AN INVESTIGATION OF HEMISPHERIC LATERALIZATION DURING VISUAL SEARCH FOR EMOTIONAL FACES

BUKET KARA

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AN INVESTIGATION OF HEMISPHERIC LATERALIZATION DURING VISUAL SEARCH FOR EMOTIONAL FACES

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Prof. Dr. Cengiz Erol

Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Assoc. Prof. Dr. Hakan Çetinkaya

Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assoc. Prof. Dr.Hakan Çetinkaya

Supervisor

Examining Committee Members

Assoc. Prof. Dr. Hakan Çetinkaya

Prof. Dr. Sonia Amado

Asst. Prof. Dr. Seda Dural

ABSTRACT

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Kara, Buket

Experimental Psychology Master Program, Graduate School of Social Sciences

Supervisor: Assoc. Prof. Dr. Hakan Çetinkaya

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The present thesis examined hemispheric lateralization in preferential activation of cognitive mechanisms in response to threatening stimuli. The early and faster detection of threatening stimuli is closely associated with a defense mechanism, which is likely to be acquired through the evolutionary process of the human mind. In this respect, crowd of human faces with emotional content were used to provide ecologically valid stimuli, and a visual search task was adopted to investigate the mechanism. Behavioral and eye tracking data indicated early attentional capture of faces with a threatening expression (i.e. anger), which were presented among distractor faces, and longer attentional allocation of faces with a threatening expression, which were used as distractors. A visual field bias for detecting emotional faces in crowds was investigated in two follow up experiments by adopting divided visual field methodology and flicker paradigm of change detection. The results were evaluated on the basis of two prominent hypotheses on processing of facial emotions. Evidence for left visual field bias in the detection of emotional faces among crowds would provide new perspectives to understand the cognitive mechanisms for processing and search of facial stimuli.

Keywords: Change detection, facial expression, lateralization, threat detection, visual search

ÖZET

YÜZ İFADELERİNİN GÖRSEL TARANMASINDA HEMİSFERİK YANALLAŞMANIN İNCELENMESİ

Kara, Buket

Deneysel Psikoloji Yüksek Lisans, Sosyal Bilimler Enstitüsü

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Bu çalışmada, tehlike sinyalleyen uyarıcılara karşı tercihli olarak harekete geçen bilişsel mekanizmalardaki hemisferik yanallaşma incelenmiştir. Tehlikeli uyarıcıların erken ve hızlı saptanması, insan zihninin evrimsel süreçte kazandığı düşünülen savunma mekanizmasıyla yakından ilişkilidir. Söz konusu mekanizmayı incelenmek için ekolojik açıdan geçerli uyarıcılar olarak, yüzlerinde duygu ifadesi bulunan kalabalık insan grupları, bir görsel tarama görevinde kullanılmıştır. Davranışsal tepkiler ve göz izleme verileri, kalabalık gruplar içinde sunulan tehlikeli yüz ifadesine sahip (öfkeli) bireylerin dikkati daha erken çektiğini, tehlikeli ifadeli kalabalık grupların ise dikkati daha uzun süre tuttuğunu göstermiştir. Kabalık gruplar arasındaki duygu ifadelerinin saptanmasında görsel alan yanlılığının varlığına ilişkin birinde *görsel yarı alan* tekniği, diğerinde *değişimi saptamada yanıp sönme* paradigması kullanılan iki çalışma daha yürütülmüştür. Sonuçlar, yüzdeki ifadelerin işlemlenmesine yönelik olarak öne çıkan iki hipotez kapsamında değerlendirilmiştir. Kalabalık yüz grupları içindeki duygu ifadelerinin saptanmasında gözlemlenen sol görsel alan yanlılığının yüz ifadelerinin taranması ve işlemlenmesiyle ilgili olarak çalışan bilişsel mekanizmaların anlaşılmasında yeni bakış açıları kazandıracağı düşünülmektedir.

Anahtar Sözcükler: Değişimi saptama, görsel tarama, tehlike saptama, yanallaşma, yüz ifadesi

I dedicate my first scientific effort

to my beloved brother.

Although we have chosen parallel but different paths trying to contribute to the world,

I know that I could not have found my path -of science- without you.

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CHAPTER 1

INTRODUCTION

Every day and each moment, we encounter uncountable numbers of stimuli. In such a bombardment of information, our limited information processing system is able to process some of them, while the rest is filtered out, or attenuated from further processing. As William James (1890) emphasized "my experience is what I agree to attend to", what we see, hear, feel or remember shaped not only by the information that is reached to our sensory modalities, but also by the aspects that we choose to attend.

Selective attention to and processing of certain stimuli has been under investigation since 1950's. Cherry (1953) of electronics research laboratory at Massachusetts Institute of Technology, was fascinated about the "cocktail party problem": When we were in a party and surrounded by groups of talking people, how we were able to follow the conversation of our group? Moreover, what was the difference in processing for the sounds of attended conversation and the sounds of other conversations?

Cherry carried out dichotic listening tasks in which listeners were presented two different passages of text from the same voice, one of them to left ear, and the other to the right ear simultaneously, and were required to shadow one of the channels by repeating back out loud, while ignoring the other. Very little information seemed to be extracted from the non-attended passage that the listeners rarely noticed when the passage spoken in a foreign language, for instance. Cherry's shadowing task impressed and inspired other scientists, especially Broadbent, whose ended up with his famous bottleneck theory of filtering (1958). The theory suggests a filter that prevents overloading of limited capacity mechanism beyond the filter by selecting certain stimuli to be processed further and filtering out other, irrelevant stimuli. When the stimuli presented, an initial parallel processing of all stimuli is operated, which extracts the basic physical properties, such as pitch, color, and orientation. Then, the irrelevant information is filtered out, and the information from certain stimuli is selected for later processing based on its non-physical, semantic features. One challenge for Broadbent's theory on early filtering of non-attended information was the phenomenon of reporting information, which is presented through the non-attended channel, but semantically related to the context of the shadowed message, called "breakthrough" by Treisman later on (1960). Even though a filtering was necessary to prevent the overloading of limited capacity information processing mechanism, Treisman (1960) suggested that the filter reduced, or attenuated, the analysis of non-attended information, rather than filtering it out completely.

The location of the bottleneck was more flexible in comparison to the arguments of Broadbent, allowing the processing of semantic information of the stimuli at a level. As a result, signals of the partially processed stimuli on the non-attended channel are weaker than the signals of fully processed stimuli on the shadowed channel. On the other hand, when the non-attended information displays salient features, it sometimes exceeds the threshold of conscious awareness; hereby the phenomenon of breakthrough is manifested. At this point, the striking study of Corteen and Dunn (1974) should be mentioned to illustrate the breakthrough effect. Prior to the shadowing task, participants were trained with the city names, which were paired with the electrical stimulation. During the shadowing task, participants were instructed to attend one channel and ignore the other, and press a button if they heard a city name in either ear. Although participants pressed the button only for 2% of the city names presented from the non-attended channel, 72% of the city names, presented from the non-attended channel, elicited increment in galvanic skin response. The most important finding, however, was that people were not trained with the 30% of those city names previously. Even in the absence of attention and conscious awareness, processing of semantic information that was significant for the individual carried on.

Some stimuli that we encountered have a direct relevance for our well-being and survival: They may signal danger or threat, such as predators, or they may signal chances for growing and expansion, such as food resources or potential mates.

There is a clear evolutionary advantage for an organism to have an information processing mechanism that becomes activated preferentially for significant stimuli among unlimited stimuli encountered, and processes selectively certain stimuli, in favor of survival and reproduction success. Although the underlying mechanisms of processing of information has been investigated for distinct sensory modalities and for the nature of adaptation that it leads, in the current study, the main focus will be on the preattentive and attentional mechanisms that provide rapid responding to the presence of potential threat in the visual environment.

Attentional Mechanisms and Threat Detection

Research on attentional mechanisms during a visual search, which requires detection of the discrepant stimulus, or target, among an array of other stimuli, or distractors, has been subject of hot debate, mainly on the distinction between preattentive processing and attentional processing (Cave and Batty, 2006). Preattentive processing refers to the early processing of information during which attention is spread over a wide region, whereas attentional processing refers to the processing during which attention is narrowed and focused. In 1980, Treisman and Gelade introduced their Feature Integration Theory and proposed a visual search model with two distinct stages: Parallel search and serial search. In parallel search, basic features such as color, orientation and movement are processed concurrently across the entire visual field. The processing is carried out preattentively that in the absence of focused attention on individual items. As a result, reaction times to detect a target defined by a unique feature do not vary with the number of items on the field (or set size); a black vertical bar among black horizontal bars, for instance, “pops-out”.

On the other hand, when a target defined by conjunction of features that are also shared by distractors, serial search is carried out. In serial search, focused attention is deployed item by item in turn, until the target is found. Reaction times to detect a white vertical bar among white and black horizontal bars increase with the number of items on the field. As an indicator of parallel or serial search, search slopes are calculated (i.e. reaction times/set size) and inferred with the critical value of 10ms/item (Treisman and Gelade, 1980). If the search slope is shallower than 10ms/item, it indicates a parallel search, in which detecting the target is independent of the set size; whereas if the search slope is steeper than 10ms/item, serial processing is carried out that the detection time is influenced by the set size.

It has been noted, however, that the dichotomy of parallel and serial processes in search performance cannot be implemented, with the possible exception of pop-outs of search (Wolfe, 1998). The nature of parallel and serial processes is dichotomous and operated in distinct brain regions (Frischen, Eastwood, and Smilek, 2008); however, they can jointly contribute to the search performance (Wolfe, 1998). Without completely abandoning the Feature Integration Theory, Wolfe proposed Guided Search Model, which suggests a continuum of parallel/serial processing in search, rather than a strict dichotomy. The model suggests that some visual features, which are detected relatively early by the lower levels of visual system preattentively, can guide attention to a likely target location.

Treisman and Gelade (1980) envisaged features such as motion, orientation and color for early and parallel detection by relatively simple computational mechanisms, partly because of the existence of individual neurons in the visual cortex that are tuned to respond those properties. However, Guided Search Model goes beyond those basic features of objects. Although three dimensional structures and surface properties are processed later in the visual stream than colors or orientations, because they require more complex processing and integration of information across wider locations; there still can be parallel mechanisms for reconstructing these properties simultaneously across the visual field. Therefore, preattentive processing includes parallel construction of representations of surfaces, simple 3-D structure, information about simple visual features such as color and orientation from the entire visual field. Through the information encoded by preattentive representation, locations and/or objects are selected according to their salience. Attention is guided to the selected area for further processing of complex spatial relationships, comparisons against memory representations, identification and categorization. In a visual search task, detection of a target can be facilitated with the guidance of preattentive mechanisms by focusing the attentional mechanisms to the area of target candidate. If the selected input matches with the features of the target, it may receive additional attention; whereas nonmatching distractors may be inhibited to prevent their reexamination and to reduce demands on working memory involves searching performance (Klein and Dukewich, 2006).

The processing of evolutionarily relevant threatening stimuli has been under spotlights through the last few decades. Distinct methods were used to interrogate the phenomena of interest, although the results were similar: Threatening stimuli were effective in capturing attention, and the effect facilitated further processing of information. For instance, contrast sensitivity, a process that was carried out in primary visual cortex, was enhanced for the stimuli that were cued with a fearful face, rather than a neutral face (Phelps, Ling, and Carrasco, 2006); visual short-term memory processing was enhanced for angry faces (Jackson, Wu, Linden, and Raymond, 2009); the amygdala modulated enhanced awareness of negative stimuli that attentional blink, the phenomenon of deficit in the processing of the second of the two temporarily proximal non-emotional stimuli, decreased when the second target was negative (Ogawa and Suzuki, 2004); when cued with threatening stimuli on the one side, and neutral stimuli on the other side in a double cuing paradigm, attention was biased to the side that a threatening stimulus was used as the cue, and resulted in a faster performance for the target stimulus presented on that side (Lipp and Derakshan, 2005); the level of threat signaled by the stimuli revealed distinct effects on the double cuing task performance in which the high threatening stimuli resulted in vigilance, whereas minor threat led to avoidance (Wilson and Mcleod, 2003); differential attentional allocation was observed for angry and happy faces, which indicated a neural evidence for threat detection advantage (Feldmann-Wüstefeld, Schmidt-Daffy, and Schubö, 2011); an orienting bias toward emotionally negative faces was observed with brief and backward masked visual presentation, in which the conscious awareness of facial stimuli was restricted (Moog and Bradley, 1999);

visual search experiments indicated that the threatening stimuli, such as snakes or spiders, among distractors were detected faster than neutral stimuli among distractors (Öhman, Flykt, and Esteves, 2001); and discrepant angry faces, which were displayed among happy faces, were detected faster in comparison to the discrepant happy faces that were displayed among angry faces (Hansen and Hansen, 1988).

The visual search paradigm bears resemblance to everyday situations in which people attempts to find a target among distractors, just as looking for a friend in a café among crowd of other people. In visual search tasks, it is instructed to detect the presence or absence of a specified target among irrelevant distractors. In comparison to other paradigms that lacking assessment of either spatial shifts of attention (e.g. emotional stroop and attentional blink) or speed of attentional allocation on an item (e.g. dot cueing), it is advantageous to use visual search paradigm, because it provides both spatial and temporal resolution. Therefore, the present paper will focus on studies that used visual search paradigm, and adopt it as the main experimental paradigm for the current study.

Processing of Emotional Facial Expressions

Despite that the study of Hansen and Hansen (1988) was confronted with heavy criticisms such as having low-level perceptual confounds, dark spots on the chin area of angry faces for instance, studies on visual search for emotionally provocative facial stimuli have been pursued for decades later on. Significant amounts of studies, which investigated the relationship between threat detection mechanisms and attention, involved stimuli of emotional faces.

The rationale for using emotional facial stimuli in visual search studies lies under the basic mechanisms of face recognition. Face recognition is an old form of social communication and provides a wealth of information about both biological attributes, such as gender, age and physical properties, and social attributes, such as identity and emotional state, of encountered individuals. Those attributes are computed in the brain via separate neural systems, which are also shared with other primates (LeDoux, 1996). As an explicit manifestation of the emotional state, facial expressions provide a great deal of information about other peoples' intentions. A face with happy expression may suggest friendship, for example, whereas a face with angry expression may indicate threat or hostility. Thus, an attentional mechanism that favors detection of facial expressions would be of a considerable adaptive value, in terms of anticipating beneficial or dangerous situations.

