 100 ms of stimuli presentation (e.g., Fernandes et al., 2011); thus, there is still the possibility that I would be able to observe attentional bias with a brief presentation of sad stimuli. In Experiment 1-3, I measured the attentional window in individuals with high and low trait anxiety with short stimuli presentation in a digit-parity task to further investigate the change of attentional window with the passing of time.

2. Method

2.1. Participants

A total of 38 university student volunteers (18 females and 20 males; ages ranging from 18 to 24, *M* = 19.55) participated in and completed the present experiment.

2.2. Materials and Tasks

I used the same questionnaires and digit-parity task used in Experiments 1-1 and 1-2; however, the presentation time of the facial stimuli was 250 ms.

3. Results

As in Experiments 1-1 and 1-2, the participants were divided into high and low anxiety groups, according to their STAI-T scores (Table 2-4). The average STAI-T score among all participants was 45.23; thus, the participants with STAI-T scores of 46 and above were put into

Table 2-4

Descriptive statistics of each group divided by STAI-T score in Experiment 1-3.

Group	High Anxiety	Low Anxiety
n	20	18
Age	19.70	19.39
Gender(F/M)	5/15	5/13
STAI-T *M*(*SD*)	52.95(4.40)	36.67(3.61)

high anxiety group, while the rest were included in the low anxiety group. In the same way as in Experiments 1-1 and 1-2, a mixed design 2 × 2 ANOVA, in which trait anxiety (high, low) as a between-subject factor and distance (near, distant) as a within-subject factor, was conducted (Figure 2-5). The two-way interaction between anxiety and distance was not significant ($F(1, 36) = 0.16$, $p > .10$, $\eta_p^2 = .00$), and no significant main effects were found ($p > .10$).

4. Discussion

The results of Experiment 1-3 showed no significant effect of anxiety and distance. The effect of sad stimuli, which was observed in Experiment 2, was not found in Experiment 1-3; thus, presentation of sad stimuli requires at least 500 ms to make the attentional window narrow. Moreover, there was no significant effect of anxiety, as expected. Since sad facial stimuli are not highly threatening, it is natural that no attentional narrowing occurred, even among individuals with high trait anxiety.

General Discussion

In Experiment 1-1, I tested attentional bias to sad facial stimuli with a digit-parity task to measure the spatial extent of the attentional window. From looking at the results of previous studies, attentional bias was expected to appear in individuals with depression when sad stimuli were presented, since individuals with depression are assumed to selectively allocate their attention to sad emotional stimuli. Thus, the attentional window would be narrower when sad stimuli are presented to individuals with high levels of depression. Contrary to my expectations, the results did not show significant evidence of a depressive attentional bias. Breadth of attentional window was not significantly affected by individuals’ depression levels. On the other hand, there was a significant effect of trait anxiety on breadth of attentional window when sad stimuli were presented. However, narrowed attentional window in response to sad stimuli was found in the low anxiety, but not the high anxiety group in Experiment 1-1. Results of Experiment 1-2 implicated significant effects of sad

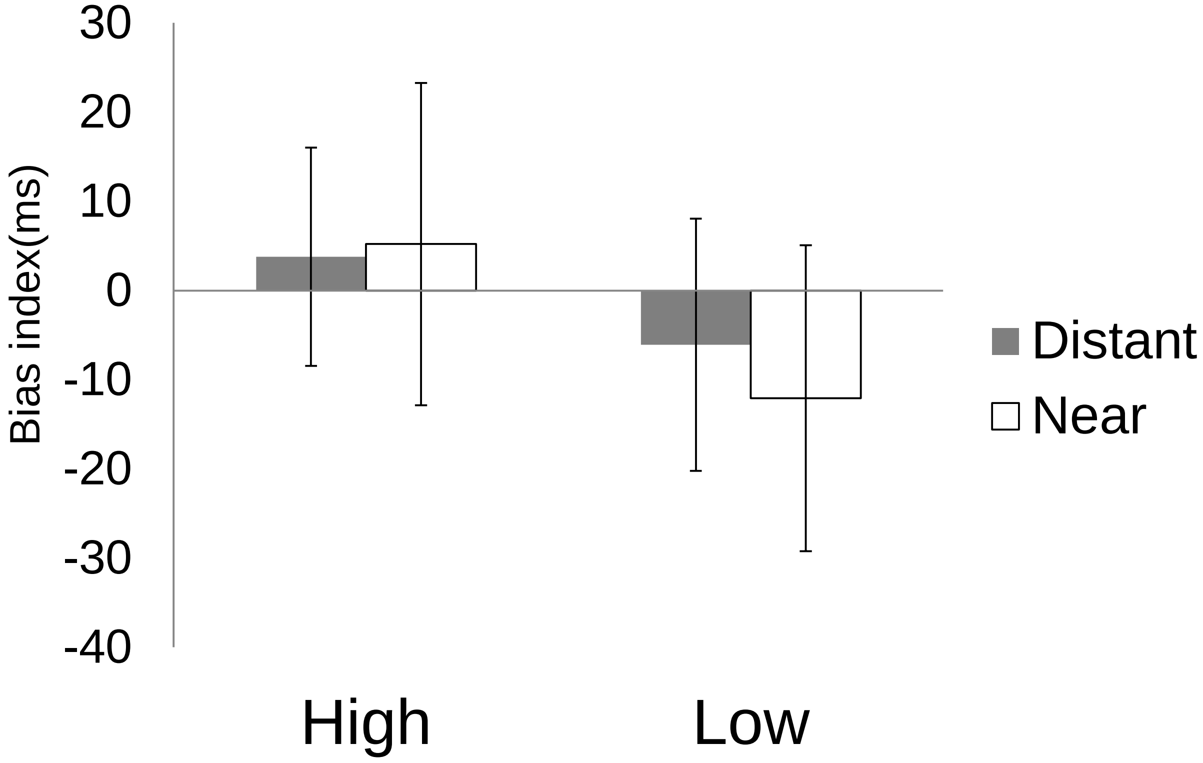

Figure 2-5. Bias index for each condition in Experiment 1-3. High indicates high anxiety group and Low indicates low anxiety group here. Error bars indicate standard error.

stimuli, but there was no effect of anxiety level on attentional window. Furthermore, Experiment 1-3 showed no significant effect of distance and anxiety, implying that the sad stimuli effect appeared at a relatively late stage. Comparing the results of Experiments 1-1 and 1-2, it seems that attentional window was once narrowed by the sad stimuli themselves when emotional stimuli were presented for 500 ms both among high and low anxiety individuals. Then, only individuals with high trait anxiety make their attentional window broader when emotional stimuli are presented for a longer duration, as the results of Experiment 1-1 show.

Why does the attentional window become broader in individuals with higher trait anxiety with a longer period of exposure to sad faces? The first possible explanation may be in line with the vigilance-avoidance hypothesis (Mogg et al., 2004), as discussed in Experiment 1-1. Anxiety is related to initial threat vigilance, but it may also be a defensive state that prepares one to escape from danger (Lang, Davis, & Öhman, 2000); thus, individuals with higher anxiety detect negative stimuli faster, but they later avoid processing these negative stimuli. In other words, individuals with low trait anxiety do not avoid sad stimuli, even when exposed to it for a long time. However, it is doubtful whether the vigilance-avoidance hypothesis can be applied to the present results, since individuals with anxiety showed attentional avoidance when threatening stimuli were presented in a previous study (Mogg et al., 2004; Schwerdtfeger & Derakshan, 2010). The present experiment used sad facial stimuli as the emotional stimuli; thus, there seems to be no threatening information there that anxious individuals have to avoid. Moreover, if anxious individuals avoid attending to sad stimuli, it should have been difficult for them to respond in the near trials when sad stimuli are presented, since targets are presented by facial stimuli in the near trials.

There is another possible explanation, according to Gable and Harmon-Jones (2010). Individuals show a broader attentional window when a sad mood is induced prior to performing the Navon task (Navon, 1977). Though their study did not measure how attention was allocated to sad stimuli, it is possible that individuals with higher anxiety may have processed sad faces intensively, and that they were induced to be in a sad mood (presenting facial stimuli can be used for mood induction, as Schneider, Gur, Gur, & Muenz (1994) reported) when emotional stimuli were presented for a long time. This resulted in a broader attentional window and an insignificant effect of sad stimuli.

It is more likely that individuals with higher anxiety are always alert to external threat, as observed among individuals with social anxiety (Moriya & Tanno, 2010); thus, individuals with higher anxiety first attend to sad stimuli, and they broaden their attentional windows to seek other threats after they judge sad stimuli are free from danger. The present experiment does not offer enough information to examine this hypothesis; thus, this issue should be examined in future studies. Although it cannot be concluded from the present experiment what kind of mechanism underlies the present results, it can at least be said that the present experiment reveals an uninvestigated aspect of attentional reaction to negative stimuli in anxiety. Further research is also needed to investigate the relationship between the attentional window and orienting, in the presence of different types of biases. In addition, there is one important question that must be answered in the future research. There was no significant effect of depression on attentional window, even though sad stimuli, which are related to depression, were presented. This was not congruent with previous studies that reported selective attention to sad stimuli. One possible explanation for this incongruence is that depressive mood broadens the attentional window, and it may have neutralized the window’s narrowing. Depressive mood is defined as a sad, discouraged mood. Sadness is assumed to broaden the attentional window (Gable & Harmon-Jones, 2010); thus, individuals with depression may originally have broader attentional windows, which lessen the performance difference between the distant and near trials.

There is a limitation in the present experiment. In Experiment 1, facial set from Ekman and Friesen (1976) was used as emotional stimuli. Facial stimuli of Ekman and Friesen do not include faces of Asian people, though most of participants in Experiment 1 are Japanese. I used faces of Ekman and Friesen to secure comparability of the results with previous studies, since there are very limited amount of attentional studies which applied Asian facial stimuli. However, the present results should be replicated with Asian facial set in the future study. In the term of stimuli selection, the present experiment did not use verbal stimuli since I considered that crowding effect may occur when verbal stimuli are centrally presented and digits presented near the stimuli. However, since some studies discussed that individuals with depression often show depressive cognitive bias when verbal stimuli were used (see Wisco, 2009), replication with verbal stimuli is necessary. Finally, the present study did not observed eye-movement during the task trials. Though there are some previous examples which measured eye-movement in depressive samples (see Armstrong & Olatunji, 2012), there is no eye-tracking study which applied digit-parity task. Thus eye-tracking measure should be applied in the future study to conclude whether there is an influence of eye-movement on the present results or not.

Overall, I found a narrowed attentional window caused by sad stimuli with a 500 ms presentation; however, the windows of individuals with high trait anxiety broadened when sad stimuli were presented for 1000 ms. On the other hand, depression made no difference in attentional window when the sad stimuli were presented. These results differ from the expectations I drew from previous studies. My results imply that individuals with anxiety and depression may show very different performance when their attentional biases are observed in measurements of attentional window compared to when their attentional biases are measured with an orienting task. Future research must further examine the attentional window in depression and anxiety to gain a better understanding of attentional bias.

Experiment 2

1. Introduction

The cognitive style of individuals with depression is characterized by selective processing of negative information, which is known as depressive cognitive bias. Depressive cognitive bias is believed to play an important role in the maintenance and reinforcement of depressive mood (Coyne & Gotlib, 1983; Disner et al., 2011; Mathews & MacLeod, 1994). In particular, selective attention to negative stimuli, or depressive attentional bias, has been widely investigated for the past two decades. Since attention is related to a relatively early stage of information processing, biased attention should be a key factor in depressive cognition in that it possibly influences later stages of information processing such as memory (Koster, De Raedt, Leyman, & De Lissnyder, 2010) or interpretation (Hertel & El-Messidi, 2006). A large number of previous studies have investigated attentional bias to negative information in individuals with depression (see Peckham et al., 2010), and the mechanism of negative attentional bias in depression has been examined in detail. It has often been reported that a longer presentation of negative stimuli is required in order to observe attentional bias (Koster et al., 2005; Mogg & Bradley, 2005; Peckham et al., 2010) and that attentional disengagement from negative information is difficult in individuals with depression (Koster et al., 2005).

Along with maintenance of negative mood, decreased positive emotionality is an important aspect of depression. Loss of pleasure, or anhedonia, has been considered to be one of the key symptoms of depression (e.g., DSM-5, American Psychiatric Association, 2013; BDI-II, Beck, Steer, & Brown, 1996), and Clark & Watson (1991) even claims that, in their tripartite model, depression and anxiety can be differentiated by the existence of anhedonia. If negative mood can be maintained by attentional bias to negative information, it can be speculated that lack of positive emotion is created by inattention to, or attentional avoidance of, positive information. However, while research on selective attention to negative stimuli in depression has greatly progressed, attention to positive information has not been largely investigated using depressed samples. Though a recent meta-analytic review of eye-tracking studies found a decreased viewing time of positive stimuli in depressed individuals (Armstrong & Olatunji, 2012), there remain a limited number of studies investigating attention to positive information in individuals with depression. Moreover, the few results that do exist are not congruent. Some studies, most of them using eye-tracking measures, reported attentional avoidance of positive stimuli in individuals with depression (e.g., Bradley, Mogg, & Millar, 2000; Kellough, Beevers, Ellis, & Wells, 2011; Sears, Newman, Ference, & Thomas, 2011). In contrast, other studies reported that attentional bias to positive stimuli exists in non-depressed samples and that positive attentional bias does not exist in depressed samples (e.g., Joormann & Gotlib, 2007; Joormannet al., 2007; Koster, et al., 2005). The small number of previous studies and these mixed results make it difficult to discuss a detailed mechanism of attention to positive stimuli in individuals with depression. For these reasons, before conducting further research on attention to positive stimuli in depression, it is necessary to confirm the existence of attentional avoidance of positive stimuli or the lack of positive attentional bias in individuals with depression.