Extracting facial expressions depends on subtle changes in the spatial configuration of facial features that seems to be a very complex computational task including both processing of constituent parts and the global representation of the face as a whole. Individual facial components may define specific expressions, such as V-shaped eyebrows and a downward curved mouth of an angry expression (Lundqvist, Esteves, and Öhman, 1999); with a strong impact that a simple geometric shape of "V" is capable of activating neural networks known to be associated with many realistic, contextual threatening displays (Larson, Aronoff, Sarinopoulos, and Zhu, 2008).

On the other hand, it is suggested that the impression of emotion conveyed by those components is much stronger when they are displayed in a face-like configuration than when they are presented in isolation or in a non-face context (Lundqvist, Esteves, and Öhman, 2004).

It is further advantageous to use faces as stimuli in visual search studies, because many aspects of face perception, including the perception of emotional expression, are disrupted when the faces are inverted (Yin, 1969). Thus, if emotional valence is the crucial factor that provides angry faces a detection advantage, then the advantage should have lessen or disappear when the faces are inverted. In contrast, if relatively simple configurations of lines are the critical factor in searching for angry faces, then the performance will be similar regardless of upright or inverted presentation of faces.

Psychophysiological data asserts that emotional facial expressions may be processed automatically (Dimberg and Öhman, 1996; Eastwood, Smilek, and Merikle, 2003; Esteves, Dimberg, and Öhman, 1994; Öhman, 2002). Even in the absence of attention or conscious awareness, when people are exposed to emotionally expressive faces, they automatically respond with their facial muscles (Dimberg, Thunberg, and Elmehed, 2000; Öhman, 2002), with autonomic responses and with activation of specific brain regions (Öhman, 2002; Whalen et al., 1998). The amygdala is the crucial brain structure for the analysis of emotional facial expressions, in particular for the analysis of negative expressions, such as fear (LeDoux, 1996; 2000). LeDoux (2000) argues that information about a stimulus can reach the amygdala in two ways: Cortical and subcortical pathways.

Through the cortical pathway, the stimulus is underwent all stages of normal perception before reaching the amygdala; on the other hand, through the subcortical pathway, some stages of perception is skipped, thus allows amygdala to make fast and rough assessment of emotional significance of the stimulus. Neuroimaging studies revealed projections from the amygdala to the occipital cortex, which are involved in enhanced visual processing of emotionally salient stimuli (Armony and Dolan, 2002; Morris et al., 1998; Shupp, et al., 2004), and pathway between the sensory thalamus and the amygdala, which is involved in responding defensively to ambiguous stimuli, before the object is identified as threatening or innocuous, such as a snake-like narrow curved object lying on the ground (LeDoux, 1996). Such findings are evident for biologically prepared, or "hard-wired", preferential and selective processing of threatening stimuli. It seems valid to argue that the subcortical assessment could be resulted in attentional bias and enhanced processing of negative stimuli. Fox (2002) argued this possibility as "emotionally relevant stimuli (positive and negative) may be processed automatically, but attention then gets allocated only to the potentially threatening stimuli" (p. 62).

Previous studies indicated repeatedly that the evolutionarily relevant threatening stimuli were effective in attracting attention, and the effect facilitated further processing of information (Feldmann-Wüstefeld et al., 2011; Jackson et al., 2009; Lipp and Derakshan, 2005; Mogg and Bradley, 1999; Ogawa and Suzuki, 2004; Öhman et al., 2001; Phelps et al., 2006; Wilson and Mcleod, 2003), which implies that emotional stimuli may be detected preattentively.

Extracting facial expressions is a very complex task that includes processing of both facial features and the global representation of the face as a whole. According to Guided Search Model, it should not be possible to perform this task in parallel across visual field. If the task is done preattentively, then guidance-by-features framework should be rejected. Therefore, visual search experiments should be evaluated carefully in terms of preattentive and attentional processing.

Attentional Processing and Visual Search for Threatening Facial Stimuli

Visual search paradigm is the prominent method for evaluating claims of preattentive processing and attentional guidance. The efficiency of search for distinct target categories is inferred by comparing search slopes. Search slopes cannot be calculated without varying set size. Thus, response times should be obtained from at least two set sizes. Search slopes are measured by dividing the mean increase in overall detection time by the number of additional items in the visual array. By comparing search slopes for threatening and friendly facial targets, one can assess whether the preattentive processing is sensitive in distinguishing characteristics of target faces with specific expressions. Whereas a pop-out effect (<10ms/item) can provide evidence for biased attention towards faces with emotional expression (Treisman and Gelade, 1980), it should also been noted that the absence of a pop-out effect does not necessarily indicate the absence of guidance of attention. Some features may have been preattentively available, but may be found inefficiently when the contrast between target and distractors is small.

Wolfe (1998) has proposed that the preattentive and attentional processing jointly contribute to search performance in different degrees and that different degrees of search efficiency can be categorized for certain ranges: A search with a slope of 0-5ms/item is very efficient, 5-10ms/item is quite efficient, 10-20ms/item is nearly efficient, 20-30ms/item is inefficient, and over 30ms/item is very inefficient. Indeed, visual search is rarely entirely under the control of preattentive processing (Frischen et al., 2008). Failure to find evidence for efficient search for emotional faces does not refute processing of preattentive guidance completely; a relatively shallow slope for a feature may suggest relatively good guidance of attention by that feature (Horstmann, Becker, Bergman, and Burghaus, 2010). Therefore, comparing relative magnitudes of search slopes to assess sensitivity of preattentive processes to emotional expression will be the course of action.

Early work on visual search suggested faster detection of a discrepant angry face presented among happy distractor faces than vice versa, and the detection time of angry target did not increase with the set size, inferring preattentive processing of angry faces (Hansen and Hansen, 1988). However, results could also be explained by the distractor difference that the happy distractors might have been disregarded more rapidly than angry distractors, or due to familiarity effect (Öhman, Lundqvist, and Esteves, 2001) happy distractors might have been processed more efficiently than angry distractors. Indeed, studies indicated that negative crowds were searched more slowly than positive crowds (Fox et al., 2000; Hansen and Hansen, 1988), and search for the target among emotional distractors are less efficient than among non-emotional distractors (Öhman et al., 2001).

Thus, the faster detection of discrepant angry faces may be related to the distractor type, rather than the expression of the target face. In order to assess guidance-by-features framework without the confounding of distractor disparity, targets should be presented against a consistent distractor background. Besides this, so called "*anger superiority effect*" was highly criticized by having inadvertent low-level perceptual cues favoring detection of angry faces (Purcell, Stewart, and Skov, 1996). Indeed, when contrast artifacts were eliminated by using grey scale versions of the same photographs used by Hansen and Hansen (1988), Purcell and his colleagues could find no superiority for angry faces (1996).

In visual search experiments with photographs of faces, it is quite problematic to control simple features across targets and distractors. Moreover, it has been argued that most individuals find it difficult to produce a convincing angry face on demand; whereas most people have plenty of practice producing a smile on demand for social situations, which result in little problem in producing a convincing happy face (Öhman, Lundqvist, and Esteves, 2001). For generating experimental stimuli, individuals need to produce a variety of different poses to convey expression of anger, which may be resulted in heterogeneity in sets of angry faces, compared to the sets of happy faces. Since homogeneous crowd of distractors is more easily grouped, and the heterogeneity of distractors reduces search performance (Duncan and Humphreys, 1989), this difference in heterogeneity of angry and happy facial sets will bias experimental results (Öhman, Lundqvist, and Esteves, 2001). These problems have led some experimenters to prefer schematic (i.e. line drawing) faces to use in visual search studies, instead of photographs of real faces.

In such a study of Öhman, Lundqvist, and Esteves (2001), neutral schematic faces were used as distracters while the targets were happy or angry schematic faces; thus a differentiation in detection of targets would be resulted from the emotional content of the target, rather than the distracter type. When presented among neutral distractors, the slopes of search for angry and happy targets were similar. Moreover, angry faces did not pop out among happy faces. But, regardless of the set size, overall detection times were faster for angry targets. Interestingly, when the faces were inverted, equivalent anger superiority effect was observed. Although it could be speculated as an evidence for a low level explanation of detection time difference observed for angry and happy faces, Öhman and his colleagues argued it as the attentional advantage for angry faces is so much stronger that inverting them did not have an influence.

Other studies indicated that the search slope for sad faces was shallower than the slope for happy faces when embedded among varying sizes of neutral distractors (Hahn and Gronlund, 2007; Suslow, et al., 2004; Suslow, Jugnhanns and Arolt, 2001; Suslow, Roestel, Ohrmann and Arolt, 2003), suggesting that preattentive search processes are sensitive to negative facial expression and guide attention. Similar results were evident in series of experiments by Fox et al. (2000), using schematic faces. Presented among neutral faces, target faces with expression of anger were detected faster and more accurately than of happiness; but when displayed upside down, there was no detection time difference between angry and happy target faces, supporting the view that it was the facial expression rather than some low level confound that resulted in faster detection of particular expression.

The search slopes did not indicate “pop-out”, on the other hand, showed an advantage for sad targets (16ms/item) over happy targets (29ms/item). Consistent with the findings of Fox et al. (2000), Eastwood, Smilek and Merikle (2001) found that sad faces (13ms/item) were detected more efficiently than happy faces (20.5ms/item) without “popping-out”, but the effect was diminished for sad and happy faces when the stimuli inverted (15.5 vs. 16.8ms/item).

More efficient search for negative faces has not always supported. In Nothdurft’s (1993) study, happy target faces were presented among angry distractor faces or vice versa, and results pointed out inefficient search with a slope of 61.7ms/item and no search asymmetry. On the other hand, White (1995) found that both sad targets embedded among happy distractors and happy targets embedded among sad distracters “popped-out”, without a search asymmetry. To prevent distractor disparity confound, Horstmann, Scharlau and Ansorge (2006) used superimposed positive and negative schematic faces as neutral distractors and found that when presented among neutral distractors, search efficiencies were similar for negative and positive target faces. Diverging results from Eastwood et al. (2001) and Horstman et al. (2006) have been evaluated as the choice of “neutral” distractor stimulus is a crucial factor for search efficiency of negative and positive targets. On the other hand, the superimposed neutral distractors resemble to have a widely open mouth as resulted from surprise or fear. Thus, it seems valid to argue that semantic association of other expressions may have an influence on processing of so called “neutral” distractors.

In such case, it would be more efficient to detect happy targets among neutral distractors due to higher dissimilarity between happy and fearful neutral faces, in comparison to angry and fearful neutral faces (see Duncan and Humphreys, 1989).

In an attempt to investigate the reasons of heterogeneous results, Horstmann (2007) re-tested the studies of Öhman et al. (2001), Fox et al. (2000), and White (1995) to find out whether the non-uniform, even contradicting, findings were resulted from differences in experimental procedure and stimulus factors. Same procedure was used across experiments, but original stimuli were used for each replication. Experimental trials were consisted of presenting angry faces among happy distractors, happy faces among angry distractors, angry crowd and happy crowd. Experiments consistently revealed that angry/sad faces were detected more efficiently than happy faces, when stimuli similar to Öhman et al.'s (2001) study (32 vs. 46 ms/item); Fox et al.'s (2000) study (32 vs. 65ms/item); and White's (1995) study (13 vs. 36ms/item). The latter was the closest to a pop-out effect, and tested again while the stimuli inverted: Sad faces were detected more efficiently than happy faces. Overall, the results indicated a search asymmetry favoring threatening or negative faces to different degrees, but consistently. By using the same procedure, Horstmann (2007) indicated preattentive search for lollipops presented among circles (3 vs. 19ms/item); but no evidence for preattentive discrimination of threatening or negative faces was observed. On the other hand, the study is prone to the misleading distractor disparity effect discussed above, thus evaluations should be done carefully.

Studies indicated search efficiency differences with various emotional expressions. However, it is not clear whether the differences in search slopes are due to preattentive guidance of attention or post-attentive processing. To test this phenomena, Smilek, Frischen, Reynolds, Gerritsen and Eastwood (2007) conducted a study that angry and happy targets were detected among varying numbers of neutral distractors in two conditions: Standard viewing condition and restricted viewing condition. In the former, stimuli were presented and viewed simultaneously, whereas the latter condition resembled serial attentional processing, in which the facial stimuli were presented behind black squares and participants required to move the mouse to the squares to see the face. In standard viewing condition, shallower search slopes for negative faces than positive targets were observed. When, however, preattentive guidance was not possible and attentional processes were in operation, search for negative faces was no more efficient than search for positive faces. Preattentive guidance of attention towards threatening stimuli is found to be a crucial factor determining search efficiency.

Supportive findings were also evident in a separate research of Reynolds, Eastwood, Partanen, Frischen and Smilek (2008) which examined patterns of eye movement while searching for emotional faces. Preattentive processes were assessed by the number of fixations and the time elapsed until the target was fixated for time first time; whereas attentional processes were assessed by the number of fixations and the time elapsed between the first target fixation and the response of participant.

Results indicated that negative faces detected more efficiently than positive faces; but more importantly, it took less time and fewer fixations to fixate the negative targets for the first time, compared to the positive targets. Moreover, set size did not affect the performance once the target was fixated. Findings indicated the asymmetric effect of guidance of attention on search efficiency for detecting emotional faces.

By combining eye-fixation monitoring with visual search, Calvo, Avero and Lundqvist (2006) have examined the reasons behind the detection superiority of angry faces. Two main components of visual system have been investigated: Initial orienting and engagement of attention. Orienting is the phenomenon of shifting of attention towards a stimulus, in other words, direction of attention. On the other hand, engagement refers to the maintenance of attention, or amount of attention that is allocated to the stimulus. Calvo and his colleagues measured eye-movement patterns across emotional and neutral targets to assess the involvement of the attentional orienting and the processing efficiency hypothesis in the facilitated detection of angry faces. If the shifting mechanism facilitates the detection of angry faces, then the probability of placement of the first fixation will be higher for the angry target face following the onset of the display. On the other hand, if the faster detection of angry faces is related to the processing efficiency that the angry faces are identified more efficiently once attention is directed to them, regardless of when, then fewer fixations and processing time will be necessary to detect them. Calvo et al. also examined the affective components behind detection superiority of angry faces, namely threat processing, negativity, or emotionality.

If angry faces are detected faster because they signal danger, then the visual system is particularly sensitive to threatening cues. But, if the detection superiority of angry faces is resulted from negative affect, or distressing emotional experience of angry person, then similar results will be obtained for, for instance, sad faces. Whereas the shape of eyebrows has been accounted for the largest proportion of variance in the emotional ratings of faces (Lundqvist, Esteves, and Öhman, 1999) and without V-shaped eyebrows, scheming faces are interpreted as sad faces, equivocally to angry faces (Fox et al.,2000); studies still indicated anger superiority effect (Eastwood et al., 2001; Fox et al., 2000). By taking these findings into consideration, the issue of which affective component determines the facilitated search and detection of angry faces requires careful evaluation. Finally, if the facilitated detection is due to general attribute of reflecting an emotional state, then both negative and positive expressions will be detected faster than neutral faces. Schematic angry, happy, sad and neutral faces were used as stimuli, with corresponding downward-curved, upward-curved or straight mouths and v-shaped, Λ-shaped or straight eyebrows. In series of experiments, the discrepant angry face among neutral distractors has been detected faster than other target faces. Eye movement results have revealed that angry faces are detected faster than other emotional faces because they are identified more efficiently, with fewer and shorter fixations. On the other hand, in the target-absent conditions, emotional faces are looked earlier and more likely to be re-fixated than neutral faces. Calvo and his colleagues have proposed that overt attentional orienting (i.e. attentional shift via eye movement) is determined by the emotionality of faces.

However, the speed of detection and processing efficiency are affected by the threat signal conveyed by the faces. Processing efficiency for angry faces in parafoveal vision may be related to preattentional processing. Once the angry target face is fixated, covert attention (i.e. attentional shift without eye movement) may result in saving fixation time and number of fixations. Thus, preattentional processing is likely to involve covert attention.

Overall, the findings obtained with schematic faces consistently showed that angry or threatening faces are processed more efficiently as a result of preattentive guidance of attention, and detected faster than faces with other emotional expressions when they are presented as a discrepant targets among neutral distractors or among other emotional distractors (Calvo et al., 2006; Eastwood et al., 2001; Fox et al., 2000; Hahn and Gronlund, 2007; Hortsmann, 2007; Lipp, Price, and Tellegen, 2009; Mak-Fan, Thompson, and Green, 2011; Öhman et al., 2001; Smilek et al., 2007; Suslow, et al., 2004; Suslow et al., 2001; Suslow, et al., 2003), with few exceptional studies that were ended up to supportive results when re-tested with convenient visual search methods (White, 1995; cited in Horstmann, 2007). Interestingly, the perception of emotional expression was not disrupted when the faces were inverted (Horstmann, 2007; Mak-Fan et al., 2011; Öhman et al., 2001), suggesting the simple configurations of lines are the critical factor in searching for angry faces, rather than the emotional expression. However, Schubö, Gendolla, Meinecke and Abele (2006) have indicated that the detection superiority of discrepant angry faces is observed only when the facial features has formed a perceptual gestalt of a face, rather than facial features without facial outlines as stimuli.

Consistent results have been observed even the task difficulty is increased with a backward masking procedure. Weymar, Löw, Öhman and Hamm (2011) have provided neurobiological support that threatening faces are detected faster than friendly faces and associated with occipital N2pc between 200 and 300 ms more; threatening configurations contained eyebrows and eyes are detected faster than friendly-related configurations of eyebrows and eyes; but no difference is observed when only a single feature, eyebrows, is to be detected. Altogether, direct electrophysiological evidence is provided for faster attention to facial threat, and the advantage is seem to be driven by configural information, rather than the low level visual features.

Visual Search Paradigm with Images of Real Faces

Whereas studies employed schematic faces to manipulate and control perceptual differences between emotional expressions (Calvo et al., 2006; Eastwood et al., 2001; Fox et al., 2000; Hahn and Gronlund, 2007; Hortsmann, 2007; Lipp et al., 2009; Öhman et al., 2001; Smilek et al., 2007; Suslow, et al., 2004; Suslow et al., 2001; Suslow, et al., 2003), they have been criticized for lacking ecological validity. First of all, schematic expressions exaggerate facial features, for instance, downward curved line to represent frowning; thus, schematic features do not always represent intended expressions closely. Another fundamental criticism of using schematic faces is, of course, that they are not real faces. A visual system that selects threatening features to locate, recognize and respond quickly in favor of survival would have evolved as a result of stimuli in the natural environment, rather than controlled artificial representations of stimuli.

Due to similar reasons, using schematic faces as crowd or distractors is inconvenient. The ecological validity of highly homogeneous distractors of schematic faces is therefore questionable. As Duncan and Humphreys (1989) have proposed, homogeneous crowd of distractors is more easily grouped and increases search performance for the target. Taken together, the necessity of investigating whether anger superiority effect in visual search studies with schematic faces is due to the threat detection systems or perceptual features becomes important and reorients the research.

The running theme of the recent visual search studies is to investigate the involvement of threat detection mechanisms in processing of crowd of real faces with emotional expressions (Becker, Anderson, Mortensen, Neufeld, and Neel, 2011; Calvo and Marrero, 2009; Calvo, Nummenmaa, and Avero, 2008; Fox and Damjanovich, 2006; Horstmann and Bauland, 2006; Juth, Lundqvist, Karlsson, and Öhman, 2005; Lipp et al., 2009; Öhman, Juth, and Lundqvist, 2010; Pinkham, Griffin, Baron, Sasson, and Gur, 2010; Pitica, Susa, Benga, and Miclea, 2012; Schmidt-Daffy, 2011; Williams, Moss, Bradshaw, and Mattingley, 2005). Some of those studies provided evidence for anger superiority effect (Fox, and Damjanovich, 2006; Horstmann and Bauland, 2006; Lipp et al., 2009; Pinkham et al., 2010; Pitica et al., 2012; Schmidt-Daffy, 2011); whereas others found evidence for happiness superiority effect (Becker et al., 2011, Calvo and Marrero, 2009; Calvo et al., 2008). Moreover, in some of them, evidence found superiority effect for both anger and happiness conditionally (Juth et al., 2005; Öhman et al., 2010; Williams et al., 2005).

The diversity of results may arise from methodological differences and suffering shortcomings, which should be interrogated in detail.

In several of these studies, only two or three models from the Ekman and Friesen (1976) Pictures of Facial Affect stimulus set were used to generate visual arrays of search (Fox, and Damjanovich, 2006; Horstmann and Bauland, 2006; Lipp et al., 2009), to control over perceptual confounds between models but comprises the ecological validity of heterogeneous crowd. Moreover, the similarity between target and distractors, and between distractors themselves, introduce other confounds to search performance (Duncan and Humphreys, 1989).

On the other hand, using multiple models as facial stimuli is not sufficient to maximize ecological validity, as the study of Calvo and his colleagues (2008) has shown. An eye-movement monitoring visual search task designed by Calvo, Nummenmaa and Avero (2008) investigated aforementioned orienting vs. processing efficiency hypotheses and affective components by using real faces of multiple individuals from the Karolinska Directed Emotional Faces (Lundqvist, Flykt, and Öhman, 1998) with six different emotional expressions: Anger, disgust, fear, happiness, surprise and sadness. Contradicting to their previous study with schematic faces (Calvo et al., 2006), detection advantage is observed for happy, surprised and disgusted faces in line with the eye-movement patterns that suggest both earlier orienting and more processing efficiency. One possible explanation for these findings is features of stimuli. Although the low level visual properties, such as luminance, contrast and color, have been controlled for each target and neutral distractor, in some of target faces the teeth were exposed, while the rest were close-mouthed.

Moreover, the intensity or expressiveness of facial emotions has not been assessed and equated. Smiling faces with exposed teeth may be perceived as more convincing while the expressiveness of angry faces may not suggest a convincing anger. Indeed, Calvo and his colleagues reported better categorization for happy faces. Moreover, in an attempt to reduce interference between emotional expression and face identity, for each trial, pictures of the same individual posing different emotional expressions served as both the target and the distractors. Besides the violation of ecological validity, more easily grouped homogeneous distractors (Duncan and Humphreys, 1989) may increase search performance of better identified happy faces. Same methodological considerations are prevailed for the following study of Calvo and Marrero (2009), which resulted in faster and more accurate detection performance for more-accurately-and-faster-identified happy faces.

Further inquiries on distractor uniformity have shown that the targets embedded among homogeneous distractors detected faster compared to the targets presented among heterogeneous distractors (Öhman et al., 2010), regardless of the stimulus set size. Besides this, the detection is faster when the target is female and smiling, rather than female and angry. Similar with the Calvo et al.'s studies, the happy expression of the models selected from the Karolinska Directed Emotional Faces (Lundqvist et al.,1998) has been identified faster than neutral or angry faces; creating a disparity among to-be-compared affective components. Despite this imbalance, when the set size is small (formed by six individuals), male targets with angry expression are detected faster. Nevertheless, on some boundary conditions, both happiness superiority and anger superiority are observed.

Detection superiority of anger, compared to sadness and fear, is also observed in Williams et al.’s (2005) study. With multiple models selected from the MacBrain set of facial expressions (or “NimStim”; Tottenham et al., 2009) and heterogeneous distractors generated, the detection speed of angry and happy faces is faster than of sad and fearful faces. Moreover, when the set is consisted of eight faces, locating angry faces is faster than locating happy faces. The study indicated anger superiority effect, although suffered from the lacking of models with equally intensive, convincing angry and happy expressions. Indeed, no identification or expressiveness controls have been carried out before stimuli selection.

In a series of experiments conducted by Becker et al. (2011), happiness superiority effect is found consistently. In order to increase the ecological validity, heterogeneous distractors have been generated throughout the study. In the two of those experiments, six male models selected from the Pictures of Facial Affect stimulus set (Ekman and Freisen, 1976) were used as stimuli. Again, no identification or expressiveness scores have been reported. In the first experiment, happy faces were detected among neutral distractors faster, compared to the angry faces. In the second experiment, as the happy expressions bear exposed teeth, everything below the nose have been removed for each face to eliminate the confound. Whereas Fox and Damjanovich (2006) have previously found that eyes are sufficient to trigger the threat detection advantage, while Horstmann and Bauland (2006) have suggested that the advantage is due to mouth, rather than eyes; Becker et al.’s study indicated detection superiority for happiness, when the search is done with eye region.

It should have been noted, however, that the participants have been given search strategies that they should look for emotional brow in a crowd of neutral brows. As visual search for perceptual features is sensitive to top-down modulation of search strategy and task demands (Frieschen et al., 2008), instructed search strategies may result in more efficient search in favor of more easily identified, and probably more intensive, happy expression. Nevertheless, erasing the lower half of the face does not eliminate the intensiveness of happiness conveyed by the grinning face; facial muscles on the eye region remain the same. Three more visual search experiments have been conducted with four male models that convey either open-mouthed (e.g. a toothy grin or an expression of anger baring teeth) or close-mouthed expressions selected from NimStim (Tottenham et al., 2009). Multiple-target search methodology is adopted for the experiments that the displays consisted of either two faces including one, two or no targets with equal probability, or four faces including one, two, four or no targets with equal probability. In the first experiment, search close-mouthed expression of anger and happiness in a crowd of neutral distractors has resulted in happiness superiority affect. In the second experiment, open-mouthed expression of anger and happiness are searched in a crowd of neutral distractors, and consistently, happy expressions detected faster. Disparately, faces with open-mouthed expressions have been rated on a 9-point scale with 1 identified as angry, 5 identified as neutral and 9 identified as happy, before the second experiment. Although the open-mouthed angry faces slightly differed from neutral expressions to a greater degree than happy faces, happy faces are discriminated among neutral faces faster.

In the final experiment, search for open-mouthed expression of anger and happiness among crowd of fearful (also open-mouthed) distractors resulted in more rapid detection of happy faces, as a predicted result, since happy faces are dissimilar from neutral distracters to a greater degree than angry faces (see Duncan and Humphreys, 1989).

Studies, on the other hand, that employ preliminary studies to select facial stimuli from multiple models, which were comparable in terms of perceptibility, intensity or expressiveness, indicate anger superiority effect (Pinkham et al., 2010; Schmidt-Daffy, 2011). Schmidt-Daffy (2011) has selected models among the ones whose angry and happy expressions found to be perceptually similar and homogeneous in terms of distinguishableness from neutral expressions in a recognition task with a delayed masking procedure. Facial expressions of selected models have also rated by their intensity, and found to be similar across to-be-compared angry and happy expressions. Therefore, the detection superiority of angry faces cannot be ascribed to a difference in intensity, perceptibility or heterogeneity of the expressed emotions. Similarly, Pinkham and her colleagues have selected their facial stimuli of nine models with the highest recognition accuracy out of 23. Each selected facial expression then validated by using the Facial Action Coding System (Ekman and Friesen, 1978) to identify the presence of expression specific characteristics of facial muscles. The chosen stimuli have been verified to be a representative of the target emotions. Angry faces are found more quickly and accurately than the happy faces among the heterogeneous crowd of neutral distracters.

These results also replicated with photographs selected from other database, namely the NimStim (Tottenham et al., 2009), by Pitica et al. (2012).

With the foregoing considerations in mind, the current study on visual search for threatening stimuli had regarded referred lines: Selection of facial stimuli in terms of perceptibility and expressiveness with preliminary studies to be similar across to-be-compared emotional expressions; controlling of low-level visual confounds such as contrast and luminance; using heterogeneous crowd of distractors to increase ecological validity; keeping distractors constant while investigating the effects of specific categories of targets, whereas keeping targets constant while investigating the effects of specific categories of distractors. The last point has remained an important theme in the current study exploring the disengagement from threatening facial stimuli. Despite the early detection of discrepant angry expression, it has been reported that detecting the absence of discrepant face among all angry-crowd takes much longer than among all happy-crowd (Fox et al., 2000; Pinkham et al., 2010), inferred as the attentional hold of angry expressions. Thus, it has been proposed that there would be a search asymmetry of discrepant neutral faces embedded among angry distractors and happy distractors, in which the attentional hold of angry distractors would result in slower detection of neutral target faces, compared to happy distractors. Moreover, in order to investigate the involvement of attentional processes, eye-movement patterns have been examined.

With an inspiration of studies that indicate differential hemispheric specializations in the processing of facial expressions, the present study has also investigated a visual field bias for detecting emotional faces in neutral crowds and whether the detection advantage would differentiate across fields of presentation. With this regard, visual search paradigm has been combined with divided visual field methodology, and flicker paradigm of change detection.