In the current literature, previous studies on spatial attention to positive stimuli in depression have limited themselves to primarily eye-tracking measures or attentional orienting tasks (e.g., dot-probe task, MacLeod & Mathews, 1986; exogenous cueing task, Posner, 1980), while other aspects of spatial attention have been ignored. These measures cannot determine the spatial extent of distributed attention, known as the attentional window or attentional focus (Eriksen & St. James, 1986; Eriksen & Yeh, 1985; Theeuwes, 2004; Turatto et al., 2000); thus, it is still unclear how the attentional window behaves when positive stimuli are presented to individuals with depression. If researchers are interested in attentional avoidance or lack of positive attentional bias, the attentional window can be a direct index of allocation of attentional resources. I can describe concentrated attention as an attentional window focused on positive stimuli and conceptualize attentional avoidance as a combination of inattention to central areas around positive stimuli and increased attention to peripheral areas.

The aim of Experiment 2 is to investigate attentional avoidance from positive emotional stimuli and the absence of positive attentional bias in individuals with higher levels of depressive symptoms. To address this issue, I employed an emotionally modified digit-parity task (Aquino & Arnell, 2007; Fernandes et al., 2011; Wolford & Morrison, 1980). In the emotionally modified digit-parity task, positive or neutral facial stimuli are centrally presented and a target digit pair appears near or distant from the central stimuli. When the attentional window is narrow, the response to distant targets is delayed, and when it is broad, the response to distant targets may not be delayed. If non-depressive individuals have positive attentional bias, their response to targets near the positive faces will be faster and the response to distant targets will be slower since it is assumed that non-depressive individuals concentrate attention on positive information and that the attentional window will be narrower when they attend to positive faces. This pattern of results will not be observed in individuals with higher levels of depression. If individuals with higher depressive symptoms avoid attending to positive emotional stimuli, they may not attend to the area around positive faces and may attend to an area distant from the positive stimuli. Thus, their response to targets near the positive faces will be delayed and the response to targets distant from the positive faces will be accelerated.

2. Method

2.1. Participants

A total of 34 university student volunteers participated in the experiment (18 females and 16 males; age ranged from 18 to 24 years, *M* = 19.47). These participants were recruited from an introductory psychology class at the University of Tokyo.

2.2. Materials and Tasks

2.2.1. **Questionnaire**. Depression was measured using the Japanese version of the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977; Shima et al., 1985).

2.2.2. **Facial stimuli.** I selected eight happy facial stimuli as positive emotional stimuli from the face set developed by Ekman and Friesen (1976). In addition, eight neutral faces were selected from the same face set.

2.2.3 Digit Parity Task. An emotionally modified digit-parity task (Aquino & Arnell, 2007; Fernandes et al., 2011; Wolford & Morrison, 1980) was employed in Experiment 2. The digit-parity task was programmed and carried out with E-prime 2.0 software (Psychology Software Tools Inc., Pittsburg, PA). Experiment 2 applied the same digit-parity task as Experiment 1-1, except that neutral or positive facial stimuli were used as emotional stimuli.

The present digit-parity task consisted of 64 near trials and 64 distant trials. Positive faces were presented in half of each trial type, and neutral faces were presented in the other half. Moreover, target digits were matched in half of each type of trial and mismatched in the other half. These trials were presented in random order and separated into two blocks with a break between them.

A bias index for each participant was calculated as an index of attentional avoidance of happy faces observed in digit-parity task. This index was computed as follows using reaction time (RT): (average RT on trials in which happy faces were presented) – (average RT on trials in which neutral faces were presented). The positive value of this bias index indicates a slower response when happy faces were presented than when neutral faces were presented. Conversely, a negative value indicates that presentation of happy faces accelerates the response when compared with presentation of neutral faces.

2.3. Procedure

Participants were individually invited to the laboratory and completed the questionnaire. They then performed the digit-parity task in a dark room. Using a chin rest, the viewing distance from the computer screen (85 Hz, 17-inch monitor; Sony CPD-E230) was fixed at 60 cm. After they completed the task, participants were debriefed and compensated with monetary reward.

3. Results

3.1 Descriptive statistics and data cleaning. The descriptive statistics of the sample are shown in Table 2-5. Before computing the bias index, trials with errors were removed and trials with RT above or below 2 standard deviations of the overall average RT for each participant were excluded as outliers. As a result, I found that 1 participant made an extremely large amount of mistakes and outliers (above 2 *SD* of the average amount of mistakes and errors). Thus I excluded data from this participant from the present analyzes.

3.2. Bias index. I first conducted my analysis using the bias index as a dependent variable. Participants were allocated to high depression group and low depression group according to their CES-D score (Table 2-5). The overall average score was 12.26; hence, participants with scores of 13

Table 2-5

Descriptive statistics of participants in each group divided by CES-D score in Experiment 2.

o

	High-depression	Low-depression
n	12	21
Age	19.33	19.75
Gender (F/M)	9/3	8/13
CES-D (*M*(*SD*))	20.42(7.83)	5.95(2.45)

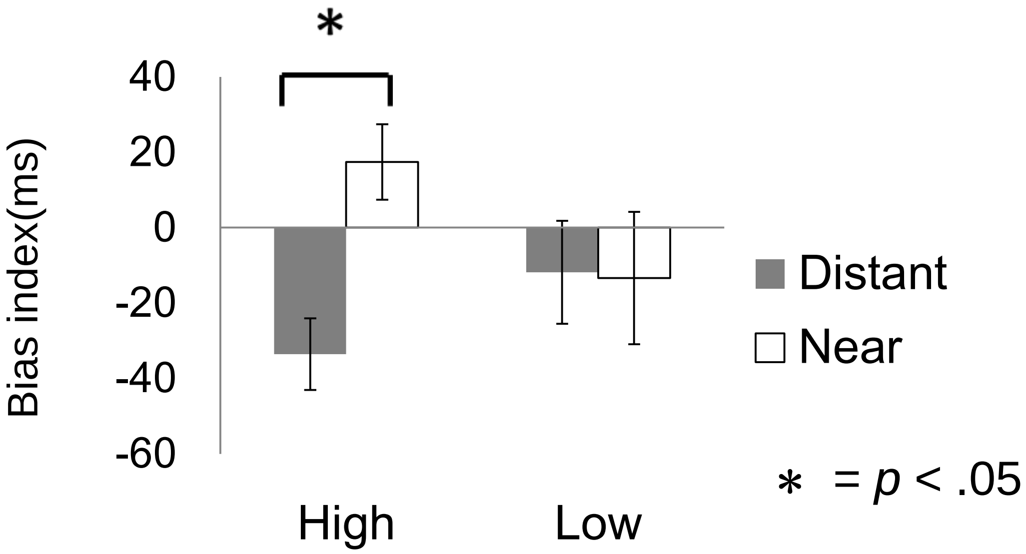

Figure 2-6. Bias index for each condition in Experiment 2. High indicates high depression group and Low indicates low depression group here. Error bars indicate standard error.

or above were distributed into the high depression group, and others were distributed into the low depression group. The bias index for each condition is shown in Figure 2-6. A mixed design 2 × 2 ANOVA was conducted with depression (high, low) as a between-subject factor, and distance (near, distant) as a within-subject factor. The ANOVA revealed that there was a marginally significant main effect of distance, $F(1, 31) = 3.34$, $p < .10$, $\eta_p^2 < .10$, and a two-way interaction between depression and distance, $F(1, 31) = 3.75$, $p < .10$, $\eta_p^2 = .11$. To further investigate the two-way interaction between depression and distance, I conducted further analysis utilizing Bonferroni corrected *t*-tests. Following my hypothesis, I compared the bias indices on distant trials and near trials in the high depression and low depression groups. A significant difference was found between distant and near trials in the high depression group, $t(11) = 2.80$, $p < .05$, $d = 1.19$, with the bias index significantly lower in distant trials ($M = -33.55$) than near trials ($M = 17.45$) when positive stimuli were presented. This result indicates that the high-depression participants were slower to make responses in near trials but faster in distant trials when happy faces were presented, which implies that high-depression individuals avoid attending to positive stimuli and the area around those stimuli. This difference was not significant in the low depression group, $t(20) = 0.08$, $p > .10$, $d = 0.09$.

3.3. Correlation analysis. I tested the correlation between CES-D score and bias index. If individuals with higher depression show attentional avoidance of positive emotional stimuli, then a slower response in near trials and faster response in distant trials should be found when positive stimuli are presented. In other words, CES-D score should positively correlate with bias index in near trials and negatively correlate in distant trials.

Between the bias index and CES-D score, I found a marginally significant positive correlation for near trials ($r = .33$, $p < .10$; Figure 2-7A) and a significant negative correlation for distant trials ($r = -0.35$, $p < .05$; Figure 2-7B). These results were congruent with my hypothesis, indicating that responses to targets near a happy face became more difficult and responses to targets distant from the happy face become easier as the level of depressive symptoms increased.

4. Discussion

In Experiment 2, I investigated the width of the attentional window in individuals with

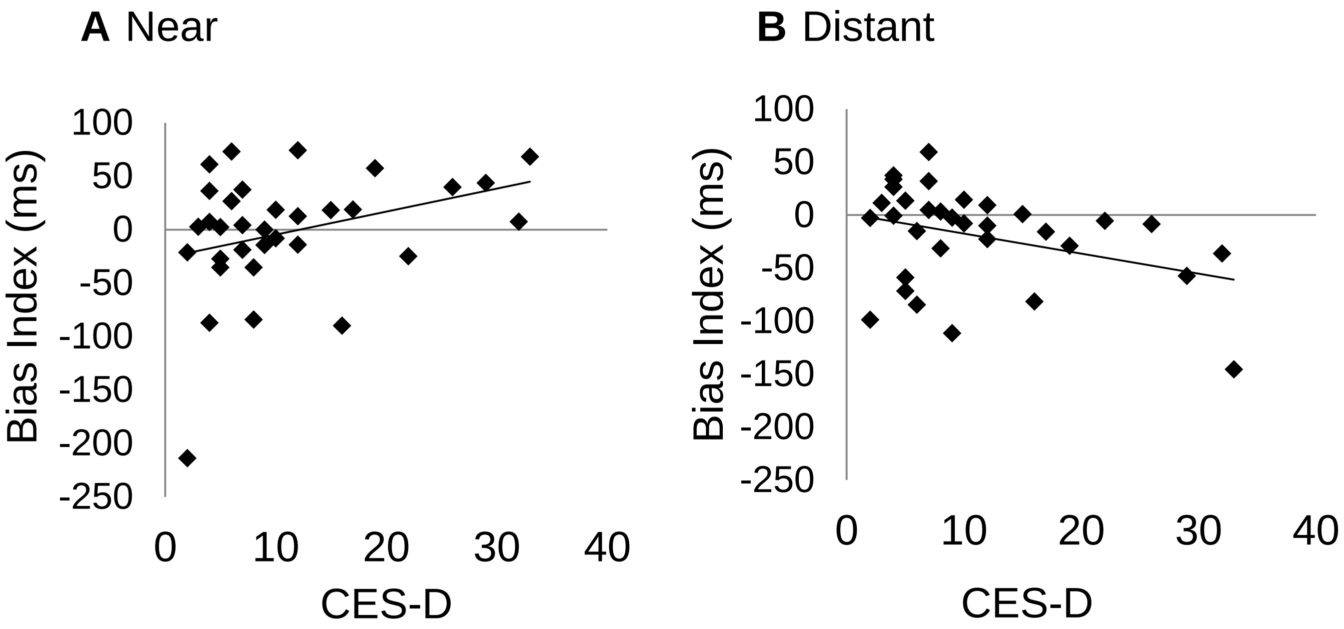

Figure 2-7. Correlation between bias index and CES-D score in two types of digit distance. Figure 2-7A shows bias index in near trials, and Figure 2-7B shows bias index in distant trials.

depression. According to previous studies, it was hypothesized that individuals with a higher level of depression a) possibly avoid attending to positive emotional stimuli, and thus should have more difficulty responding to targets near positive stimuli and less difficulty responding to targets distant from positive stimuli, and b) do not show the positive attentional bias that should manifest as a narrow attentional window when positive stimuli are presented, which is expected to be observed in individuals with lower levels of depression.

Overall, my results seem to support the existence of attentional avoidance of positive stimuli in individuals with higher levels of depression. As the results of the ANOVA and correlation analysis on the bias index showed, it was easier for individuals with higher levels of depression to respond to distant targets than to respond to near targets when positive faces were presented. Correlation analysis also indicated that the level of depression was negatively correlated with the bias index in distant trials, which implies that they allocate more attention to the area distant from happy faces in proportion to the level of depression. It should be noted that the level of depression was positively correlated with the bias index in near trials, although it was a marginally significant correlation. This positive correlation implies that individuals become less attentive to the area around positive faces as their level of depression increases. Taken together, the present results revealed that individuals with an elevated level of depression avoid allocating attention to the area around positive faces and allocate more attention to the areas distant from a positive face. Considering that the attentional window can be “donut-shaped” (Müller & Hübner, 2002), it is possible that fewer attentional resources were allocated to the central area of the visual field and more allocated to the peripheral area in individual depression when positive stimuli were presented. It is surprising that my results implicate that individuals with depression attended less to positive information even when they were instructed to fix their gaze on centrally presented positive stimuli. Attentional allocation and eye movement are thought to not always coordinate (Klein, 2009; Posner, 1980), and the present results showed that attention was allocated to the peripheral area. To that end, employment of the digit-parity task in the Experiment 2 may have successfully supplemented the previous eye-tracking results in that it was confirmed that individuals with depression avoid placing their attention on positive information, whether accompanied by eye movement or not.

On the other hand, Experiment 2 did not show any types of attentional bias to positive stimuli in individuals with lower levels of depression. This result is incongruent with some previous results, which reported a positive attentional bias in non-depressed individuals. These previous studies and the Experiment 2 are clearly different in that all previous studies employed cognitive tasks to measure attentional orienting or an emotional Stroop effect, while the Experiment 2 measured the attentional window.

In summary, Experiment 2 revealed a possibility that individuals with higher depression show attentional avoidance of positive emotional stimuli. Since lack of positive stimuli is thought to be an important aspect of depression, investigating detailed mechanisms and establishing models of attentional avoidance of positive information should be beneficial for further understanding of depressive cognition. Recently, a training program to modify attentional bias to emotional stimuli, called ABM, was developed and intensively investigated. In fact, although the ability of ABM to modify negative attentional bias has often been reported (as a review, Hakamata et al., 2010), very few studies have investigated ABM in regard to increasing attention to positive information (e.g., Baert et al., 2010; Boettcher et al., 2013). I speculate that since research on attention to positive stimuli is still in an early stage, establishing ABM for attention to positive stimuli is more difficult than establishing ABM for negative attentional bias. Finally, further studies to systematically investigate attentional avoidance of positive stimuli are required to reveal details of attentional avoidance of positive stimuli, such as time course or reactivity to stimuli type (e.g., word, face or other pictorial stimuli) since Experiment 2 has limitations same as Experiment 1: I did not used Asian facial stimuli and verbal stimuli.

Chapter 3. Modification of Attention to Negative and Positive Information

Experiment 3

1. Introduction

Studies assessing emotional disorders, like depression and anxiety, have shown a tendency for people in a negative mood to selectively process negative information (Mathews, Mackintosh, & Fulcher, 1997; Peckham, McHugh, & Otto, 2010). Such biased information processing is generally referred to as a negative cognitive bias, which plays an important role in the maintenance and development of emotional disorders.

Recent studies suggest that negative attentional biases are key cognitive factors contributing to depression and anxiety disorders (Koster et al., 2011; Ouimet, Gawronski, & Dozois, 2009). In cognitive models of depression and anxiety, selective allocation of attentional resources to negative information leads to negative interpretation of stimuli or processing of negative aspects of self-image, and disables inhibition of negative thoughts and disengagement from them (e.g., Beck, 1967; De Raedt & Koster, 2010; Rapee & Heimberg, 1997). Some previous results have indicated that individual differences in negative attentional biases predict future increases in depression and other negative moods (Beevers & Carver, 2003; Ellenbogen, Schwartzman, Stewart, & Walker, 2006; Johnson, 2009; MacLeod & Hagan, 1992; Sanchez, Vasquez, Marker, LeMoult, & Joorman, 2013), and provide evidence for a link between negative information processing biases and emotional disturbances. Additionally, in more recent studies, attentional bias was often found in the disengagement of attention (Fox et al., 2001; Koster et al., 2005; Moriya & Tanno, 2011) among three components of attentional orienting: engagement, shifting, and disengagement (Posner et al., 1987). On the basis of these findings, some recent models of attentional bias regard the impairment of attentional disengagement as especially important for the maintenance of negative mood (Cisler & Koster, 2010; Koster et al., 2011). This raises the question of whether it is possible to train individuals not to attend to negative information. The attentional bias modification (ABM) procedure was developed to retrain negative attentional biases. MacLeod et al., (2002) developed an attentional retraining task, which was a modified version of a dot-probe task, in order to promote disengaging attention from negative stimuli. In their task, participants were instructed to respond to a target stimulus, which was preceded by a pair of threatening and neutral words. In one group, targets always appeared in the location of the preceding negative words, while in the other group, targets were in the opposite location of the negative words. In this way, participants in the former group were trained to attend toward negative stimuli, and participants in the latter group were trained to disengage from negative stimuli. MacLeod et al. observed different emotional responses to experimentally induced stress between these two groups; participants in the attend-negative group reported more distress than those in the disengage-negative group. In line with these results, studies utilizing similar training procedures have suggested that facilitating attentional avoidance from negative stimuli could decrease negative emotions (e.g., Amir et al., 2009; Schmidt et al., 2009; Wells & Beevers, 2010). Recently, some meta-analytic reviews suggested that ABM effects are beneficial for the future therapeutic treatment of emotional problems like anxiety or depression (Bar-Haim, 2010, Hakamata et al., 2010; Hallion & Ruscio, 2011).

Although evidence suggests that ABM has the potential for being an effective cognitive treatment for emotional disturbances, it is still unclear what mechanisms help ABM to successfully reduce negative emotions. Thus, Experiment 3 examined how ABM procedures affect attentional functioning by addressing three major limitations in the existing literatures. First, it is still unclear whether ABM actually improves attentional disengagement from negative stimuli. Previous studies have assessed several forms of outcome measures for determining how ABM influences negative emotions including stress-reactivity (MacLeod et al., 2002) and symptoms of anxiety (Amir et al., 2009), and depression (Baert et al., 2010); however, improvements in attentional functioning have only been measured with a dot-probe task in most past studies. This limited evidence regarding cognitive alterations caused by ABM indicates that the mechanisms underlying ABM are unclear because the dot-probe task cannot differentiate between attentional engagement and disengagement (Fox et al., 2001; Koster et al., 2005). As discussed in Hertel and Mathews (2011), ABM might have a transfer effect; in other words, the effect of ABM might be observed not only during the specific task used for training (i.e., dot-probe task; MacLeod et al., 1986) but also on other attentional tasks. For example, if individuals were trained to efficiently disengage attention from negative stimuli through a modified dot-probe task, improvement could be observed in other visuospatial tasks, such as gap-overlap task (Fischer & Weber, 1993; Moriya & Tanno, 2011), which can be thought as a specialized measure of attentional disengagement from negative stimuli. As ABM is assumed to help individuals allocate less attentional resource to negative stimuli, individuals with ABM training should be better able to disengage attention from negative stimuli.

Second, it is possible that the ABM procedure improves attentional processing of non-emotional information. Moriya and Tanno (2009) tried to investigate the relationship between negative affect and non-emotional attentional function, with the attentional network test (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002). The ANT can measure the efficiency of three types of attentional functioning: alerting, orienting, and executive attention. Alerting is the ability to maintain a state of response sensitivity to an incoming target. Orienting includes attentional engagement, shifting, and disengagement, which are often tested in spatial cueing tasks. Executive attention is the function used to monitor and resolve cognitive conflicts. The results of Moriya and Tanno suggested that individuals high in negative emotionality have a deficit in attentional orienting toward non-emotional stimuli. Additionally, Compton (2000) reported that efficacy in attentional disengagement from non-emotional stimuli which is included in function of attentional orienting, was negatively correlated with negative emotional responses to negative stimuli. Overall, these studies suggest that impairment in attentional orienting ability toward non-emotional stimuli can amplify negative emotion among individuals high in negative emotionality. During a typical ABM training session, participants repetitively practice shifting their attention away from negative stimuli, which could result in improved orienting functioning. Thus, I tested the possibility that ABM also improves non-emotional attentional orienting, such as attentional disengagement from non-emotional information.

Third, there could be an influence of the type of instructions given to an ABM trainee. Most ABM studies manipulate attentional biases by using a modified dot-probe task where targets are always presented at the opposite location of preceding negative stimuli, and participants are not informed about this unique target-stimulus contingency. Thus, studies suggest that the positive effects from ABM training could be established even if participants have no awareness of the training manipulation (Amir, Beard, Taylor, Klumpp, Elias, Burns, & Chen, 2009). However, a recent study reported an increased efficacy of the effect when the target and negative stimulus contingency was explicitly instructed (Krebs, Hirsch, & Mathews, 2010). Here, individuals given an explicit instruction showed greater improvement in dot-probe task performance than those given the standard (i.e., no information regarding the contingency) instruction. When participants were given explicit instructions, they would control their attention more effortfully than those given a standard instruction. This is because explicit instructions provide expectations regarding target location. It is likely that this type of top-down attentional control contributed to the larger training effect for the explicitly instructed group relative to the standard instruction group. However, no additional studies have investigated the effect of explicit instructions. Thus, replication and further investigation regarding how explicit instructions improve ABM training are necessary.

Taken together, Experiment 3 investigated the influences of ABM on emotional and non-emotional attentional functioning. I provided two different ABM instructions, and Experiment 3 had the following specific aims. First, I tested the transfer effect of bias modification training using three cognitive tasks that examine improvement in different areas of attentional functioning: dot-probe task, gap-overlap task, and attention network test (ANT) during a pre- and post-training phase. I employed a dot-probe task to measure selective attention to negative stimuli, the gap-overlap task to measure attentional disengagement from negative stimuli, and the ANT to measure attention toward non-emotional stimuli. In the current study, these tasks were administered before and after ABM training (the ABM training involved a modified version of a dot-probe task). Thus, if there were no transfer effect, the ABM effect would be observed only within the dot-probe task test phase. In this case, the beneficial effect of ABM would be task-specific or possibly just the byproduct of cognitive training (e.g., enhanced concentration or temporal distraction). On the other hand, if there were a transfer effect, attentional disengagement from negative stimuli and/or general attentional control ability of non-emotional stimuli would be enhanced, which would lead to the conclusion that ABM enhances specific attentional functions useful for alleviating emotional problems.

The second aim was to examine the effect of two different ABM instructions. I tested the training enhancement effect through the use of explicit instructions. As results from Krebs et al. (2010) suggested, explicit instruction should enhance ABM effects, given that top-down attentional control is better trained within an explicitly instructed group. Thus, in Experiment 3, I expected that an explicit instruction would facilitate a training transfer from ABM performance to other, related attentional functioning more efficiently than a standard instruction.

2. Method

2.1. Experimental Design

Participants completed a pre-test session, training session, and a post-test session. During the pre-test session, the dot-probe task, gap-overlap task, and ANT were performed. Following the pre-test assessment, participants received training on a modified version of the dot-probe task over three days. Participants were divided into two groups; one received explicit instructions detailing the cue-stimulus contingency (i.e., the explicit instruction group), and the other did not (i.e., the standard instruction group). During the post-test session, attentional functioning was assessed on the same tasks as those used during the pre-test session. Analyses focused on the effects of instruction (explicit and standard) and time (pre-test and post-test).

2.2. Participants and Procedure

Participants were 42 university students from the University of Tokyo. Of the 42 participants, 40 finished all experimental sessions (two students dropped out). The experiment was explained to the participants before the pre-test session began, and each participant completed an informed consent form. Subsequently, the Japanese version of the Center for Epidemiological Studies Depression scale (CES-D; Radloff, 1977; Shima et al., 1985) and the Japanese version of the Trait form of the State-Trait Anxiety Inventory (STAI-T; Shimizu & Imae, 1981; Spielberger et al., 1970) were also administered. Participants were allocated to the two groups during the attention modification session (fully counterbalanced). Half of the participants (n = 20, seven women) were assigned to the explicit instruction group in which participants were explicitly instructed to attend to the opposite location of a negative target. The other half (n = 20, eight women) was assigned to the standard instruction group in which participants were not told where to attend. The two groups were not significantly different in terms of depression, $t(38) = 0.3$, *n.s.*, or trait anxiety, $t(38) = 0.0$, *n.s.* Participants assigned to one instruction group were not provided information about the other group (Table 3-1). For consideration of statistical power, post hoc power analysis was conducted with G*Power (Buchner, Erdfelder, Lang & Faul, 2007). Power analysis was conducted on the basis of the present sample size for within-between interaction on repeated measures ANOVA with $\alpha = .05$. As a result, statistical power was above .90 ($(1 - \beta) > .90$) when the effect size was $\eta_p^2 = .10$. Since my main purpose is to observe interaction between group (explicit instruction and standard instruction) and time (pre-test and post-test), it was assumed that there was adequate statistical power with the present sample size if the effect size of two-way interaction is above $\eta_p^2 = .10$.