Hemispheric Specialization in the Processing of Facial Emotions

Another branch of the research on the processing of emotional faces examines the hemispheric lateralization. The cerebral cortex of the brain is divided into two hemispheres: the left hemisphere and the right hemisphere. Although seem similar in appearance and structure, the two hemispheres of the brain are anatomically asymmetric and possess different information processing abilities and propensities. Each hemisphere is specialized for different functions and hemispheric lateralization reveals itself as the biological and behavioral manifestations of these asymmetries (see Hellige, 2002 for a brief and comprehensive review on lateralization). Each hemisphere controls the contralateral, or opposite, side of the body, and stimulated by the information from contralateral side. Then, they exchange information through the corpus callosum, a set of fibers of axons that connects the left and right cerebral hemispheres, with a brief delay. In the case of vision, each hemisphere receives input from the opposite half of the visual environment (see Figure 2.1 for the route of visual input to the two hemispheres of the brain). The total area in which objects can be seen in the side (peripheral) vision while the eyes fixated on the center is called visual field.

A stimulus presented in the left visual field is initially received and processed by the right hemisphere, whereas a stimulus presented in the right visual field is initially received and processed by the left hemisphere. Then, with a brief delay, the two hemispheres exchange information that they have received.

For the last few decades, the question of how the brain is organized to process emotions has been debating, with the particular emphasis on the lateralization of these processes between the two hemispheres of the brain. Emotion can be defined as a phylogenetically integrated multi-component adaptive system that consisted of both primitive, hard-wired functional structure and more complex, learned social patterns, which are highly associated with cognitive systems (Gainotti, 2012). Whereas cognitive system carries out exhaustive analysis of highly processed information, emotional system carries out fast computations of poorly processed sensory data, just sufficient to associate if the stimuli refer an emotional meaning (e.g. dangerous stimuli is associated with fear) to the organism and select the most appropriate response from a small number of innate operative patterns corresponding to associated emotion, such as postural changes, locomotion, recruitment of the autonomic nervous system. It has been proposed that the emotional system is divided into three subcomponents dealing with the experience of emotion, the expression of emotion, and the perception of emotion (Davidson, 1995). The existence of hemispheric asymmetries in emotion processing has been demonstrated in many studies; however the debate in the field of affective neuroscience on the involvement of the hemispheric lateralization in the processing of facial expressions has not reached to fruition.

Two main hypotheses on cerebral lateralization of facial expressions have become prominent with the accretion of scientific supports: The Right Hemisphere Hypothesis (RHH) and the Valence-Specific Hypothesis (VSH).

RHH suggests that the right half of the brain is specialized in the processing of all emotions, regardless of the affective valence (Adolphs, Damasio, Tranel, and Damasio, 1996; Adolphs, Jansari, and Tranel, 2001; Borod et al., 1998). Evidence for RHH took its form early as the beginning of 20^{th} century that damage to the right side of the head resulted in a decrement of emotional expression (Gainotti, 1972; Mills, 1912), followed by the findings that the left side of faces have been emotionally more expressive (Indersmitten and Gur, 2003; Sackheim, Gur, and Saucy, 1978); ERPs, fMRI, tachistoscopic presentations of faces have suggested better perception and more efficient processing of emotions, when presented to the right hemisphere (Aljuhanay, Milne, Burt, and Pascalis, 2010; Dutta and Mandal, 2002; Kanwisher, McDermott, and Chun, 1997; Ley and Bryden, 1979; Schwartz, Davidson, and Maer,1975); and right hemisphere advantage in unconscious processing of emotions (for review, see Gaionotti, 2012).

VSH proposes that each half of the brain is specialized in processing of particular categories of emotion that the left hemisphere is dominant for positive emotions and the right hemisphere is dominant for negative emotions (Davidson, 1995). Studies indicated a depressive-catastrophic reaction following the damage to the left hemisphere, whereas damage to the right hemisphere resulted in pathological laughing reaction (Sackheim et al., 1982).

These findings suggested the left hemisphere as a center for positive emotions and the right hemisphere as a center of negative emotions. Others have found that damage to right hemisphere impairs recognition of negative facial emotions (Borod, Koff, Perlman Lorch, and Nicholas, 1986; Mandal, Tandon, and Asthana, 1991), whereas the left hemisphere damage impairs recognition of positive facial emotions (Borod et al., 1986).

There are also studies that support neither RHH nor VSH. For instance, when the arousal levels of the stimuli take the stage with affective valence, ERPs for high arousal stimuli indicate right hemisphere dominancy over parietal lobes, whereas right hemisphere dominancy observed for negative high arousal stimuli and left hemisphere dominancy observed for negative low arousal stimuli over the frontal lobe (Zhang, Zhou, and Oei, 2011). Another study indicated for verbal stimuli that the right hemisphere systems are biased toward the processing of emotional valence and arousal in general, whereas the left hemisphere systems are involved in processing of positively valenced, highly arousing stimuli (Mneimne et al., 2010). Moreover, Killgore and Yurgelun-Todd (2007) propose an integrated model. When unilateral affective presentations are compared across hemispheres (e.g. unilateral happy face presented in left visual field and right visual field), one will find evidence for RHH due to the superior processing of facial emotions in the right hemisphere. On the other hand, positive emotional expressions are less demanding to identify compared to the negative emotional expressions that the left hemisphere can processes positive emotions easily.

Thus, when affective natures of stimuli are compared within the presented hemisphere (e.g. both happy face and sad face presented in the right visual field), one will find evidence for VSH.

The task type and cognitive processes, which are under examination, may have a moderating effect on hemispheric asymmetries. While the prosecution of investigation of the most appropriate model on lateralization in facial expressions, in the current study, it has been investigated whether the detection of emotional faces among neutral crowd of distracter faces lateralized to one of the cerebral hemispheres. A hemispheric bias in the detection of emotional faces among crowds would provide new perspectives towards understanding of the emotional and cognitive mechanisms based on the processing of emotional facial stimuli. Divided visual field paradigm has been adopted to investigate the existence of lateralization in the processing of *finding the face in the crowd*, with a direct scope of comparing the effect of emotional valence of faces on detection, as the second experiment of current study.

Hemispheric Specialization and Change Detection

From an evolutionary viewpoint, the ability to detect changes in the visual environment is crucial for human survival to monitor for and rapidly detect the presence and motion of animate objects, both human and nonhuman animals, which would be signaled by visual change. The empirical evidence for this idea comes from New, Cosmides and Tooby (2007) that changes to animals and humans have been detected more quickly and more often than changes to inanimate objects in a flicker paradigm (Rensink, O’regan, and Clark, 1997).

Moreover, inanimate objects have been associated with change blindness, the phenomenon of failure to see large changes that normally would be noticed easily, in a greater extent. The difference in detection time of change observed for animate and inanimate objects has been eliminated when the photographs are inverted, indicating that the difference is not due to saliency or low-level visual features. The detection advantage of change for animate objects does not reflect stimulus exposure or expertise effect; highly familiar other animate objects such as motor vehicles do not provide change detection advantage over animals and humans.

Nevertheless, the phenomenon of change blindness suggests that visual details from one moment to another are not retained automatically to compare and detect changes in the visual environment (Levin, Simons, Angelone, and Chabris, 2002). It has been argued that attention and encoding of specific features in the visual environment that are different between following time points are important for successful detection of change (O'Regan, Deubel, Clark, and Rensink, 2000). Studies also indicated that the detection of saccade-contingent changes is found to be difficult (Grimes, 1996). Besides eye movements, blinks and other reasons of interference attenuate the detection of changes (O'Regan et al., 2000; Rensink et al., 1997) that provide fertile environment for change blindness to occur. Changes in visual environment result in a motion signal as a low-level visual cue. The attenuation of motion signal by using interferences disrupts change detection. It has been suggested that the visual system encodes only a small amount of the environment, and objects should be encoded by the visual system to be detected (Rensink et al., 1997; Simons and Rensink, 2005).

Although not sufficient (O’Regan et al., 2000), focal attention to the objects is necessary for detecting the changes (Rensink et al., 1997; Simon and Rensink, 2005).

With these in mind, Rensink et al. (1997) have developed flicker paradigm, which consisted of repeated presentations of an original image and a modified image alternately, with brief blank screens following each image, while participants view the flickering presentation freely and make a response when the change is detected, and then report where they detect the change. In flicker paradigm, the motion signal is attenuated by the presentation of blank screen that eliminates both low-level cues to attract attention to the location of change and disruptions caused by saccade-contingent blindness. In these conditions, detection of change will depend on focal attention to objects in the display. Attentional modulation and allocation plays an important role in change detection (O’Regan et al., 2002). Iyilikci, Becker, Güntürkün, and Amado (2010) investigated whether visual field bias presented in visuo-spatial tasks that require attentional allocation has also be observed for change detection performance. The study revealed that changes occurred in the left visual field detected faster than the changed presented in the right visual field. On the other hand, eye movement patterns have been similar across the visual fields. These findings suggest more efficient processing of visual information on the left visual half of the field.

Differential allocation of attention is proposed to be involved in change detection of animate objects, but it may not the only mechanism associated with the change detection advantage (Rees, 2008).

It is a clear evolutionary advantage to detect and respond to changes in the visual environment quickly, especially when the change signals potential threat, such as an approaching predator. As discussed in earlier sections that the threatening stimuli have been shown to be processed superior due to preference and selection of some attentional mechanisms; Mayer, Muris, Vogel, Nojoredjo, and Merckelbach (2006) indicated that threat-related changes better detected than threat-irrelevant changes. Moreover, hypervigilance for specific threat-related stimuli, for example phobia of spiders, resulted in better detection of changes to the particular phobic stimuli compared to the non-phobic performance.

Further investigation on change detection performance has focused on whether there would be an asymmetry in detecting changes to threatening and non-threatening facial expressions. Amado, Yildirim, and Iyilikci (2011) have postulated that the change from a neutral facial expression to the angry expression is signals threat that should be resulted in faster detection of change compared to the changes into the happy expression. Indeed, they received supportive evidence from a flicker paradigm that six neutral expression of the same model placed on a suppositional circle, which was equidistant to the center of the display, and the neutral expression of the one of the faces changed into an emotional expression alternately, until the change was detected. They found that when the model is male, changes in neutral expression to the angry expression has detected faster compared to the fearful and happy expressions, probably because of males are perceived more threatening as they have more potential for committing violence*.

* For the sake of earlier discussions, it should be mentioned that the facial stimuli that were used in the experiment was rated for their expressiveness and found to be equal across emotional expressions (Amado et al., 2011).

Moreover, the detection advantage is disappeared when the faces are inverted, indicating that the advantage is not due to low-level features or saliency.

The question as to whether the detection of changes in the facial emotion would be asymmetric on the left and right visual fields has been yet unanswered. Previous studies indicated the involvement of the right hemisphere in change detection (Beck, Rees, Frith, and Lavie, 2001; Spotorno and Faure, 2011) and change blindness (Beck, Muggleton, Walsh, and Lavie, 2006; Beck et al., 2001). On the other hand, the contribution of emotional system in the processing of change detection may have a moderating effect. As the final experiment of current study, it has been postulated that a hemispheric lateralization, if exist, in the processing of detection of emotional faces embedded among neutral distractor faces would manifest itself as the faster detection of changes in the emotional expression of faces. The visual search paradigm of *finding the face in the* crowd and flicker paradigm of change detection would be combined and the lateralization effects would be investigated by response time and eye-movement patterns obtained from each visual half field during the detection of changes in large set of facial heterogeneous crowd of neutral faces into an emotional expression, or vice versa.

Hemispheric Processing during Visual Search for Emotional Faces

The running theme of the current thesis has been to investigate the affective contribution and components of attentional processing during the visual search for emotional faces, and existence of hemispheric lateralization for the performance. Three experiments have been designed and implemented to examine the phenomena.

In the first experiment, a visual search task has been conducted to investigate the existence of a performance asymmetry for faces with specific emotional content. Aforementioned shortcomings of previous studies have been tried to overcome: A preliminary study for the selection of facial stimuli among multiple models has been pursued; selected facial stimuli were comparable in terms of perceptibility and expressiveness; low-level visual confounds such as contrast and luminance were controlled; heterogeneous crowd of distractors were used to increase ecological validity; neutral faces were used as distractors while investigating the effects of specific affective categories of targets, whereas neutral faces were used as discrepant target items while investigating the effects of specific affective categories of distractors. It has been predicted to observe the anger superiority effect both for attentional capture of emotional discrepant faces presented among neutral distractor faces, and for attentional hold of emotional distractor faces presented around neutral discrepant faces, or crowd of emotional faces. Eye-movement patterns have been also examined to investigate the involvement of attentional processes.

In the second experiment, visual search task paradigm has been combined with divided visual field methodology to investigate whether the detection of emotional faces lateralized to one of the cerebral hemispheres or the lateralization of processing differed for negative and positive emotional expressions. If the search for emotional discrepant faces has been more efficient in the left visual field, regardless of the valence of the facial expression, it would be an indication of the right hemisphere is involved in visual search for emotional faces.

On the other hand, if the lateralization of processing has differed for negative and positive emotional expressions that the happy discrepant faces have been detected faster in the right visual field, whereas the angry discrepant faces have been detected faster in the left visual field, it would be a support for the Valence-Specific hypothesis.

In the third experiment, visual search paradigm was combined with flicker paradigm to investigate whether the detection of change in the expressions of faces would differed for specific emotions, and whether the detection of changes in the facial emotion would be asymmetric when presented on the left and right visual sides. Pattern of eye-movements and detection times for specific emotional changes in the facial expressiveness across left and right visual halves of presentation have been evaluated on the basis of the Right Hemisphere hypothesis and the Valence-Specific hypothesis. If the detection of change of the facial expression would be faster in the left visual field, regardless of the valence of the facial expression, it would be supportive for the Right Hemisphere hypothesis; whereas if the detection of change from neutral into the angry expression on the left visual field, and from neutral into the happy expression on the right visual field have been observed to be faster, the Valence-Specific hypothesis would be supported.

CHAPTER 2

EXPERIMENT I

In the Experiment I, a ‘Finding the Face in the Crowd’ task was developed to determine whether there was a detection superiority favoring angry faces among neutral faces compared to happy faces among neutral faces (i.e. *Anger Superiority Effect* hypothesis). Further hypotheses were also tested, such as the existence of a higher attentional hold of angry distractors which resulted in slower detection time of neutral faces in angry crowds compared to detection time of neutral faces in happy crowds, and of a negative favoring attentional hold which resulted in slower reaction time for crowd of angry people, compared to reaction time for happy-people-crowd or neutral-people-crowd. Eye-movement patterns were evaluated as assertion of preattentive and attentive processing.