Participants were individually tested and trained in the laboratory. Participants performed all experimental tasks in a dark room, sitting 60 cm from a computer screen. On the first day, participants were given details regarding the experiment and provided their informed consent. Next, the pre-test

Table 3-1

Descriptive Statistics of Participants Who Completed All Sessions

Group	Explicit Instruction				Implicit Instruction			
N	20				20			
Age	19.45				19.40			
Gender(F/M)	7/13				8/12			
	Pre		Post		Pre		Post	
CES-D *M* (*SD*)	11.70	(6.88)	11.43	(7.56)	11.15	(6.96)	12.93	(8.37)
STAI-T *M* (*SD*)	46.25	(10.10)	46.18	(11.23)	46.10	(11.58)	46.08	(16.10)

Note. CES-D = Center for Epidemiological Studies Depression scale, and STAI-T = Trait form of the State-Trait Anxiety Inventory.

session started. During the pre-test session, attentional functioning was tested via a dot-probe task, gap-overlap task, and the ANT. These tasks were performed in a counterbalanced order across participants. Participants then completed three training sessions. The attention modification task was performed during the training sessions. Participants underwent one training session per day for three days. After the training sessions, participants performed the three attentional tasks during a post-test session. The order of tasks was the same as during the pre-test session.

2.3. Materials and Tasks

I selected 160 words (80 negative, 80 neutral) from Matsumoto's (2006) valence- and familiarity-controlled word list. Negative stimuli were selected according to the strength of negativity and did not correspond with specific emotional condition like depression or anxiety. These words were split into two word sets, each including 40 negative words and 40 neutral words. The word set was used for all tasks except the ANT during the pre-test and attention modification session, while the other set was used for all tasks except for the ANT in the post-test session.

2.3.1 Dot-probe task. The dot-probe task (MacLeod et al., 1986; Figure 3-1) was performed during the pre-test and post-test sessions. At the beginning of each trial, a fixation cross (0.7° in width, 0.7° in height) was presented at the center of the screen for 500 ms. Afterwards, two words (24 point, Courier New font) appeared 3.0° to the right and left of the fixation cross for 1500 ms. This relatively longer presentation time was set to enable participants to process the meaning and emotional valence enough because attentional bias to negative verbal stimuli has been found when stimuli were enough deeply processed (Wisco, 2009). The words disappeared and were replaced by one white square target (24 point, Courier New font). Participants were asked to indicate the location of the target (left or right) by pressing a key within 1000 ms, otherwise the trial counted as a mistake. When participants responded, or 1000 ms elapsed without any response, the trial was finished, and the next trial began.

During the dot-probe task, there were three types of trials: neutral, congruent negative, and

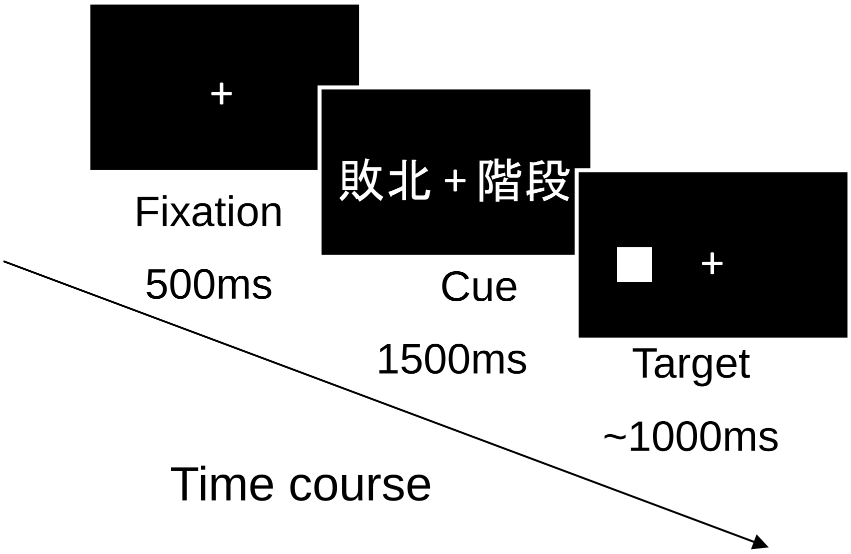

Figure 3-1. Sequence of dot-probe task.

incongruent negative trials. During the neutral trials, both words had a neutral valence. During the negative congruent trials and negative incongruent trials, there was one negative word and one neutral word in the word pair. Targets appeared at the same location of the negative words for the negative congruent trials while the target appeared at the opposite location of negative words for the negative incongruent trials. One test session consisted of 80 neutral, 40 negative congruent, and 40 negative incongruent trials. These trials were presented in random order and separated into two blocks of 80 trials. In both explicit and implicit instruction group, the same instruction was given in this task, for pre- and post-test session. Participants were told that fixation cross is presented at the beginning of a trial, then words will appear at left and right side of the cross, and finally target will appear on either of left or right side of fixation after the words disappear. Participants were not given any information about relationship between emotional valence of words and the place where targets appear in this task. I calculated a bias index for each participant as an index of negative attentional bias observed in dot-probe task. This index was computed as follows: ((average RTs on incongruent negative trials) – (average RTs on congruent negative trials)) / (average RTs on all trials). A higher bias index means that the participant attended more to the location of negative words.

2.3.2 Gap-overlap task. The gap-overlap task (Fischer & Weber, 1993; Moriya & Tanno, 2011; Figure 3-2) was administered to participants during the pre-test and post-test sessions. At the start of each trial, a fixation cross (0.7° in width, 0.7° in height) was presented at the center of the screen for 500 ms. Next, a word (24 point, Courier New font) was presented at the center of the screen for 1500 ms. Then, an X or N appeared as a target at 3.5° right or left of the word during *overlap* trials, or a blank screen was presented for 120-200 ms (randomized) before a target appeared during *gap* trials. Participants had to answer whether they saw an X or N via a key press within 1000 ms, otherwise the trial counted as a mistake. The trial completed once the participant made a response or 1000 ms had elapsed. One session consisted of 80 gap trials and 80 overlap trials. In half of each trial type, negative words were presented, while neutral words were presented in the other half. These trials were

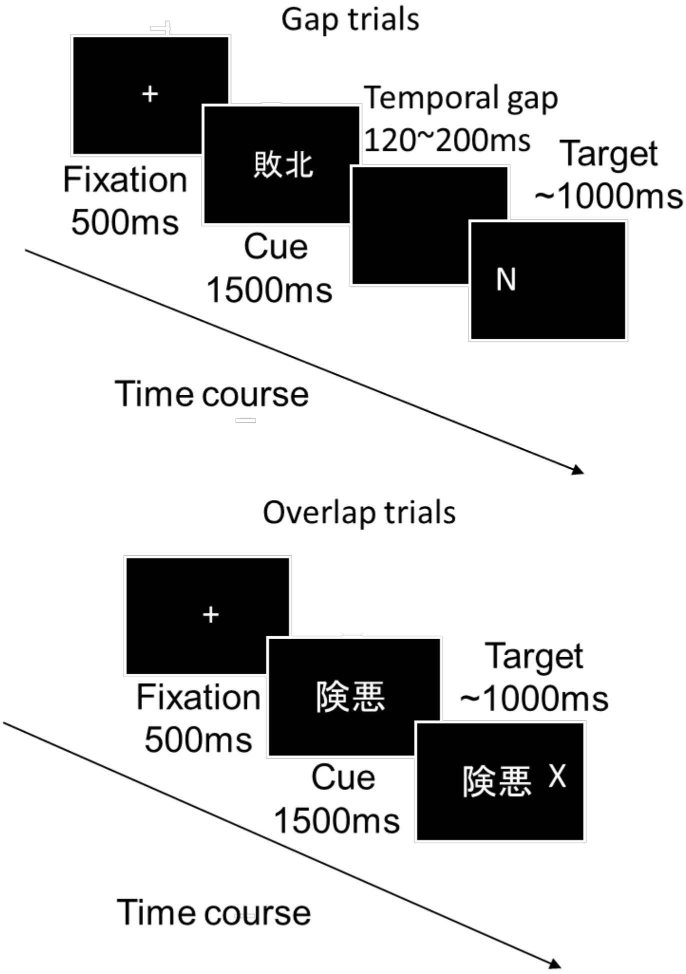

Figure 3-2. Sequence of gap-overlap task.

presented in random order and separated into two blocks.

I calculated a gap effect as an index of attentional disengagement (Kikuchi, Senju, Akechi, Tojo, Osanai, & Hasegawa, 2011). The gap effect was calculated as follows: ((average RTs on overlap trials) - (average RTs on gap trials)) / (average RTs on all trials).

2.3.3 Attention network test. The ANT was presented to participants during the pre-test and post-test sessions (Figure 3-3). First, a fixation cross (0.7° in width, 0.7° in height) was presented at the center of the screen for 500–5000 ms (randomized). Next, a cue presentation period was presented for 100 ms. Three cue conditions were shown: center cue, spatial cue, and no cue. In the center cue condition, a cue asterisk (0.7° in width, 0.7° in height) was presented at the center of the screen, replacing the fixation cross. In the spatial cue condition, a cue asterisk was presented at 2.4° above or below the fixation cross, indicating the target location of the trial. In the no cue condition, nothing was presented except for the center fixation cross. After the cue presentation period, the cue disappeared and only the center fixation cross was presented for 250–550 ms. Subsequently, a target was presented 2.4° above or below the fixation cross. A target arrow was flanked by congruent or incongruent arrows. The target and flanker arrows were presented in a row, and spaces between the arrows subtended 0.1°. The target and flanker arrows pointed in a rightward or leftward direction (a single arrow was subtended 1.0°). Participants had to indicate the direction of the target arrow by pressing a key as soon as possible. The target and flanker arrows remained on the screen until the participant responded or until 1500 ms elapsed.

In one session, participants completed 144 test trials. There were six trial types (three cue conditions and two target conditions), and all trial types were presented in a counterbalanced order. According to Fan et al. (2002) and Fan, Fossella, Sommer, Wus, and Posner (2003), three attention network indices are measured by the ANT: alerting, orienting, and executive attention (Table 3-2), calculated as follows:

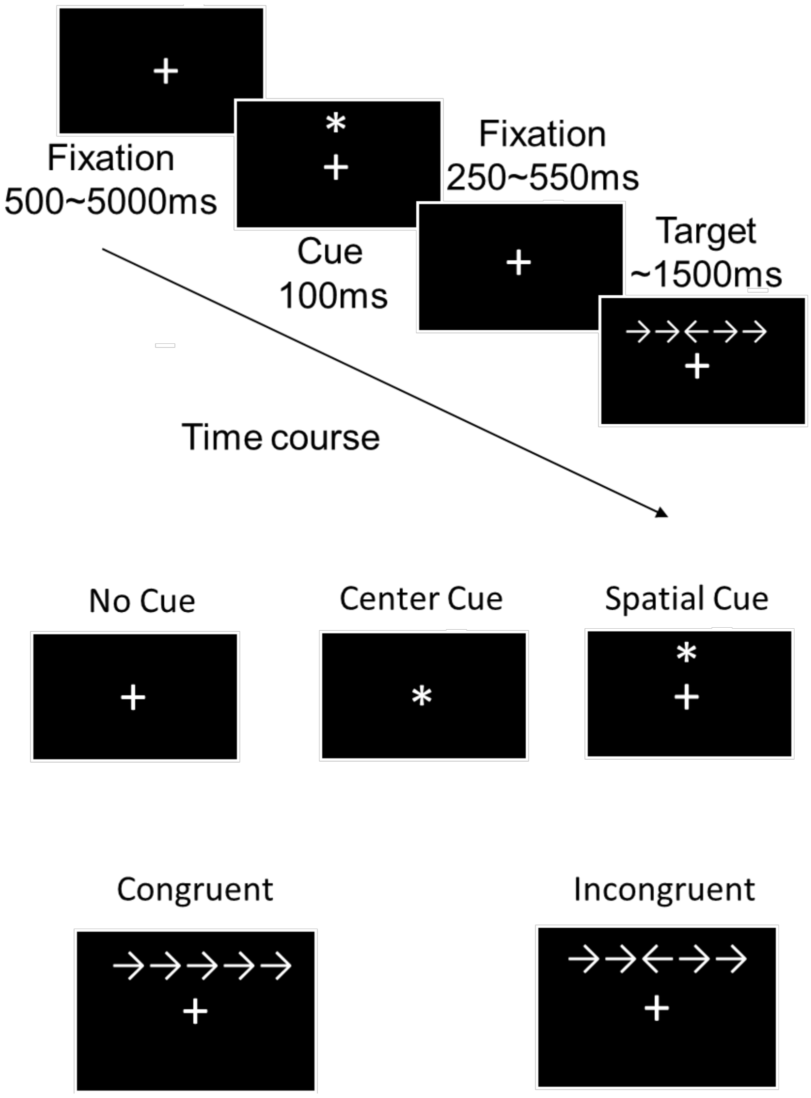

Figure 3-3. Sequence of ANT.