Method

Participants

Candidates of participation who scored less than 60 (i.e. minimum score for being a dominant right-handed) in the Edinburgh Handedness Inventory (Oldfield, 1971) and/or more than 15 (i.e. indicates moderate or severe anxiety) in Turkish standardized version of the Beck Anxiety Inventory (Ulusoy et al, 1998) did not participate in the experiment. Thirty-six undergraduate and graduate students of Izmir University of Economics were recruited in the experiment by a convenience sampling technique based on voluntarism. All of the participants were right-handed; they had normal or corrected vision and no clinical diagnosis that would indicate an existing psychopathology.

The data of five participants, who failed following instructions or behaved improperly during the experiment such as moving the head or body, shifting attention from the screen, closing eyes for a long time, were eliminated. Furthermore, the data of two participants were excluded from the analyses due to excessive number of missing or outlying data from the eye tracker, after the data screening procedure was carried out. Therefore the data from 14 female and 15 male participants was regarded as viable for further analyses. The age of participants ranged between 18 and 32, with a mean of 22.59 years.

Stimuli, Apparatus and Material

A pilot study conducted to select the pictures of individuals, whose facial emotions were identified correctly and expressed sufficiently the emotion that they bear. Angry, happy, and neutral faces of 18 individuals (nine women) selected from the NimStim face stimulus set (Tottenham, et al., 2009) with the criteria that they had no noticeable differentiating characteristics such as ethnicity, age, facial hair and scars. A total of 54 facial pictures from 18 individuals with three expressions, namely angry, happy, and neutral were selected. The pictures presented eight raters who were among academic staff and research assistants of Psychology Department in Izmir University of Economics. Their task was to identify the emotional category, in which each facial expression falls among the categories of angry, disgusted, fearful, happy, sad, surprised, or neutral, and then to rate on a 7-point scale (1 is being not expressive for that emotion and 7 is being very expressive for that emotion) in regard to how expressive the given face for the particular emotion. Pictures of six individuals, whose facial expressions were confused with another expression and misidentified by more than two raters, were eliminated. Pictures of two individuals, whose mean expressiveness ratings for particular emotions were less than 4, were also eliminated; even though they were correctly identified by the raters. For the remaining four female and five male facial pictures, the Cronbach's α interrater reliability was .79 and there were no significant difference between the mean expressiveness ratings of angry (M = 5.44, SE = 0.54), happy (M = 5.81, SE = 0.43) and neutral faces (M = 5.79, SE = 0.41), F (2, 14) = .80, p > .05.

A total of 27 pictures obtained from nine models with three expressions were selected as facial-emotional stimuli. The selected pictures were desaturated; and out of the facial regions such as hair and the background were carefully blackened. The height of the pictures was resized to 150 pixels, and the pictures were inserted on the center of 150x150 pixels black background. In order to reduce the possible effects of low-level stimulus properties such as luminance and contrast, a MatLab toolbox developed by Willenbockel and colleagues (2010), the Shine, was used. Hereby the luminance and contrast values of all pictures were equated by using the *histMatch* function of the Shine. The fundamental principle of *histMatch* function was to equate the luminance histograms of given pictures and optimize the structural similarity. Before the histogram matching procedure, foreground/background segmentation was carried out. By selecting the *specify lum* option, to-be-equated images also served as templates for figure-ground segmentation, in which the background luminance was specified as black, and the rest as the figure. The *Shined* faces of models, which hold the equal luminance and contrast values, were used for generating stimulus-sets that would be displayed in the FFiC task.

The presentation, sequence and randomization of experimental trials, and response recording were implemented by E-Prime® (Psychology Software Tools, Inc., version 2.0.10.182) experimental design software. E-Prime® which was run on a personal computer (Intel® Pentium® D, CPU 2.80 GHz 2.81 GHz, 2 GB of RAM), and connected to a 22” stimulus presentation monitor with a screen resolution of 1680*1050 pixels, and refresh rate of 59 MHz.

E- Prime® was also used to trigger iViewX® (SensoMotoric Instruments, Inc., version 2.6.20), which was running on a notebook computer (Intel® Core™ i7, CPU 2.67 GHz 2.66 GHz, 3 GB of RAM). iViewX®, in general, was used to control the remote eye tracker hardware (SensoMotoric Instruments, Inc., Model: RED 250): The signal was sampled and stored at a rate of 120Hz. The eye tracking data were analyzed by using BeGaze® (SensoMotoric Instruments, Inc., version 3.2.29.1). The experiment was conducted in two adjacent rooms: One for running E-Prime (i.e. the control room), and the other for running iViewX® and collect data (i.e. the experimental room). The general view of the settlement and details were described in Figure 1.1. A chin rest was used to stabilize the viewing distance and subject's head. The viewing distance was 60 cm.

Procedure

There were two sets of stimuli presented in the current FFiC task: The target-present sets, and the target-absent sets. The target-present sets included trial types of angry face among crowd of neutral faces (*target angry*), happy face among crowd of neutral faces (*target happy*), neutral face among crowd of angry faces (*target neutral in angry*), and neutral face among crowd of happy faces (*target neutral in happy*). The target-absent sets included trial types of crowd of angry faces (*angry crowd*), crowd of happy faces (*happy crowd*), and crowd of neutral faces (*neutral crowd*). Each set consisted of the trial-corresponded faces of nine models. Each face was 150*150 pixels sized and presented in a 3x3 matrix, with a fixed 150 pixels distances between the adjacent faces (see Figure 1.2 for a sample stimulus-set).

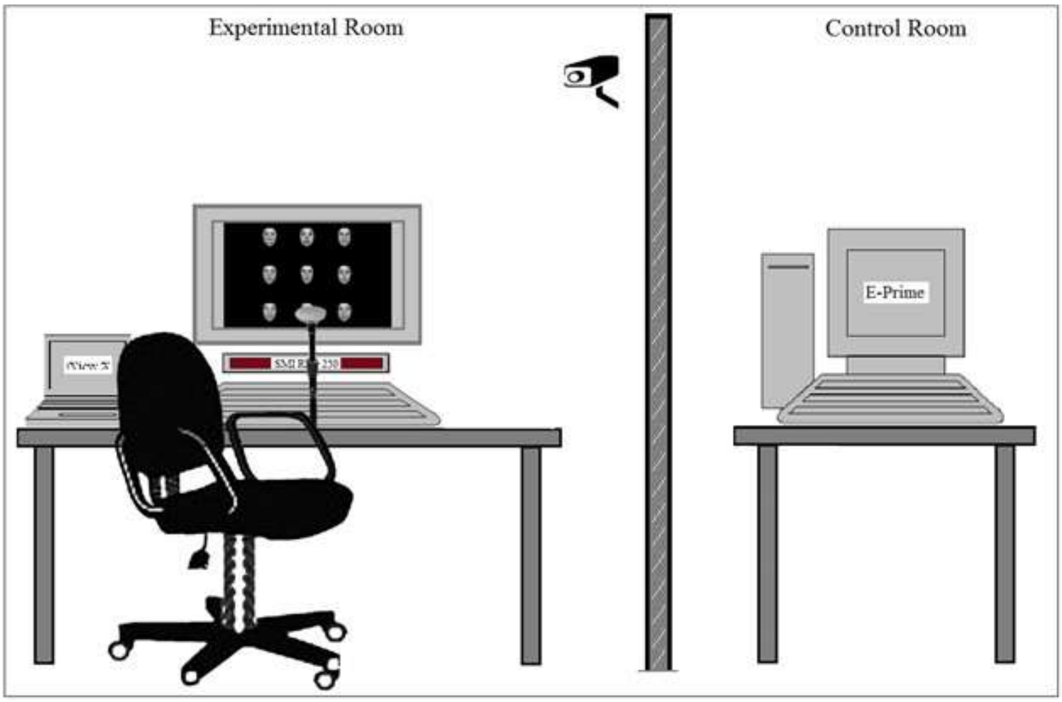

Figure 1. The general view of the experimental setup. The FFiC experiment was conducted in adjacent chambers. While the participants were taking their position in the experimental room, the E-Prime® (Psychology Software Tools, Inc.) which was installed on the PC in the control room and connected to the 22” monitor in the Experimental Room was started by the researchers. The participants were presented stimuli through that monitor and they responded through the keyboard below the monitor. The remote eye tracking hardware (SensoMotoric Instruments, Inc., Model: RED 250) placed between the keyboard and the monitor. iViewX® (SensoMotoric Instruments, Inc.) was installed on the laptop in the experimental room and triggered by the E-Prime® for sending message to eye tracker to collect eye-tracking data at rate of 120Hz. Behavioral data was recorded by E-Prime®.

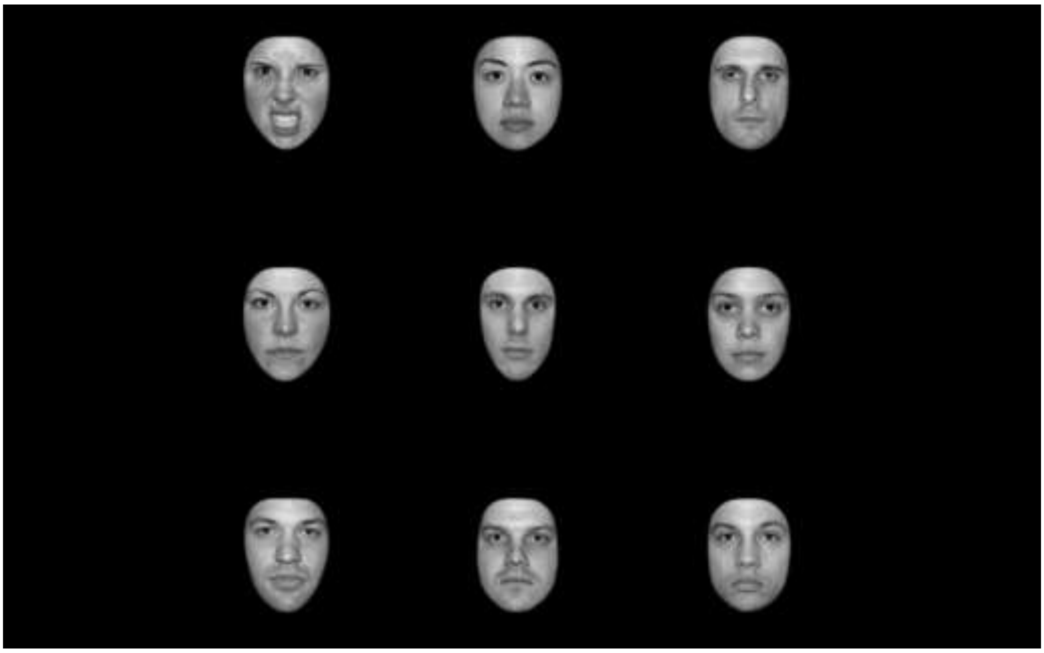

Figure 1.2. A sample stimulus-set. Faces of different models were presented in a 3x3 matrix with the fixed 150 pixels interval between the adjacent faces, displayed in the center of 1680*1050 pixels of black background.

Stimulus-sets covered 750*750 pixels area of 21.83^0 horizontal and 20.25^0 vertical visual angles and were displayed in the center of black background of 1680*1050 pixels.

The target-present sets were consisted of eight distractors and a target, which were presented in a 3*3 matrix. Thus, targets appeared in nine different locations. Each model became a target twice for each trial type. There were in total of 18 sets (nine locations x two trial-corresponding targets) for each trial type of the target-present sets. To-be-target faces, locations of targets and the locations of distractors (i.e. remaining eight faces after the selection of target) were determined pseudorandomly, with the restriction that the same target would never appear in the same location for the corresponding trial type. In the target-absent sets, faces of trial-corresponded emotion were randomly inserted into the matrix. To be consistent with the target-present sets, 18 sets for each target-absent trial type were generated. In total, participants were presented 126 sets (72 target-present and 54 target-absent sets) in a random order. Before the main study, a practice task, which was consisted of random presentation of the 14 sets of target-present and target-absent sets (2 sets for each condition) generated by using grayscale schematic faces, was completed.

Before the start of the experiment, participants were given an informed consent form (see Appendix A) and completed a questionnaire consisted of personal questions that might had been related to their performance, Edinburgh Handedness Inventory (Oldfield, 1971) and Beck Anxiety Inventory in Turkish standardized by Ulusoy et al. (1998) (see Appendix B).

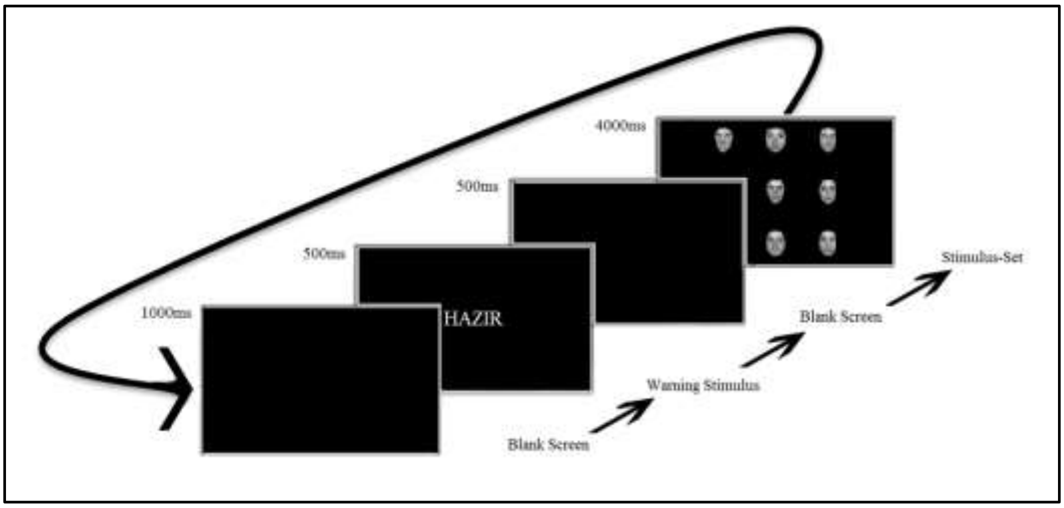

Figure 1.3. The sequence of stimuli through a trial. Each trial started with a 1000ms of blank screen, followed by 500ms of “Ready” screen, and 500ms of blank screen, respectively. Stimulus-sets were presented 4000ms, unless the participants responded. Upon the responding of the participant, the next trial started. If the participant did not respond in 4000ms, the next trial began, and the response was recorded as missing.