Table 3-2

Scores of attentional network test (ANT) in pre- and post-test sessions.

	Pre-test		Post-test	
	Alerting	*SD*	Alerting	*SD*
Explicit	0.061	0.041	0.082	0.038
Implicit	0.058	0.041	0.067	0.045
	Orienting	*SD*	Orienting	*SD*
Explicit	0.108	0.063	0.128	0.071
Implicit	0.114	0.072	0.129	0.080
	Executive attention	*SD*	Executive attention	*SD*
Explicit	0.081	0.042	0.075	0.035
Implicit	0.088	0.044	0.072	0.043

Alerting = ((average RTs on no cue trials) - (average RTs on center cue trials)) / (average RTs on all trials)

Orienting = ((average RTs on center cue trials) - (average RTs on spatial cue trials)) / (average RTs on all trials)

Executive attention = ((average RTs on incongruent trials) - (average RTs on congruent trials)) / (average RTs on all trials).

Higher alerting scores indicate an activated alerting network, and increased orienting scores indicate a higher attentional orienting ability. A higher executive attention score indicates poorer conflict resolution; thus, a lower executive attention index indicates better executive attention performance.

2.3.4. Attention modification task. The attention modification task was performed over a three-day training session. This task was the same as the dot-probe task in Experiment 3, except that there were no congruent negative trials. Out of 160 trials, 80 trials were neutral trials, and the other 80 trials were negative incongruent trials used to train participants to ignore the location of negative stimuli. Consequently, over 3 days of training session, all participants completed 240 incongruent negative trials and 240 neutral trials in total.

As noted above, participants were assigned to one of two instruction conditions: explicit or implicit instruction. Both groups completed the same attention modification task during the training session; however, the explicit instruction group was instructed to attend to the opposite location when a negative word was presented. The implicit instruction group was not informed as to the relationship between negative word location and target location.

3. Results

3.1. Dot-Probe Task

Prior to the analysis, participants' errors were removed, and trials with RTs above or below 2 *SD* of the average RTs on all trials were removed as outliers. No participant made mistakes on more than 10% of all trials. The average bias index for each condition is shown in Figure 3-4. A two-way ANOVA was conducted on bias index, with instruction (explicit, implicit) as a between-subjects factor and time (pre-test, post-test) as a within subjects factor[2]. There was a significant main effect of time, $F(1, 38) = 4.16$, $p < .05$, $\eta_p^2 = .10$, and a marginally significant main effect of instruction, $F(1, 38) = 3.55$, $p < .10$, $\eta_p^2 = .09$ which was further qualified by a significant instruction and time interaction, $F(1, 38) = 8.47$, $p < .01$, $\eta_p^2 = .18$. This interaction was further analyzed by *t* tests with Bonferroni correction. Further analysis revealed that bias index was significantly lower in post-test session compared with pre-test session for the explicit instruction group ($t(19) = 3.53$, $p < .01$, $d = 1.07$), and explicit instruction group showed significantly lower bias index compared with implicit instruction group during the post-test ($t(38) = 3.08$, $p < .05$, $d = 0.97$). However, there was no significant difference between pre-test and post-test bias index in implicit group ($t(19) = 0.14$, p = *n.s.*, $d = 0.15$), and also bias scores were not significantly different between two instruction groups in pre-test ($t(38) = 0.25$, p = *n.s.*, $d = 0.07$). These results indicate significantly lower bias index in explicitly instructed group in post-test session. No other significant effects were observed for the dot-probe task.

3.2. Gap-Overlap Task

Before the analysis, errors and outliers were removed from the data. Trials with RTs above or below 2 *SD* of the average RTs on all trials were removed as outliers. Two participants showed below 90% accuracy in the trials. Thus, the data from these participants were excluded from the analysis because it can be assumed that typically developed participants show above 90 % accuracy in easy probe detection task (Elder & Bar-Haim, 2010).

The average gap effect for each condition is shown in Figures 3-5. A 2 × 2 ANOVA was

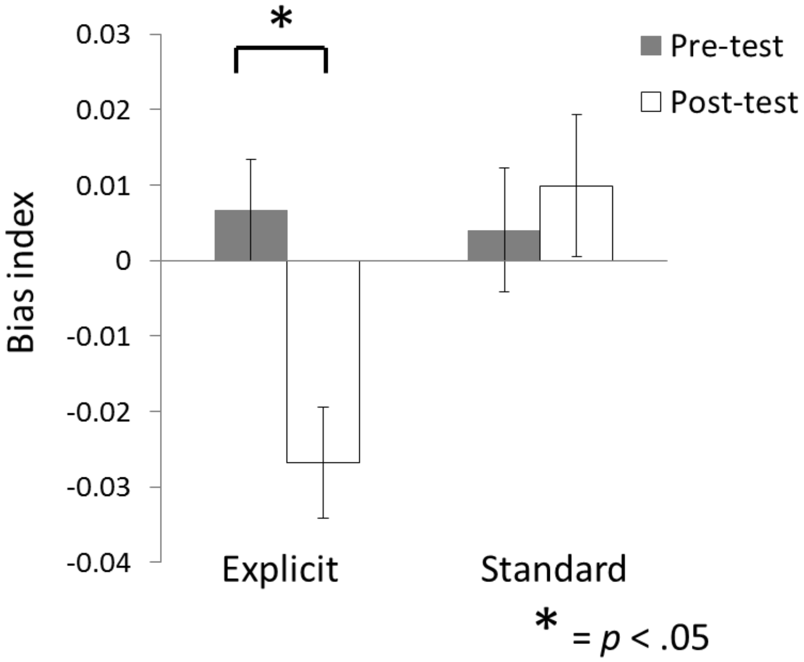

Figure 3-4. Mean bias indices and standard error of each condition.

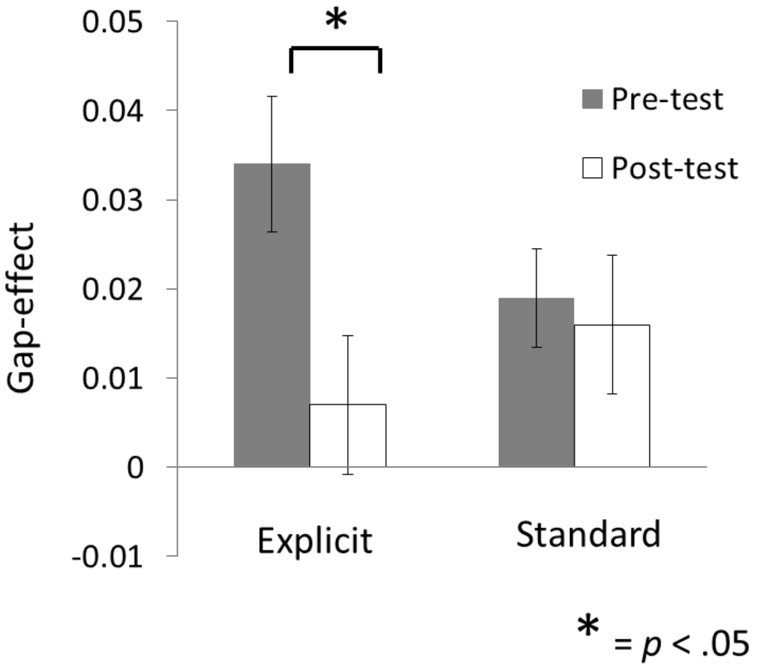

Figure 3-5. Mean gap effects and standard error of each condition.

conducted on bias index, with instruction (explicit, implicit) as a between-subjects factor and time (pre-test, post-test) as a within-subjects factor. There was a significant main effect of time, $F(1, 36) = 6.42$, $p < .05$, $\eta_p^2 = .15$. However, there was no significant main effect of instruction, $F(1, 36) = 0.10$, $p = n.s.$, $\eta_p^2 = .00$. These effects were further qualified by a significant instruction and time interaction, $F(1, 36) = 4.35$, $p < .05$, $\eta_p^2 = .11$. As a result of further analysis with Bonferroni-corrected *t* tests, a significant difference of gap effect between pre-test and post-test in the explicit instruction group ($t(18) = 3.71$, $p < .05$, $d = 0.80$), indicating that gap effect decreased after training only in explicit instruction group. There were no significant differences between instruction groups in pre-test ($t(36) = 1.54$, $p = n.s.$, $d = 0.51$) and post-test ($t(36) = 0.86$, $p = n.s.$, $d = 0.26$), and also the difference between pre-test and post-test in implicit group was not significant ($t(18) = 0.11$, $p = n.s.$, $d = 0.10$).

3.3. ANT

Before conducting the analysis, errors and outliers were removed in the same way as for the gap-overlap task. Moreover, there were two participants who made mistakes on more than 10% of all trials; thus, data from these participants were not included in the analysis. For the alerting, orienting, and executive attention indices, separate 2 × 2 ANOVAs were conducted with instruction (explicit vs. implicit) as a between-subjects factor and time (pre-test vs. post-test) as a within-subjects factor. Marginally significant main effects of time were observed for the alerting ($F(1, 36) = 3.17$, $p < .10$, $\eta_p^2 = .08$), orienting ($F(1, 36) = 3.95$, $p < .10$, $\eta_p^2 = .10$), and executive attention ($F(1, 36) = 3.76$, $p < .10$, $\eta_p^2 = .10$) indices. No other effects emerged.

3.4 Associations among task performances, depression and anxiety measures

For further investigation of relationship between each task performance, depression and anxiety measure, correlation analysis was conducted (Table 3-3). Subtracting pre-test score from post-test score, change amount of task performances, CES-D and STAI-T scores were calculated and input into the analysis. No significant correlations were found among task performances, CES-D and STAI-T scores ($p = n.s.$). Moreover, the correlation between change amount of bias index and gap

Table 3-3

Correlations Among Task Performances and Emotional Measures

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1 Bias index change	1.00																				
2 Gap effect change	-.08	1.00																			
3 Pre-test Bias index	-.50**	.12	1.00																		
4 Post-test Bias index	.73**	.02	.24	1.00																	
5 Pre-test Gap effect	.19	-.51**	.05	.26	1.00																
6 Post-test Gap effect	.08	.64**	.18	.25	.32*	1.00															
7 Alerting change	-.13	.13	.28	.09	-.18	-.02	1.00														
8 Orienting change	.07	.19	.02	.10	-.05	.17	-.54**	1.00													
9 Executive attention change	-.39*	-.19	.01	-.45**	-.24	-.42**	-.08	-.22	1.00												
10 Pre-test Alerting	.08	-.43**	.10	.19	.36*	-.16	-.63**	.32*	.04	1.00											
11 Pre-test Orienting	-.11	.19	.20	.05	-.13	.10	.22	-.24	.08	-.23	1.00										
12 Pre-test Executive attention	.11	.04	.11	.23	-.11	-.05	.14	.17	-.52**	-.04	-.01	1.00									
13 Post-test Alerting	-.09	-.26	.45**	.29	.12	-.18	.65**	-.37*	-.07	.18	.05	.15	1.00								
14 Post-test Orienting	-.05	.30	.20	.11	-.15	.20	-.18	.49**	-.09	.02	.74**	.11	-.21	1.00							
15 Post-test Executive attention	-.22	-.12	.13	-.15	-.34*	-.43**	.08	-.02	.34*	-.00	.06	.63**	.10	.04	1.00						
16 CES-D change	-.02	.14	-.14	-.13	.02	.17	-.10	.03	-.11	-.15	-.14	-.10	-.27	-.10	-.20	1.00					
17 STAI-T change	-.23	.00	.15	-.14	-.14	-.12	.32	-.24	-.03	-.38*	.13	.07	.03	-.06	.01	.24	1.00				
18 Pre-test CES-D	.06	-.24	-.25	-.13	-.02	-.28	-.15	.06	-.01	-.08	-.00	-.09	-.26	.04	-.04	-.03	.20	1.00			
19 Pre-test STAI-T	.05	.07	-.08	-.00	-.06	.02	.12	.10	-.24	-.25	.08	-.11	-.08	.14	-.20	.24	.08	.68**	1.00		
20 Post-test CES-D	.04	-.14	-.29	-.18	-.01	-.16	-.17	.07	-.06	-.14	-.07	-.13	-.35*	-.02	-.14	.50**	.30	.85**	.72**	1.00	
21 Post-test STAI-T	-.09	.06	.02	-.08	-.12	-.05	.27	-.06	-.20	-.40*	.13	-.04	-.05	.08	-.15	.32*	.63**	.64**	.83**	.73**	1.00

Note. Data of two participants who showed below 90 % accuracy was excluded for scores from gap-overlap task and ANT. Change scores were calculated by subtracting pre-test score from post-test score. CES-D = Center for Epidemiological Studies Depression scale, and STAI-T = Trait form of the State-Trait Anxiety Inventory.