In the experimental room, participants were guided to adjust the height of the experimental chair and put their chins on the chinrest to make experimental setup properly calibrated and to help them to feel comfortable during the experimental session. Participants were instructed that they would see sets of nine emotional faces for 4000ms, and their task was to decide as quickly and accurately as possible whether all the faces on the set displayed the same expression. If all the faces in the set bear the same expression they needed to press the “SAME” button on the keyboard; or if there was a face with a discrepant emotion, they were required to press the “DIFFERENT” button. After the instructions, a 5-point-calibration was completed in order to confirm that the eye tracker was recording visual gaze within 1° of visual angle for each calibration point. If the visual gaze deviated more than 1° of visual angle for any point, calibration procedure was repeated. Since the stimuli used were monochrome and presented on a black background; calibration was done by using gray points which were displayed on a black background.

Upon the successful completion of the calibration procedure, participants were presented a set of practice trials before the start of main experimental trials (see Figure 1.3 for a typical trial). Each trial started with the presentation of a 1000ms-blank screen followed by 500ms-“Ready” screen and another 500ms-blank screen, then each visual stimulus set was presented for 4000ms. Participants were instructed to determine whether all of the faces in the set had the same facial expression or different by pressing the preassigned buttons (label of SAME was attached on F button and label of DIFFERENT was attached on K button, respectively) on the keyboard as quickly and accurately as possible.

The locations of the "SAME" and "DIFFERENT" labels on the keyboard were counterbalanced across the participants. The response of the participant during the 4000ms decision period were automatically recorded for its accuracy and latency. If the participant failed to respond or omit it, the procedure continued with the next trial, and it was recorded as a missing response.

Experimental sessions were monitored and recorded by a closed-circuit video system to ensure that the participants having paid their duty in the study in accordance with the experimental terms and conditions. In such instances that a participant altered his/her body posture out of acceptable range, moved his/her head, or gazed away from the screen, the data collected from this particular participant were excluded from further analyses. After the experimental session was completed, the participants were asked to express their impressions about the experiment and their performance; then they were debriefed and dismissed.

Statistical Analyses

Throughout the experiment, reaction times and accuracy scores, along with the eye tracking data recorded for analyses. While viewing was binocular, only the left eye movements were used for analysis as a standard method suggested in the literature (Lykins et al., 2011). Minimum fixation duration was 80ms. Hence the stated hypotheses stipulated specific directional effects; one-tailed tests for RT, accuracy and gaze data were employed.

Reaction time analyses. The hypothesis that there is a detection superiority favoring angry faces, in which the angry targets among neutral distractors would be detected faster than the happy targets among neutral distractors, was tested by a *t* test for paired groups.

Further *t* test for paired groups was done to determine whether there was a higher attentional hold of angry distractors, in which the reaction time for detecting neutral targets among angry distractors was predicted to be slower than it was for detecting neutral targets among happy distractors. Likewise, as negative favoring attentional hold hypothesis suggested, it was expected to find that responses for *angry crowd* would be slower compared to responses for *happy crowd* and *neutral crowd*; *t* tests for paired groups were conducted for the comparisons.

Reaction time analyses included only correct responses. Reaction time outliers, which were calculated for the performance of each participant in each trial type separately and defined as ±2 *SD*s from the participant's mean reaction time for the corresponding trial type, were excluded (2.7% of correct responses). Distributions of the reaction times were normal for each participant and for each trial type. Reaction times of participants for each corresponding trial type were averaged and recorded as their RT score. Distributions of those calculated mean RT scores were also normal. The difference of the to-be-compared RT scores was distributed normally; thus the data was appropriate for paired *t*-test analysis.

Accuracy analyses. Accuracy scores were the average of correct response percentages of the participants, which were not distributed normally; therefore the comparisons were done by using non-parametric tests. With respect to the hypothesis of anger superiority effect, it was expected that Wilcoxon signed-rank test would reveal that angry targets among neutral distractors would be detected more accurately than happy targets among neutral distractors. However, neutral targets among angry distractors would be detected less accurately than neutral targets among happy distractors, as a result of higher attentional hold.

For the target-absent trials, consequent Wilcoxon signed-rank tests were conducted with the prediction that existence of a negative favoring attentional hold would resulted in responses for *angry crowd* to be less accurate compared to responses for *happy crowd* and *neutral crowd*.

Eye-tracking analyses. Since the nature of eye tracking data was distinct for target-present and target-absent trials; dependent variables for those were also distinct. In target-present trials, locations of targets were determined as Area of Interest (AOI) and dependent variables were accounted for the data obtained from the corresponding AOI. Hence the faces were presented on a 3x3 matrix and covered 750*750 pixels area on the screen; each AOI was determined as adjacent 250*250 pixels area.

Aforementioned dependent variables were entry time of the first fixation (i.e. the time that the first fixation occurred in that AIO), average fixation time (i.e. mean of the durations of the fixations), number of fixations, and dwell time (i.e. the total duration of all fixations and saccades in that AIO). Moreover, post-attentive processing scores were calculated by subtracting the entry time of the first fixation for the target from detection time. On the other hand, in target-absent trials average fixation time, dwell time and number of fixations for the total area of the stimuli were recorded.

Eye tracking data were attained from correct responses. However, in order to ensure the consistency with the RT data, the gaze data of reaction time outliers (described in the *reaction time analysis* section) were also excluded from the analyses.

For the target-present trials, gaze data of participants in to-be-compared trials (i.e. *target angry* vs. *target happy*, and *target neutral in angry* vs. *target neutral in happy*) were counterpoised with a criterion, which was based on the location of target. As mentioned in procedure section, targets were displayed on a 3x3 matrix, which made nine different locations for targets to appear. In each of those locations, two different faces were displayed as targets. The criterion was that if there was no gaze data observed in a particular location of a trial type, the gaze data, if any, observed in that location of the to-be-compared trial type were excluded from analysis (e.g. if there was no valid gaze data of a participant for upper-left location in the *target angry* trial type, then the gaze data of the participant for the upper-left location obtained in the *target happy* trial type was also excluded). Distributions of counterpoised gaze data were analyzed for each trial type and each corresponding dependent variable, and outliers were excluded. After the removal of the outliers, counterpoising procedure was re-applied as it was needed. The average eye-tracking scores for each dependent variable were calculated as the scores of participants. Distributions of the mean eye-tracking scores were normal. The differences of the to-be-compared eye-tracking scores were distributed normally and comparisons of the scores were done by using paired *t* test.

In regard to the anger superiority hypothesis, it was expected to find that the entry time for *target angry* trials would be shorter than the entry time for *target happy* trials. Testing of the higher attentional hold of angry distractors compared to happy distractors consisted of both analyses of the eye tracking data of *target neutral* and analyses of eye tracking data of distractors.

The gaze data of distractors were obtained from the total area of the stimulus-sets remained from AOI. The predicted pattern was that the entry time for neutral targets among angry distractors would be longer than for targets among happy distractors; whereas the entry time for angry distractors would be shorter than the entry time for happy distractors. Since the angry faces were assumed to result in higher levels of attentional hold, dwell time and number of fixations would be higher for angry distractors than for happy distractors. Higher attentional hold of angry distractors would also result in higher dwell time and number of fixations for *target neutral*s compared to happy distractors. With regard to the hypothesis of negative favoring attentional hold, higher dwell time and number of fixations were predicted for *angry crowd* compared to *happy crowd* and *neutral crowd*.

Results

The hypothesis of anger superiority effect.

As predicted, results revealed that detection of angry targets among neutral distractors (M = 1741.41ms, SE = 44.86) were faster than happy targets among neutral distractors (M = 1790.07ms, SE = 47.81), $t(28) = 1.82$, $p < .05$, $r = .33$ (Figure 1.4). Consistent results were evident for accuracy score comparisons. Angry targets among neutral distractors were detected more accurately (Mdn = 94.40%) than happy targets among neutral distractors (Mdn = 88.89%), $z = -1.70$, $p < .05$, $r = .22$. It can be seen in Figure 1.5 that the eye tracking data of entry time of the first fixation also showed that the occurrence of the first fixation was faster for angry targets (M = 912.55ms, SE = 27.01) than for happy targets (M = 969.44ms, SE = 31.98), $t(28) = -2.04$, $p < .05$, $r = .36$. Post-attentive processing was similar across angry and happy target faces, $t(28) = .268$, $p > .05$.

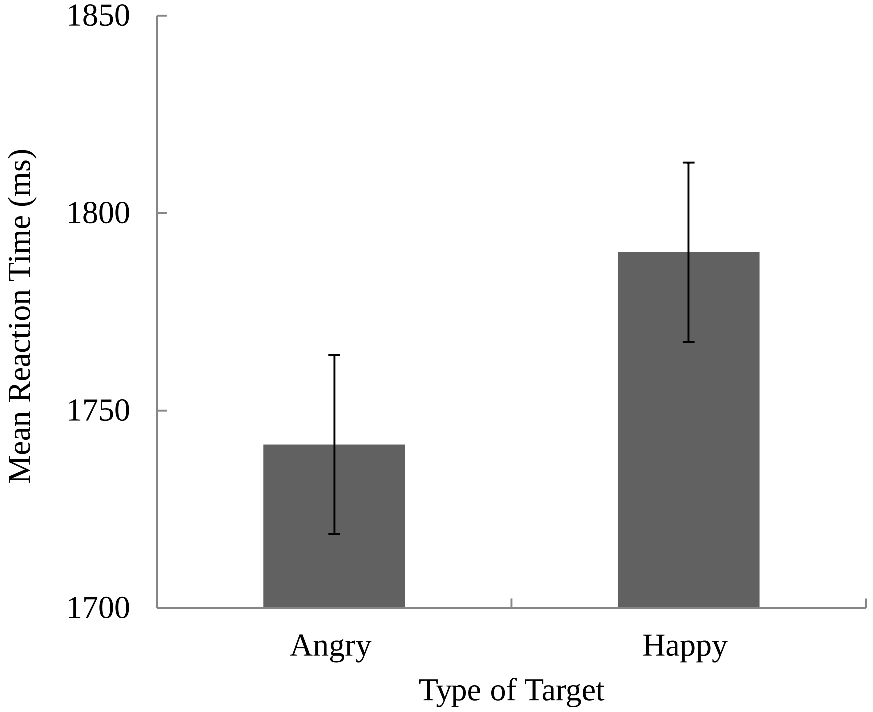

Figure 1.4. Mean (with 95% CI) reaction time by the type of the emotional target among neutral crowd.

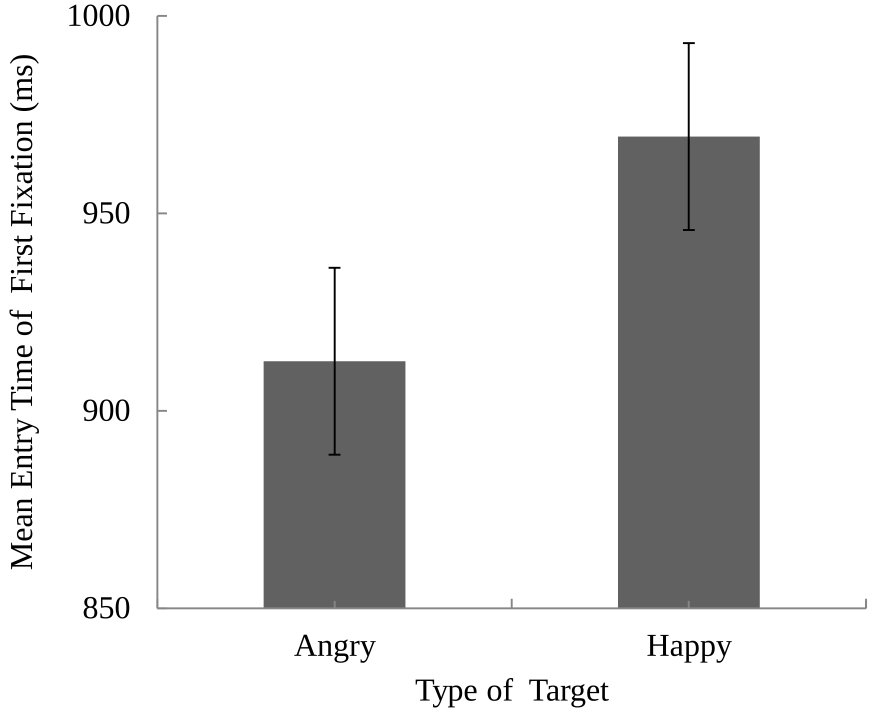

Figure 1.5. Mean (with 95% CI) entry time of the first fixation by the type of the emotional targets among neutral crowd.

No significant difference was observed for the average fixation time (*t*(28) = .27, *p* > .05) dwell time (*t*(28) = .59, *p* > .05), or the number of fixations (*t*(28) = .66, *p* > .05).

The hypothesis of higher attentional hold of angry distractors.

Comparisons showed that the reaction time of detecting neutral targets among angry distractors (*M* = 1958.93ms, *SE* = 49.82) were slower than the reaction time of detecting neutral faces among happy distractors (*M* = 1895.77ms, *SE* = 47.38), *t*(28) = 1.93, *p* < .05, *r* = .35 (Figure 1.6). Detection accuracy of neutral targets were greater when they appeared among happy distractors (*Mdn* = 88.89%) than when they appeared among angry distractors (*Mdn* = 88.89%), z = -1.86, *p* < .05, *r* = .25. Consistent pattern of results were observed for the eye-tracking data. Entry time (i.e. occurrence of the first fixation) for neutral targets among happy distractors (*M* = 1056.05ms, *SE* = 42.25) was faster than for neutral targets among angry distractors (*M* = 1130.31ms, *SE* = 38.85), *t*(28) = 1.87, *p* < .05, *r* = .33 (Figure 1.7). Distractor type did not affect post-attentive processing of neutral target faces, *t*(28) = .40, *p* > .05. Dwell time was longer for neutral targets among angry distractors (*M* = 438.90ms, *SE* = 22.19) than neutral targets among happy distractors (*M* = 405.81ms, *SE* = 20.61), *t*(28) = 2.30, *p* < .05, *r* = .40 (Figure 1.8). More fixations were observed for the neutral targets among angry distractors (*M* = 2.13, *SE* = .09) than for the neutral targets among happy distractors (*M* = 1.95, *SE* = .08), *t*(28) = 3.04, *p* < .05, *r* = .50 (Figure 1.9).