* = $p < .05$. ** = $p < .01$.

effect was not significant (*r* = -.08, *p* = *n.s.*). It was possible that these null correlations could be attributed to the variability in the baseline scores of attention tasks, because change amount of bias index was negatively correlated with bias index in pre-test session (*r* = -.50, *p* < .01), and similarly, the change amount of gap effect was also negatively correlated with gap effect of pre-test session (*r* = -.51, *p* < .01).

In order to test this possibility, I further calculated residualized change scores of task performances using simple linear regression models wherein post-test scores of attentional tasks were predicted by the pre-test scores. The residualized change scores are considered to be independent of baseline status, and actually they were not correlated with their own baseline scores (*r* = .00, *p* = *n.s*; Cohen, Cohen, West, & Aiken, 2003). The results showed similar correlation patterns to the simple difference change scores, suggesting no significant correlation between change score of bias index and gap effect (*r* = .13, *p* = *n.s.*), even when the effects of baseline scores were controlled.

Additionally, I conducted moderation analysis in which the change scores of attentional biases (and gap effects) were predicted by interactions between the pre-test scores and instruction conditions. However, the results showed no significant interaction effects on bias index change (*t* = -1.03, *p* = *n.s.*) and gap effect change (*t* = 1.10, *p* = *n.s.*), implying that the baseline scores of attentional bias (and gap effects) do not influence the explicit/implicit instruction effects of the ABM. These findings suggest (a) both dot-probe and gap-overlap performances were significantly changed after ABM training, but (b) the extent of changes in these two parameters were not correlated. Because I can eliminate the possibility of contamination of the variable baseline bias scores, it would be the case that dot-probe and gap-overlap performances were changed independently through different pathways.

4. Discussion

Experiment 3 examined whether a dot-probe-based ABM procedure could modify attentional bias, with a particular focus on attentional disengagement from negative stimuli (measured by the gap-overlap task) and orienting ability toward neutral information (measured by the ANT). Furthermore, I tested the differential outcomes between two types of training instructions: informing the stimulus contingency (explicit instruction) or not (standard instruction) before ABM training. First, my results showed that attentional disengagement from negative stimuli in the gap-overlap task was improved by the ABM procedure for the explicit instruction group. This improved performance suggests that the training effect transferred to tasks other than the dot-probe task. This result supports the notion that ABM training facilitates attentional disengagement from negative information, apart from merely improving superficial task performance. The present results may also imply that previous studies applying dot-probe training have possibly succeeded in improving the attentional disengagement of participants. Impairment in attentional disengagement is often found among individuals high in negative mood when negative stimuli are presented (Koster et al., 2004; Koster et al., 2005; Moriya & Tanno, 2011) and might relate to the ruminative thinking in depression (Koster et al., 2011).

My results also indicated that the impact of ABM is variable among participants, and this variability possibly results from participants' uneven baseline attentional bias. Correlation analysis indicated that some participants showed low attentional bias prior to the training; thus, their attentional bias was not largely improved. However, participants with relatively strong baseline bias showed larger changes in attentional bias after the training sessions. In other words, the impact of bias modification possibly differed in proportion to the strength of baseline attentional bias.

Contrary to my hypothesis, a significant correlation between residualized bias index change scores and residualized gap-effect change scores was not found herein; both the bias index and the gap-effect were modified by ABM during the explicit instruction group. This finding possibly resulted from the different attentional functions that were measured in the dot-probe and gap-overlap tasks. As noted above, the dot-probe task is not a pure measure of attentional disengagement; however, the gap-overlap task is a measure of disengagement (Fox et al., 2001; Koster et al., 2005). Thus, performance on the dot-probe task possibly represented a training effect not only for attentional disengagement but also for attentional engagement or shifting; this was not measured during the gap-overlap task. Therefore, it can be assumed that ABM affects specific attentional bias in attentional disengagement (measured by the gap-overlap task) and wider attentional dysfunctions including attentional engagement and shifting (measured by the dot-probe task). Given that ABM is effective only on biased attentional processes, one who has unbalanced bias among the different attentional functions (e.g., biased attentional disengagement but unbiased attentional engagement and shifting) may show ambivalent training reactivity between the two tasks; for example, he/she may show larger improvement in attentional disengagement, but smaller change in attentional engagement and shifting. Indeed, this may be the reason for the independent change of bias index and gap-effect in the results presented herein. Future research needs to examine the influences of ABM on each attention process by using multiple spatial attention tasks to explicitly discriminate among attentional disengagement, engagement and shifting.

I found that the ABM effect was observed in only the explicit instruction group but not the standard instruction group in Experiment 3. These results are partly congruent with Krebs et al. (2010), whereby explicit instructions produced a greater reduction of attentional bias than a standard instruction. Participants in the explicit instruction group likely controlled their attention in a top-down fashion in order to better attend away from negative stimuli. Top-down control of attention is thought to require more effort than bottom-up control, and this may have bolstered the effect of attentional training for the explicit instruction group. On the other hand, participants in the standard instruction group could not have been expected to effortfully control their attention. It is important that my results revealed that top-down attentional control might have promoted attentional training. Moreover, attentional disengagement through top-down control in an ABM procedure has not been frequently addressed in the literature. In fact, top-down attention established by an endogenous cue can decrease or extinguish the effect of exogenous attentional capture by inhibiting distraction from salient stimuli.

This produces attentional orienting toward an endogenously cued location, which is referred to as contingent capture (Folk, Remington, & Johnson, 1992; Reeck, LaBar, & Egner, 2012). In Experiment 3, explicit instructions may have helped participants train their attention effortfully, and this effortful training helped efficient disengagement from negative words and toward opposite location targets. Thus, I observed a practical use for ABM in the current study. Individuals were able to control their attention in a top-down fashion over a short training period with minimal labor. It should be additionally noted that if the present result was caused by top-down attentional control in the explicit instruction group, longer stimuli presentation or longer stimuli onset asynchrony might be necessary because short SOA can disable attentional control. In future research, how varied presentation times affect attentional control should be investigated.

For both the explicit instruction and standard instruction groups, only marginal changes were observed in the three attentional components measured by the ANT. It is interesting that these changes did not correspond to the ABM training. Significant effects of the ABM were found only within the explicit instruction group for the dot-probe and gap-overlap tasks. These results suggest that the ABM procedure can modify valence-specific attention but does not improve non-emotional attentional functioning. Koster et al. (2011) reviewed studies assessing attentional deficits in individuals with depression and argued for the importance of valence-specific attentional deficits in depression. Therefore, improvements in valence-specific attentional control may be more important than the enhancement of attentional functioning in dealing with non-emotional stimuli for the prevention of prolonged negative mood.

Additional limitations of Experiment 3 should be noted. First, I could not investigate the effect of my ABM procedure on a clinical sample. It is possible that different reactions to the present ABM procedure would be found in such a sample. Individuals with emotional disorders are typically more immersed in negative affective states, and their negative attentional biases would likely be stronger than those from a non-clinical sample. Thus, as Hakamata et al. (2010) showed, stronger attentional biases within a clinical sample may lead to larger ABM effects. However, clinical samples are thought to have difficulty with top-down attentional control (see Bishop, Duncan, Brett, & Lawrence, 2004). The effect of explicit instructions might be lower among clinical samples since explicitly instructed ABM is assumed to require effortful, top-down attentional control. Future studies should include clinical samples to address these possibilities.

Related to this limitation, no significant emotional change was observed along with attentional changes in Experiment 3. Thus, although previous meta-analytic reviews show the possible therapeutic effect of ABM (Bar-Haim, 2010; Hakamata et al., 2010), Experiment 3 is inconclusive with regard to whether my ABM procedure actually decreased negative emotion. One possible explanation of the absence of emotional change is that the participants did not have especially high prior levels of anxiety or depression. This can make it difficult to detect emotional change because the baseline negative emotion is lower. Moreover, in the present ABM task, stimuli were not chosen to modify attention to specific negative conditions, like depression or anxiety. To modify specific emotional conditions, stimuli should also be selected according to the emotional condition being targeted. Thus, it is possible that my method was useful to modify negative attentional bias but modification according to the targeted emotion must be made to achieve a therapeutic effect. The effect of such modification should be investigated in future research, and it is required to select participants with high depression or anxiety.

The results of Experiment 3 did not show a significant ABM effect in the standard instruction group, while some previous studies have reported significant effects with standard instructions (e.g., Amir et al., 2009). However, in these previous studies, participants completed several more trials in one training day (Krebs et al., 2010; MacLeod et al., 2002) or experienced a longer training period (Amir et al., 2009). In other words, the intensity of the attentional training might have been comparably lower in Experiment 3, and this might have led to the absence of a training effect in the standard instruction group. Thus, my results should not be interpreted as negative evidence of ABM with standard instruction. Future work should investigate how the results might change if both groups were trained with larger amounts of trials or training sessions of longer duration. Moreover, my ABM procedure was designed to modify attentional biases only in attentional disengagement. Since previous studies have reported not only attentional disengagement but also impaired inhibitory function in depression and anxiety, future investigations should examine how to promote inhibition of negative information for therapeutic purposes.

There is also the possibility that strategic differences among the attentional tasks affected the results. Speculatively, participants possibly responded to the two tasks differently since the dot-probe task was used in both the training session and the test session; however, the gap-overlap task was only used in the test-session. For example, some participants may be strongly conscious of the different task rules between the training session and test session, especially in explicit instruction group. Thus, they may have intentionally inhibited attentional disengagement from negative stimuli during the test session (because there was no need to disengage from negative stimuli in test session). It may also be that this type of strategic difference does not easily occur in the gap-overlap task. However, I cannot draw conclusions about the issue because there is insufficient literature on ABM that has tested the results of attentional training with multiple attentional tasks. Therefore, I recommend that future studies on ABM examine the training effect of different tasks in order to compare the effect of different attentional functions.

Finally, the present experimental design did not have a non-trained control group, in that the standard instruction group was also actively trained according to the rationale of previous ABM studies. Although the explicit instruction group showed a decreased negative attentional bias after the training, the power of the bias reduction effect cannot be compared with the baseline control group in Experiment 3. To confirm that my ABM procedure has considerable bias reduction power, comparison with a non-training group would be required in any future replications of this work.

Despite the above-mentioned limitations, Experiment 3 revealed a transfer effect of ABM and the beneficial effects of explicit instructions on ABM training. I observed that ABM had a significant effect on the modification of negative attentional biases but only a marginally significant effect on attention toward non-emotional stimuli. Thus, ABM may especially modify valence-specific attentional control toward negative information. The present results also highlight the utility of explicit instructions during ABM. Although there are still very few examples applying explicit instructions during ABM, explicit instructions likely strengthen the ABM effect. Overall, the present results revealed the mechanisms underlying the ABM effect, providing an effective method for efficiently modifying attentional biases to negative stimuli.

Experiment 4

1. Introduction

In Experiment 1, negative attentional bias was not found in depression, but I found relative inattention to negative stimuli in anxiety when the attentional window was used as an index of attentional bias. On the other hand, I found attentional avoidance from positive stimuli in depression in Experiment 2. As discussed in Experiment 2, inattention to positive information is considered an important factor of depressive cognition since avoiding positive information can lead to difficulty in recovering from depressive mood. Thus, to improve mental health, it should be important not only to decrease attention to negative information but also to increase attention to positive stimuli.

It seems that ABM can be applied to increase processing of positive information; however, previous research has shown that “attend positive” training in ABM can have negative results. Nevertheless, in none of these previous studies were participants explicitly instructed to attend to positive stimuli deliberately. Thus, in Experiment 4, I tried to increase attention to positive stimuli by using ABM with explicit instructions, which had an efficient training effect in Experiment 3. I also examined whether the effect of ABM with a modified dot-probe task transfers to improved performance on a digit-parity task, since attentional avoidance from positive stimuli was found in individuals with higher depression levels in Experiment 2.

2. Method

Experimental Design

The ABM procedure in Experiment 4 employed a design similar to that of Experiment 3, with some alterations. As in Experiment 3, during the current 5-day ABM program, there was a pre-test session on the first day, training sessions for 3 days, and a post-test on the fifth (final) day. In Experiment 4, participants performed the dot-probe task and digit-parity task but not the gap-overlap task and ANT in the pre-test and post-test sessions. Participants were divided into a training group and a control group. In Experiment 4, implicit instruction was not used; thus, all participants in the training group completed the attentional modification task with explicit instructions about cue-stimulus contingency. The control group completed a normal dot-probe task without cue-stimulus contingency.

Participants and Procedure

A total of 21 university students from the University of Tokyo participated in this experiment. The CES-D and STAI-T were administered to measure depression and trait anxiety. Participants were randomly assigned to the training group (*n* = 12, six women), where they performed the attentional modification task in which targets were always presented at the same location as the positive stimuli. The others (*n* = 9, four women) were assigned to the control group, which performed a normal dot-probe task (Table 3-4). Participants did not significantly differ in terms of depression or trait anxiety between these groups.

Materials and Tasks

In Experiment 4, 80 words each were collected for positive, negative, and neutral stimuli, from the word set of Matsumoto (2006). Splitting these words, two word sets including 40 positive, negative, and neutral words were created. The first set was used in the pre-test and training session, and the other set was used in the post-test session.

Dot-probe task Experiment 4 employed mostly the same dot-probe task as that of Experiment 3, with two modifications. First, the dot-probe task in Experiment 4 included not only neutral, congruent negative, and incongruent negative trials but also congruent positive and incongruent positive trials, to measure attentional bias to positive stimuli. All types of trials were presented 40 times each in random order. Second, presentation duration of word stimuli varied from 800 to 1200 ms in Experiment 4 to make it difficult for participants to forecast the time targets were presented.

Table 3-4

Descriptive Statistics of Participants Who Completed All Sessions

Group	Training				Control			
n	12				9			
Age	18.75				19.33			
Gender(F/M)	6/6				4/5			
	Pre		Post		Pre		Post	
CES-D *M* (*SD*)	10.08	(5.66)	8.25	(6.27)	14.22	(9.00)	15.67	(10.74)
STAI-T *M* (*SD*)	43.00	(9.51)	42.42	(11.18)	47.78	(11.13)	50.22	(10.74)

The bias index for selective attention to positive stimuli was calculated as follows: ((average RTs on incongruent positive trials) – (average RTs on congruent positive trials)). A higher bias index indicates that the participant selectively attended to the location of positive words.

Digit-parity task The digit-parity task in this experiment was mostly same as that in Experiment 1 and 2, except that negative stimuli were also presented in Experiment 4. Neutral stimuli were presented in 40 trials; positive and negative stimuli were each presented in 80 trials. Half of each type of trials were distant trials, and the other half were near trials.

The bias index was calculated in the similar way as in Experiment 2, It was calculated using the following formula: ((average RTs on distant trials with positive stimuli) – (average RTs on near trials with positive trials)).

Attention modification task Participants in the training group completed the attentional modification task during the training session. This task proceeded in the same way as the dot-probe task in the pre- and post-test sessions, but there were no incongruent positive trials. Thus, there were 40 neutral trials, 40 congruent negative trials, 40 incongruent negative trials, and 80 congruent positive trials. In this way, in the attentional modification task, the target always appeared at the same location as the positive stimuli to orient participants' attention to positive information.

The control group completed exactly the same dot-probe task as that in the pre-test session; thus, there was no attentional modification in the training session for the control group.

3. Results

Dot-probe task

I first tested the effect of attentional training on attention in the dot-probe task. Trials with errors or outliers (RTs above or below 2 *SD* of the overall average RT) were removed before analysis. To test the effect of attentional training, a two-factor ANOVA was conducted with bias index as the dependent variable (Figure 3-6). The independent variables were training group (control, training; between-subject factor) and time (pre-test, post-test; within-subject factor).

Results showed that the interaction between training group and time was not significant ($F(1, 19) = 0.01$, $p > .10$, $\eta_p^2 = .00$). Moreover, the main effect of training group and time was not significant ($p > .10$). These results indicated that no significant change in attentional bias was caused by the present training procedure.

Digit-parity task

In the same way, I conducted an ANOVA to examine the effect of training on the attentional window. Trials with errors and outliers (RTs above or below 2 *SD* of the overall average RT) were removed before the analysis.

I performed a two-factor ANOVA in which the dependent variable was bias index, and the independent variables were training group (control, training; between-subject factor) and time (pre-test, post-test; within-subject factor; Figure 3-7). Results revealed that the interaction between training group and time was not significant ($F(1, 19) = 1.09$, $p > .10$, $\eta_p^2 = .05$). The main effect of training group and time was also not significant ($p > .10$). Training to increase attention to positive stimuli was not successful in the dot-probe task, which was a task used in training session. I expected that the training effect should be more apparent in the dot-probe task, since there was greater similarity between the training and dot-probe tasks than between the training and digit-parity tasks. Thus, it is natural that bias change was also not observed in the digit-parity task, in the same way as in the dot-probe task.

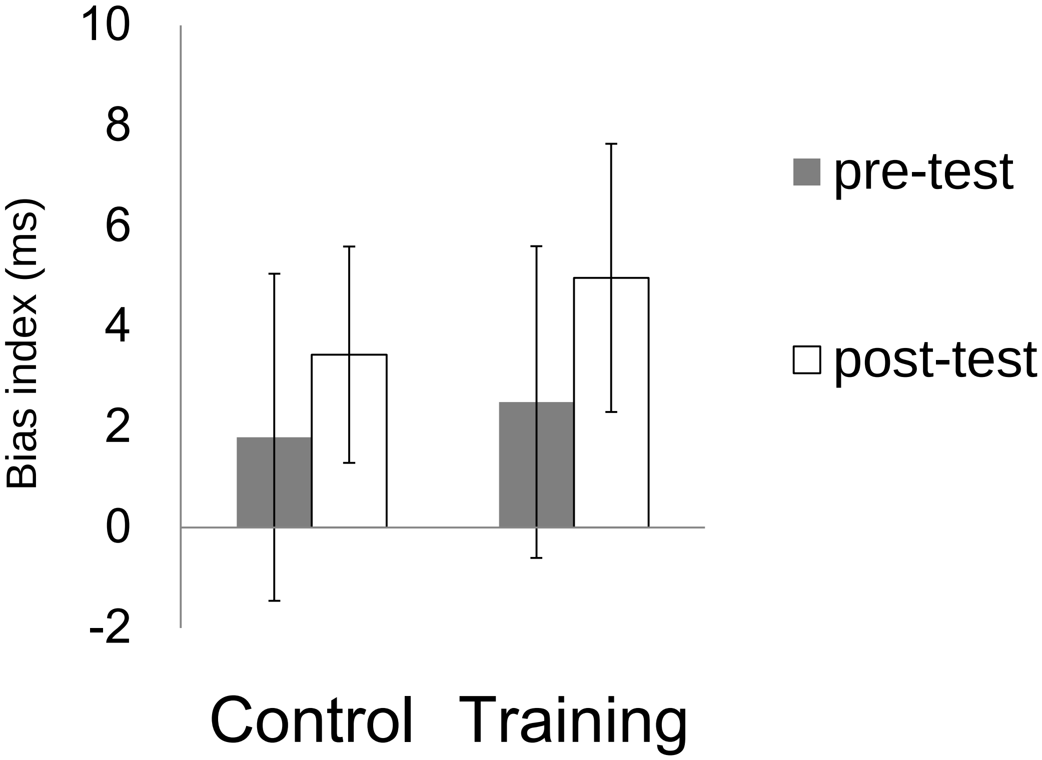

Figure 3-6. Bias index for each condition in dot-probe task.　Error bars indicate standard error.

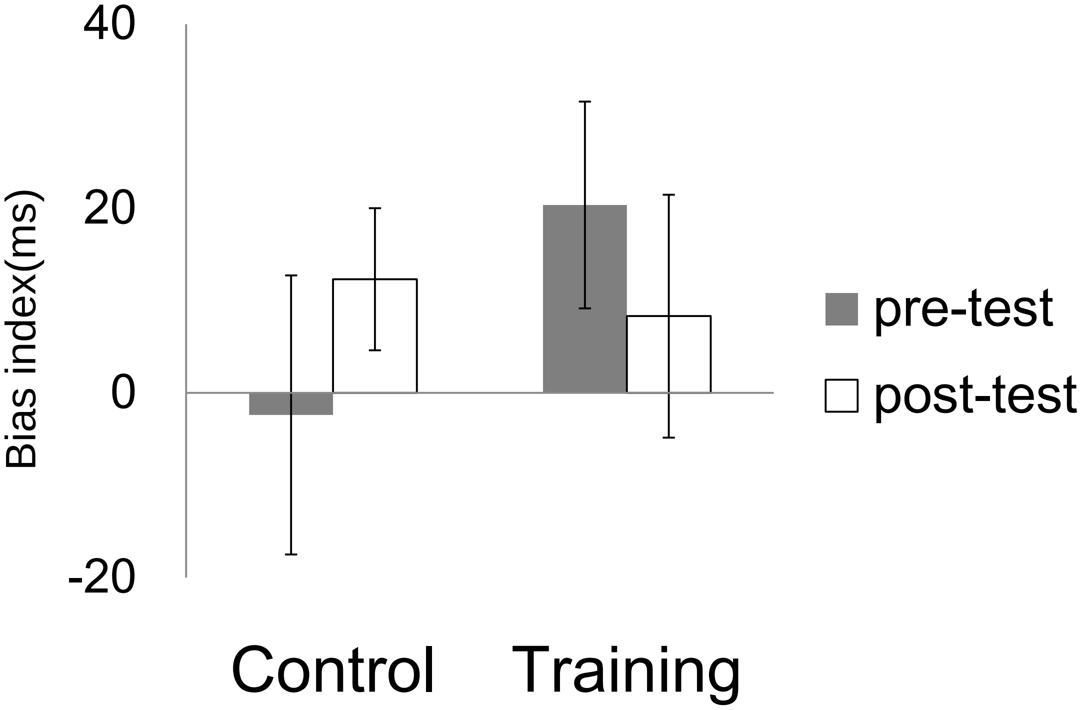

Figure 3-7. Bias index for each condition in digit-parity task. Error bars indicate standard error.

Correlation analysis

Though there were no significant changes in task performances in response to the present ABM, I conducted correlation analysis to investigate the relationship between task scores and emotional measures (Table 3-5). Correlation between pre-test scores, post-test scores and change scores were analyzed. Correlations between CES-D and STAI-T scores were significant ($p < .05$), but change scores of CES-D and STAI-T were not correlated with changes in task performances (p = *n.s.*). Moreover, change scores of dot-probe task and digit-parity task were not significantly correlated (p = *n.s.*).

4. Discussion

In Experiment 4, I tried to increase attention to positive stimuli by applying ABM developed in Experiment 3, since inattention to positive stimuli is assumed to be an important factor in depression. Moreover, I applied the digit-parity task as an attentional bias measure to observe the modification effect of ABM on the attentional window because attentional avoidance from positive stimuli was found in Experiment 2. Since the ABM procedure developed in Experiment 3 was sufficiently effective in modifying attentional bias to negative stimuli, it was expected that attention to positive stimuli would be successfully increased in the training group. My ABM procedure showed a transfer of the modification effect to other tasks; thus, it was also possible that ABM with the modified dot-probe task affected performance on the digit-parity task. However, the results were largely different from my expectations in that there was no significant modification effect caused by the present ABM procedure. ABM did not significantly increase attention to positive stimuli in the dot-probe task and the digit-parity task, and changes in performance on these attentional tasks between the pre-test and post-test were not correlated. Depression and trait anxiety were also not affected by ABM, and their changes between the pre-test and post-test were not correlated with changes in performance on attentional tasks.

Table 3-5

Correlations Among Task Performances and Emotional Measures

	1	2	3	4	5	6	7	8	9	10	11	12
1 Dot-probe bias index change	1.00											
2 Pre-test Dot-probe bias index	-.791**	1.00										
3 Post-test Dot-probe bias index	.756**	-0.198	1.00									
4 Digit-parity bias index change	-0.279	0.116	-0.323	1.00								
5 Pre-test Digit-parity bias index	0.066	-0.062	0.04	-.751**	1.00							
6 Post-test Digit-parity bias index	-0.346	0.104	-.443*	.651**	0.012	1.00						
7 CES-D change	0.297	0.026	.505*	0.231	-.460*	-0.179	1.00					
8 Pre-test CES-D	-0.28	.488*	0.073	-0.139	0.044	-0.161	0.036	1.00				
9 Post-test CES-D	-0.071	0.416	0.332	0.01	-0.212	-0.228	.568**	.843**	1.00			
10 STAI-T change	-0.231	0.151	-0.209	0.29	-.466*	-0.097	0.163	-0.003	0.085	1.00		
11 Pre-test STAI-T	-0.1	0.399	0.267	-0.017	-0.196	-0.251	0.259	.765**	.769**	-0.054	1.00	
12 Post-test STAI-T	-0.203	0.432	0.137	0.128	-0.406	-0.273	0.313	.685**	.732**	.444*	.871**	1.00

Overall, it seems that Experiment 4 failed to modify attention to positive stimuli. In fact, while there are a number of successful examples of attentional bias modification for negative information (Hakamata et al., 2010; though the effect may be small to medium, according to Mogoase & Koster, 2014), there are very limited examples of attentional modification to increase attention to positive information (Baert et al, 2010; Boettcher et al., 2013; Browning, Holmes, Charles, Cowen, & Harmer, 2012). Browinng et al. (2012) found that ABM with positive facial stimuli could significantly increase attention to positive stimuli. However, in their experiment, ABM with positive verbal stimuli failed to increase attention to positive information. These results indicate that ABM for attention to positive stimuli is less effective when verbal stimuli are used, though attentional bias to negative stimuli could be successfully modified with verbal stimuli. Browning et al. (2012) speculated that facial stimuli have a more emotional impact than verbal stimuli (Vuilleumier, 2005), though the mechanism underlying these results is unclear. In contrast, Baert et al. (2010) failed to increase attention to positive stimuli with attend-positive ABM employing verbal stimuli. Boettcher et al. (2013) did not find a beneficial effect of attend-positive ABM on social anxiety, though they did not measure changes in attention to positive stimuli. Their results also implied that the difference between training with facial stimuli and training with verbal stimuli is not important for the effect of ABM. It should also be noted that the duration of ABM was 2 weeks in the study by Browning et al. (2012).