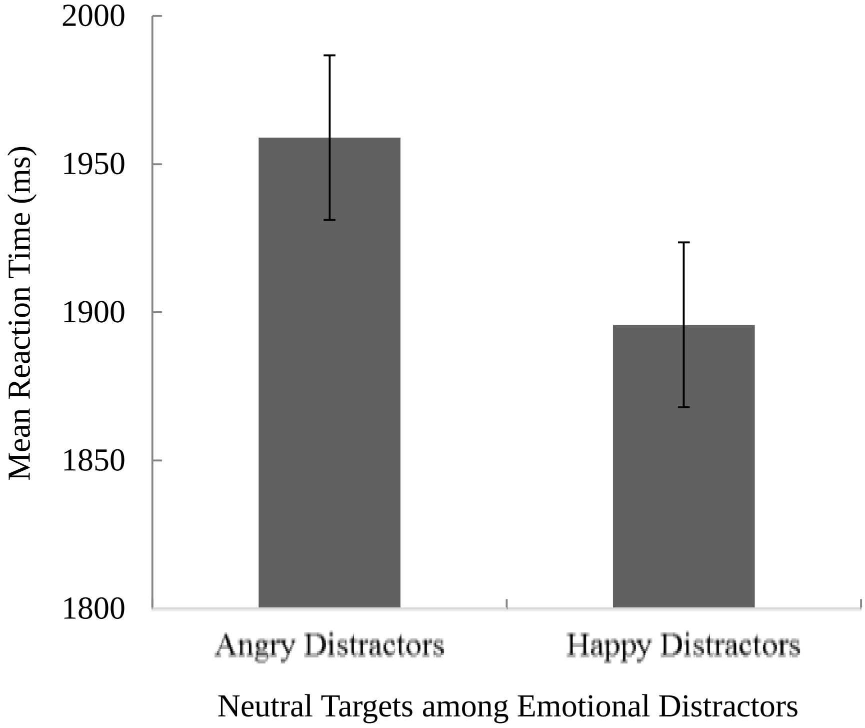

Figure 1.6. Mean (with 95% CI) reaction time for the neutral targets by distractor type.

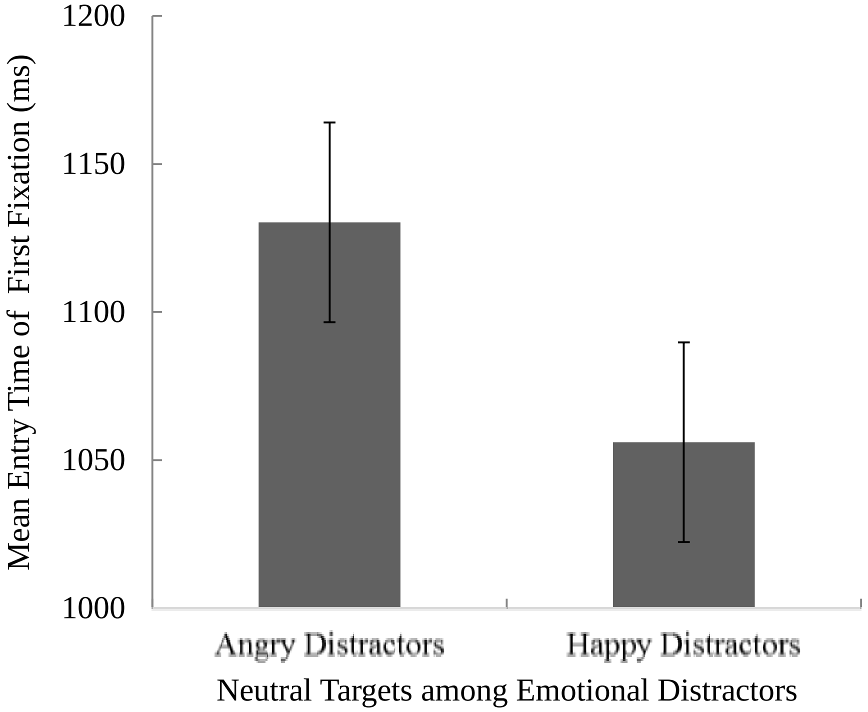

Figure 1.7. Mean (with 95% CI) entry time of the first fixation for the neutral targets by distractor type.

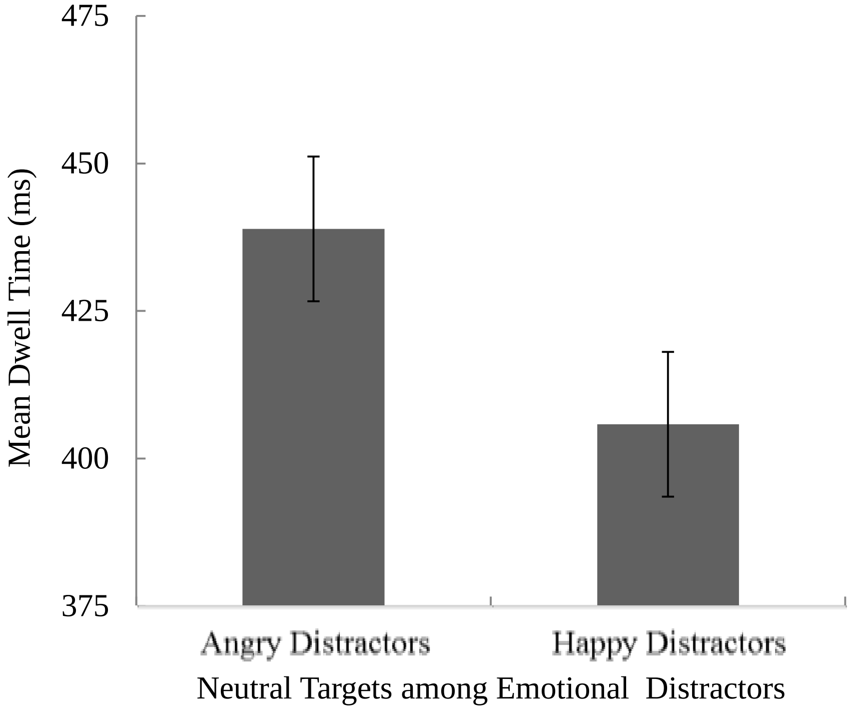

Figure 1.8. Mean (with 95% CI) dwell time for the neutral targets by distractor type.

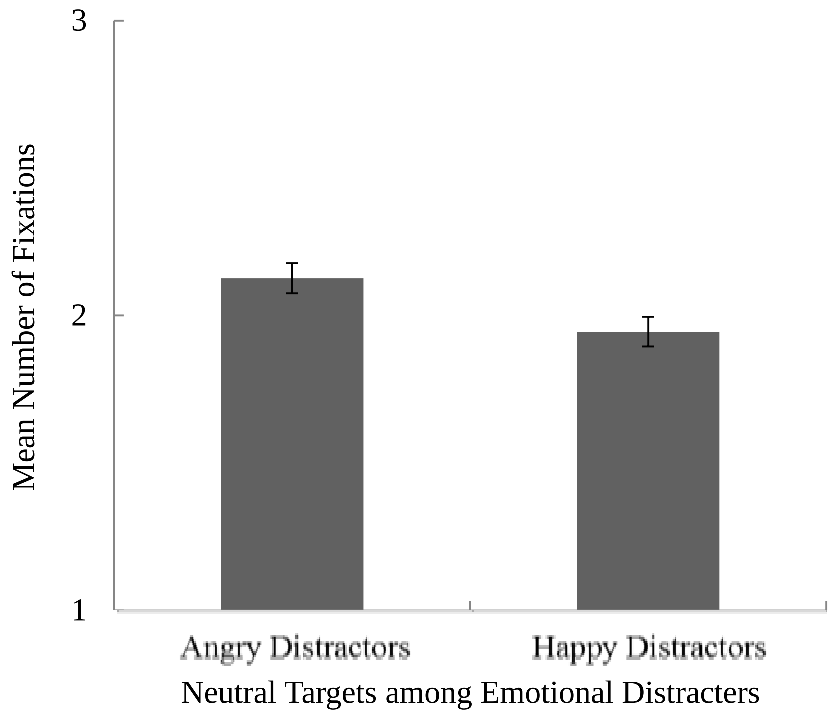

Figure 1.9. Mean (with 95% CI) number of fixations for the neutral targets by distractor type.

Additional tests were conducted to compare the eye tracking data of the distractors. The occurrence of the first fixations was faster for angry distractors (*M* = 250.10ms, *SE* = 19.99) than for happy distractors (*M* = 277.60ms, *SE* = 23.45), $t(28) = -2.39$, $p < .05$, $r = .41$ (Figure 1.10). Figure 1.11 and Figure 1.12 present mean dwell time and number of fixations for angry distractors and happy distractors, respectively. Higher dwell time for angry distractors (*M* = 1215.20ms, *SE* = 45.59) than happy distractors (*M* = 1139.63ms, *SE* = 50.63) was observed, $t(28) = 2.01$, $p < .05$, $r = .36$. Consistently, more fixations were formed for angry distractors (*M* = 6.03, SE = .24) than for happy distractors (*M* = 5.67, *SE* = .23), $t(28) = 2.16$, $p < .50$, $r = .37$.

The hypothesis of negative favoring attentional hold in FFiC.

The influence of negative favoring attentional hold on detection times was observed for the target-absent trials. Results indicated that the reaction time of *angry crowd* (*M* = 2622.94ms, *SE* = 61.79) was slower than both of *happy crowd* (*M* = 2391.50ms, *SE* = 55.29), $t(28) = 7.27$, $p < .025$[*], $r = .81$), and of *neutral crowd* (M = 2262.33ms, *SE* = 55.65), $t(28) = 10.88$, $p < .025$, $r = .90$) (see Figure 1.13). Moreover, both *neutral crowd* (*Mdn* = 100%), $z = -3.73$, $p < .025$, $r = .44$, and *happy crowd* (*Mdn* = 100%), $z = -3.96$, $p < .025$, $r = .52$, were detected more accurately than *angry crowd* (*Mdn* = 88.89%).

[*] Bonferroni correction with .025 level of significance

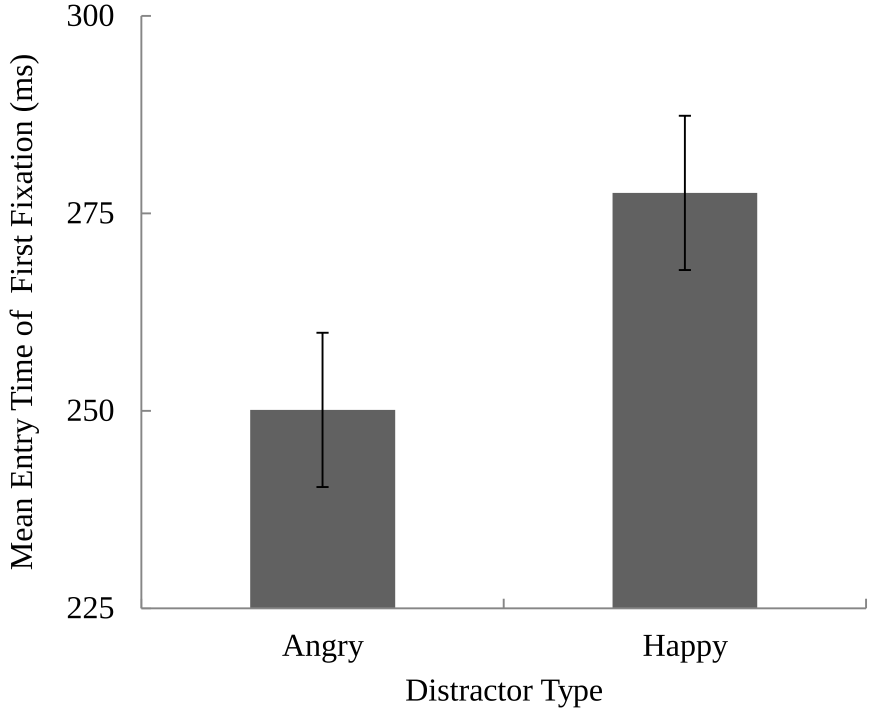

Figure 1.10. Mean (with 95% CI) entry time of the first fixations by the distractor type.

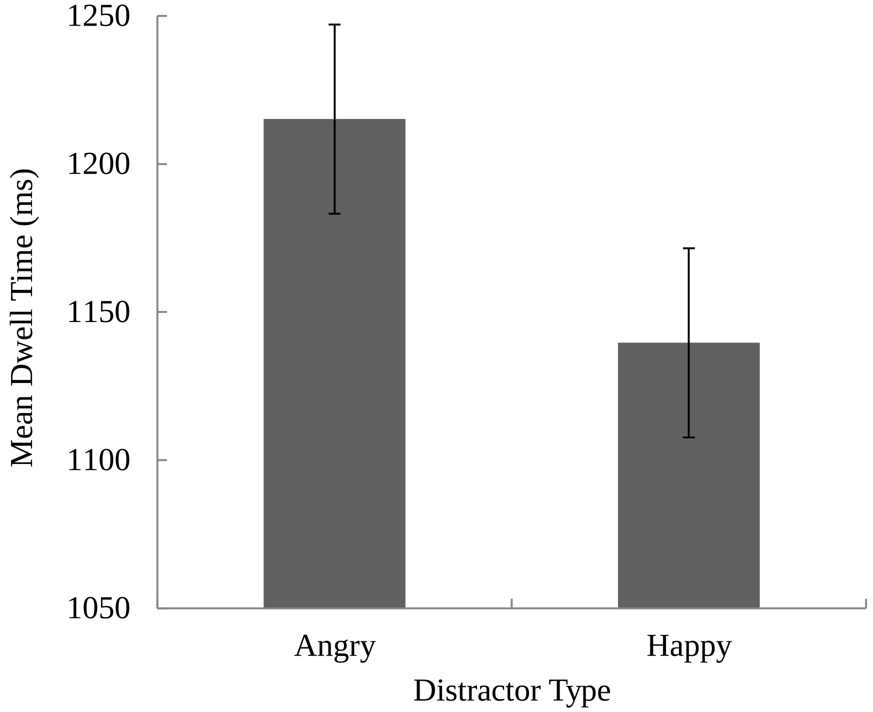

Figure 1.11. Mean (with 95% CI) dwell time by the distractor type.