These previous results show that increasing attention to positive stimuli is more difficult than decreasing negative attentional bias. Thus, even my improved ABM with explicit instructions, which could effectively decrease attention to negative stimuli, failed to increase attention to positive stimuli. This leads to the question of why it is difficult to increase attention to positive information. Eastwood, Smilek, and Merikle (2001) found that negative emotional stimuli easily grab attentional focus even when they are not attended to, compared to positive stimuli. In their study, participants were required to attend to positive stimuli in the training session; however, they were not instructed to attend to positive stimuli in the pre-test and post-test sessions in the present ABM. On the basis of the findings of Eastwood et al. (2001), it can be speculated that participants did not process positive stimuli since they did not have to attend to positive stimuli in the test sessions. In the training session, participants may have been trained to control attention after they detected emotional stimuli; thus, they could not control their attention to unattended positive stimuli in the test sessions of Experiment 4. It is also possible that participants once focused on negative stimuli even when they did not have to attend to such stimuli in Experiment 3, and subsequently could shift their attention away from negative stimuli as they were trained. Accordingly, it might have been difficult to increase attention to positive stimuli using the extant ABM method. This method therefore may need to be further refined to increase attention. Other cognitive modification methods can also affect attention to positive information. For example, Amir et al. (2010) showed that interpretation bias modification can affect attentional disengagement from threat stimuli, and Shechner et al. (2014) found that cognitive behavioral therapy can affect attentional bias. These attempts at least indicate the possibility that dot-probe based ABM is not necessary to modify attentional bias.

Of course, Experiment 4 has certain limitations. First, participants were not selected on the basis of their original attentional bias to positive stimuli. The results of Experiment 3 indicate that it should be difficult to increase attention to positive stimuli in individuals with higher attentional bias to positive information. If individuals with low attention to positive stimuli were selectively recruited, the present ABM might have been able to modify attention. Moreover, there were a limited number of participants in Experiment 4, and the sample was non-clinical. Thus, the present results cannot be generalized to clinical samples. ABM might be effective for individuals with clinically diagnosed depression or anxiety, who are assumed to have greater attentional disturbances.

Despite these limitations which must be addressed in future studies, Experiment 4 makes an important contribution to existing knowledge by showing that modification of attention to positive information is difficult with the extant ABM procedure. Future studies should reveal how attention to positive information can be improved. A more detailed understanding of the mechanisms underlying

ABM may be required for further improvement of ABM.

Chapter 4 General Discussion

Summary

The present doctoral thesis attempted to investigate attentional bias in depression and anxiety and to develop a training procedure to decrease attention to negative information and increase attention to positive information.

In Experiments 1-1, 1-2, and 1-3, the attentional window was measured with a digit-parity task to observe attentional bias in depression and anxiety. A previous study predicted that attentional bias in depression can be observed in the attentional window (Mathews & MacLeod, 1994), and the attentional window was expected to narrow when sad stimuli were presented to individuals with higher depression. However, no attentional bias in depression was found in the attentional window. Otherwise, anxiety affected the attentional window when sad stimuli were presented. Individuals with high trait anxiety showed a broadened attentional window while those with low anxiety showed a narrowed attentional window when sad stimuli were presented (Experiment 1-1). This difference caused by anxiety disappeared with shorter stimuli presentation time. In Experiment 1-2, sad stimuli made the attentional window narrower than did neutral stimuli, and there was no significant effect of anxiety and emotional stimuli in Experiment 1-3.

There was no significant effect of depression in Experiment 1, a result that is unexpected based on previous studies. Thus, I attempted to observe another aspect of attentional disturbance in depression. In Experiment 2, I measured the attentional window when positive stimuli were presented. Based on previous results, it is expected that individuals with depression will avoid attending to positive stimuli; thus, it is expected that the attentional window will become broader, and attention to stimuli near the positive stimuli will be inhibited. In my experiment, individuals with depression had slower responses in near trials and faster responses in distant trials when positive stimuli were presented while individuals with lower depression showed no difference. These results mostly supported the hypothesis.

In Experiments 3 and 4, I attempted to develop an efficient ABM. Previous studies expected ABM to be more efficient when trainees are explicitly instructed on the congruency between emotional stimuli and the target. According to this expectation, I compared explicit instruction with standard instruction in terms of the training effect of ABM in Experiment 3. The results indicated that ABM with explicit instruction may be more efficient than with standard instruction. In accordance with this finding in Experiment 3, I attempted to increase attention to positive stimuli with explicit instruction in Experiment 4. Though there are few previous examples of success in increasing attention to positive stimuli with ABM, I expected that attention to positive stimuli could be increased by ABM with explicit instruction and, moreover, that the effect of ABM could transfer to other aspects of attention even if attentional training is conducted with a dot-probe task, which is related to attentional orienting. However, the results showed no significant effect of ABM. It was speculated that positive stimuli were not well processed in the test sessions since participants did not have to attend to positive stimuli in the test sessions in Experiment 4, while negative stimuli, which were used in Experiment 3, grabbed attention even when participants did not attended in advance.

Implications

Attentional window and attentional bias in depression and anxiety

The results of Experiment 1 showed that no attentional bias to sad facial stimuli was found in individuals with higher depression. Individuals with lower anxiety showed a narrow attentional window in response to sad stimuli while individuals with high trait anxiety showed a broader attentional window when sad faces were presented for a long time. These results were not expected from previous studies, which have mainly investigated attentional bias in depression and anxiety with an attentional orienting task. It is assumed that attentional orienting tasks such as the dot-probe task and digit-parity task observe different aspects of attention; thus, it may be natural that the same pattern of attentional bias is not observed in different tasks. Considering the present results, it may be problematic that previous studies such as Koster et al. (2011) theorized the role of attentional bias in depression and anxiety based only on the results of attentional orienting since there may be other types of attentional disturbance when focusing on other aspects of attention. Researchers must further understand the detailed attentional mechanism underlying cognitive biases in depression and anxiety. Thus, I must focus on other aspects of attention, including the attentional window, as much as I do on attentional orienting.

To integrate previous knowledge on orienting bias with the findings of the present thesis, it may be of interest to compare biases between attentional orienting and the attentional window. For example, attentional disengagement is proposed as an important factor of attentional orienting bias in depression and anxiety (e.g., Koster et al., 2011). How, then, is attentional zooming-out (Ronconi, Gori, Ruffino, Molteni, & Facoetti, 2013), which is a process of broadening the attentional window after it is narrowly focused on one location. Attentional disengagement and zooming-out seem alike in the terms of taking attentional resources away from one location, but the relationship between attentional bias in disengagement and attentional zooming-out is unclear.

ABM and attention to positive stimuli

In Experiments 3 and 4, I attempted to develop ABM to modify attentional bias in depression and anxiety. Negative attentional bias was successfully modified in Experiment 3, but attention to positive stimuli was not facilitated by ABM in Experiment 4. Moreover, against my expectation, depression and anxiety were not improved in either Experiment 3 or 4, which is disappointing in terms of developing a potential therapeutic methodology.

In fact, there is a lasting argument over whether ABM can efficiently improve emotional disturbance. Cognitive bias modification (CBM), including ABM, has been enthusiastically investigated as a potential treatment for cognitive bias in depression and anxiety in this decade. If CBM is applied for treatment, it may require less effort and lower cost from individuals with depression and anxiety than previous methods. Moreover, CBM can easily be computerized, allowing for quick and uniform treatment to be provided for sufferers. Though CBM seems promising, previous results are mixed, and meta-analytic reviews have revealed that the effect of CBM is not robust (Clarke, Notebaert, & MacLeod, 2014; Hallion & Ruscio, 2011; Mogoase et al., 2014). Koster and Bernstein (2015) agreed that extant CBM does not have a satisfactory effect and cannot yet be applied for therapeutic use, but they strongly encouraged further investigation to improve CBM, since CBM is still in a very early stage of development. Koster and Bernstein suggested five steps to advance CBM studies: 1) innovation and refinement for a bias modification method, 2) further understanding of the mechanism underlying information processing bias, 3) revealing the moderator and mediator in the effect of CBM, 4) examination of the augmenting effect of existing treatment, and 5) publication to share mixed and unexpected results. Though my experiments could not show improvement in depression and anxiety, Experiment 1 revealed improvement in the attentional modification effect by explicit instruction, which corresponds to the first step suggested by Koster and Bernstein. Moreover, Experiment 1 indicated a possible effect of top-down control in ABM training, which corresponds to the second step. Experiment 2 showed no effects of ABM on either attention or emotion, but I could discuss why explicitly guided attentional training is not effective at increasing attention to positive information together with previous results, corresponding to the second and fifth steps of Koster and Bernstein. It seems beneficial to investigate why ABM is effective along with examining why ABM sometimes fails to affect attention or emotional disturbance to understand the detailed mechanism of action on ABM in future studies. The second step is also related to Experiments 1 and 2, which are attempts to understand the mechanism of attentional bias, though these experiments did not attempt to modify attention. Not only direct investigation on ABM but also research on attentional bias itself are still important to consider applying CBM for therapeutic purposes.

Limitations and future direction

There are a number of limitations in the current doctoral thesis. First, Experiments 1 and 2 investigated the attentional window in depression and anxiety since it was previously discussed that attentional bias can be found in the attentional window, but some aspects of attention remain ignored in terms of attentional bias. For example, previous studies found that depression and anxiety affect temporal attention, visual search, or attentional interference. A relatively limited number of studies have been conducted previously in these fields, and ABM studies have rarely applied attentional tasks measuring temporal attention or attentional interference. Including the present study, almost all of previous studies on attentional bias in depression and anxiety have applied tasks in which critical targets appear at unexpected location. It means that current literature is partial to tasks require transient attention rather than sustained (Nakayama & Mackeben, 1989; Sarter, Givens, & Bruno, 2001), thus further research should be conducted with tasks requiring sustained attention for targets. Future studies should examine attentional bias in depression or anxiety in these aspects of attention and whether ABM can affect them.

Second, related to the first limitation, it is unclear how biases in attentional orienting and attentional window are mutually related. Though the present results showed no correlation between attentional bias in dot-probe and digit-parity tasks (Experiment 4), I could not come to any conclusion because of certain limitations. For example, Experiment 4 only applied verbal emotional stimuli, and the effect of presentation time was not considered. It is natural that different attentional aspects may more or less share same underlying cognitive processes. More systematic and strictly controlled comparison between attentional biases in attentional orienting and attentional window is required in future study to discuss this relationship. Moreover, the present doctoral thesis could not apply neuropsychological methods. It would be helpful to measure neural activity or physiological index to further investigate the mechanisms underlying biased attention in future research.

Finally, only non-clinical samples were applied in the present thesis. Though I assumed continuity between depressive or anxiety disorders and depression and anxiety in non-clinical individuals, previous results have revealed different patterns of attentional bias between clinical and non-clinical samples. Peckham et al. (2010) found that attentional bias in the dot-probe task is larger in clinical (d = 0.70) than in non-clinical (d = 0.47) samples in terms of effect size, though the difference was not significant in the meta-analytic review. I should be careful to apply the present findings to the understanding of clinically depressed or anxious individuals, and it is strongly needed to replicate the present results with clinical samples in future studies.

Conclusion

The present thesis revealed two substantial novel findings for research into attentional bias in depression and anxiety. First, depression and anxiety affected not only attentional orienting but also the attentional window, though the pattern of attentional bias differed from previous findings in attentional orienting (Experiments 1 and 2). Second, the training effect of ABM can be promoted by explicit instruction, but only attention to negative stimuli was modified by current ABM; attention to positive stimuli was not improved (Experiments 3 and 4). In conclusion, attention seems to be affected by depression and anxiety, but there may be uninvestigated aspects of attention, which is potentially biased. Though modification of attentional bias seems beneficial for therapeutic purposes, the mechanism of attentional bias should be examined further to apply the knowledge for treatment.

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Acknowledgement

First of all, I gratefully acknowledge Dr. Yoshihiko Tanno for his great support and supervision all through my doctoral course. I am also really grateful to Drs. Toshikazu Hasegawa, Kazuo Okanoya, Takuma Ishigaki, Yuko Yotsumoto and Isamu Motoyoshi for their great help. I appreciate Drs. Keisuke Takano, Jun Moriya and Tomohisa Asai for their valuable and critical comments and suggestions on my research. I thank to Drs. Yudai Ijima, Masanori Kobayashi, Mingming Lin, for their assistance and advice on all my work in the laboratory. I also thank to all the members of Tanno laboratory for their support and many times of discussion.

Personally, I thank to my friends. Especially, Masaki Mori greatly helped and encouraged me as a colleague and a friend for a long time. Jun Kashihara, Noboru Matsumoto always motivated me to improve my works. Finally I wish to appreciate Sanae, Yurina, and Kaoru, who have warmly supported me for a long time