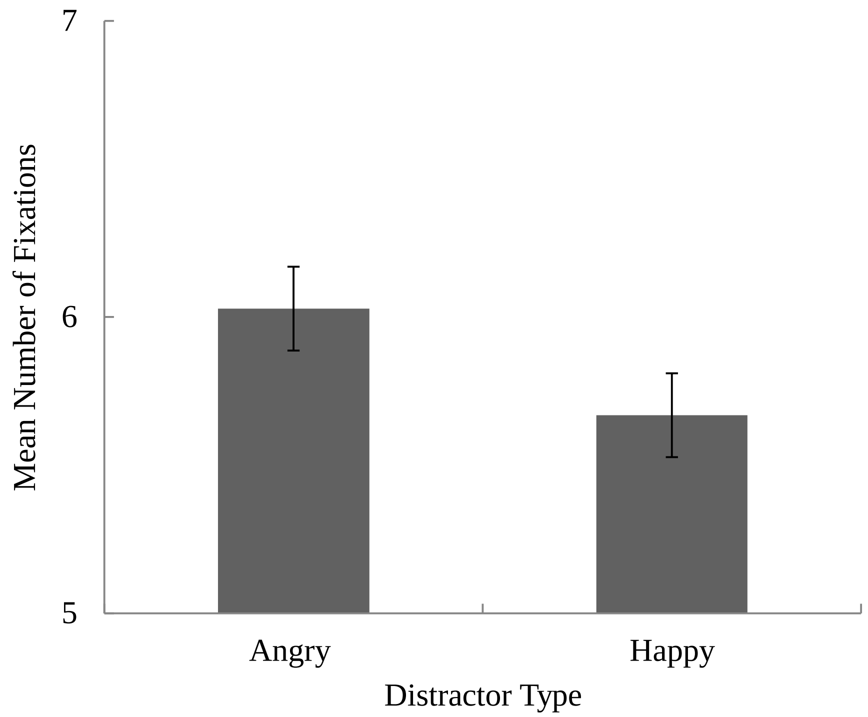

Figure 1.12. Mean (with 95% CI) number of fixations by the distractor type.

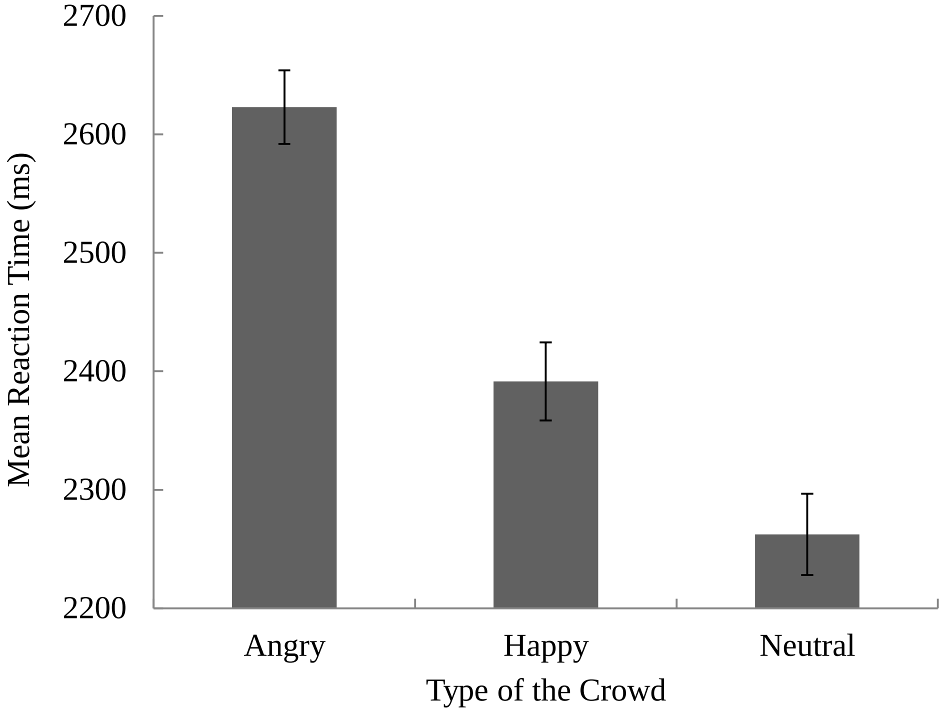

Figure 1.13. Mean (with 95% CI) reaction time by the crowd type.

Analyses of eye tracking data revealed that *angry crowd* (*M* = 11.25, *SE* = .31) received greater number of fixations than *happy crowd* (*M* = 10.03, *SE* = .34), *t*(28) = 6.09, $p < .025$, *r* = .76, and *neutral crowd* (*M* = 9.74, *SE* = .37), *t*(28) = 8.48, $p < .025$, *r* = .85 (Figure 1.14); while the mean fixation duration of *angry crowd* (*M* = 161.39ms, *SE* = 3.56) was greater than the mean fixation duration of both *happy crowd* (*M* = 157.64ms, *SE* = 3.35), *t*(28) = 2.56, $p < .025$, *r* = .44, and *neutral crowd* (*M* = 156.99ms, *SE* = 3.15), *t*(28) = 3.50, $p < .025$, *r* = .55 (Figure 1.15). Similar pattern was also observed for the dwell time. Participants performed longer dwell time for *angry crowd* (*M* = 2418.37ms, *SE* = 62.09) than *happy crowd* (*M* = 2179.93ms, *SE* = 59.71), *t*(28) = 7.60, $p < .025$, *r* = .82, and *neutral crowd* (*M* = 2081.73, *SE* = 64.83), *t*(28) = 10.26, $p < .025$, *r* = .89 (Figure 1.16).

Discussion

In the current phase of the research, the very existence of the *face in the crowd effect* was tested. The performance in the task of 'Finding the Face in the Crowd' indicated that there was, indeed, a detection (or attraction) superiority favoring angry faces. Such finding was supported by both RT and eye-tracking data. Angry targets were detected faster and accurately than happy targets. From an evolutionary perspective, preferential activation of a defense mechanism in response to threatening stimuli is crucial for organisms' survival. In this respect, the early and faster detection of angry faces could be a result of such defense mechanism. In the core of this mechanism, a fear module underlies (Öhman and Mineka, 2001), which is thought to be closely related to the attentional and pre-attentional mechanisms.

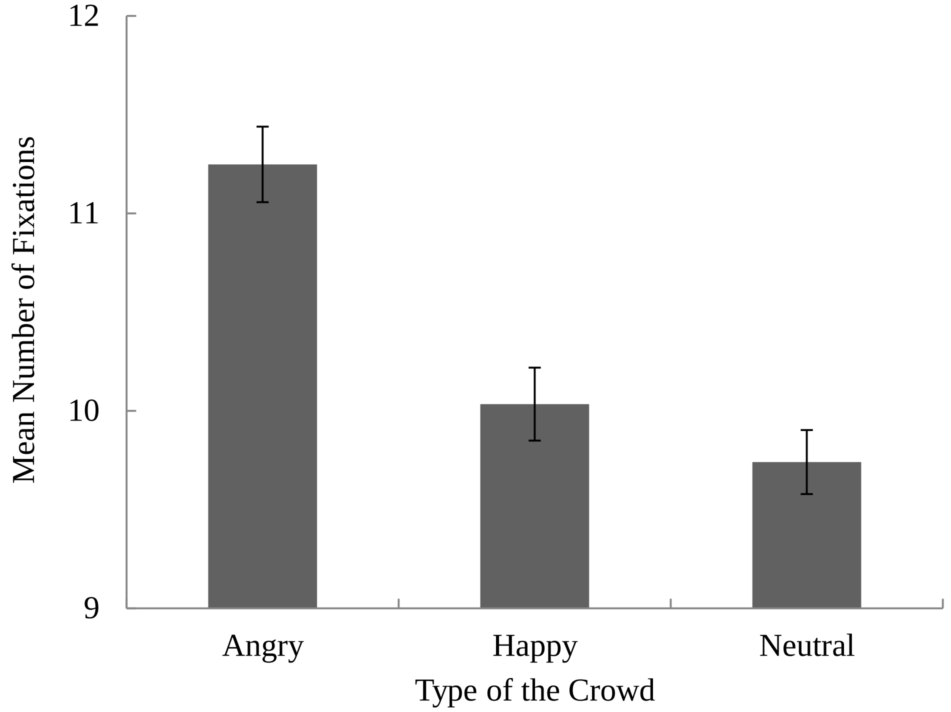

Figure 1.14. Mean (with 95% CI) number of fixations by the crowd type.

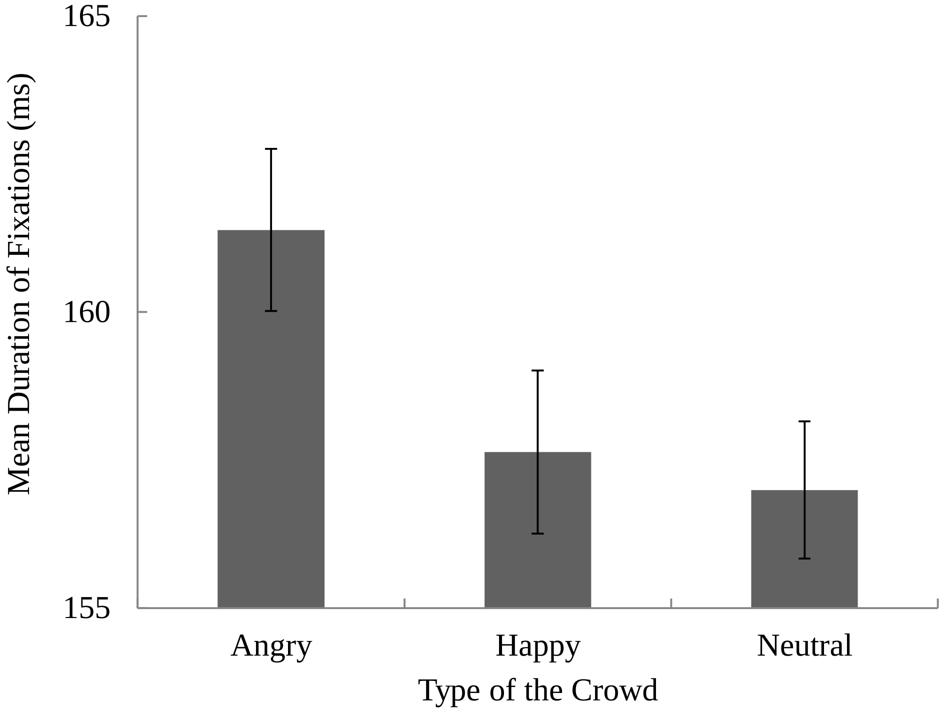

Figure 1.15. Mean (with 95% CI) duration of fixations by the crowd type.

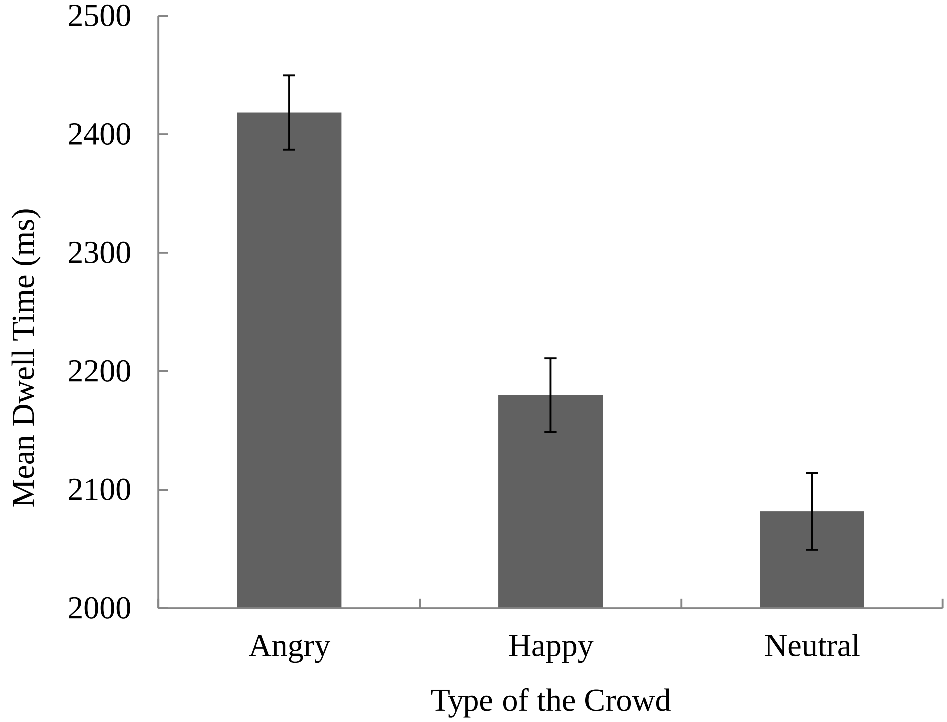

Figure 16. Mean (with 95% CI) dwell time by the crowd type.

The occurrence of first fixation was faster for angry targets than happy targets, which means angry targets attracted rapid attention compared to happy targets. It seemed valid to argue that the preattentive processing guided attention to the angry expression due to its threatening nature and resulted in faster detection time for angry faces, since the post-attentional (i.e. the time interval between the first fixation of the target and given response) processing was similar across emotional faces. Consistent finding was also observed in the trials that angry faces were distractors. Apart the findings that angry distractors inclined more fixations and dwell time compared to happy distractors, and the occurrence of the first fixation was quicker for the angry distractors; the findings also showed that neutral faces in angry distractors were detected more slowly and less accurately than neutral faces in happy distractors, which indicated that angry crowds distracted the detection of neutral targets more. The distraction was quite effective that the neutral targets in angry distractors required more fixations and dwell time to be detected compared to the neutral targets in happy distractors. The occurrence of the first fixation was also slower for the neutral targets among angry distractors compared to the neutral targets among happy distractors, suggesting more disrupted preattentional guidance towards the neutral targets faces; whereas post-attentional processing was similar for neutral faces across emotional distractors. All these behavioral and eye-tracking data indicated the existence of a higher attentional hold of angry distractors. Such negative favoring attentional hold effect was also prevalent for target-absent trials.

Slower reaction time for crowd of angry people compared to reaction time for happy-people-crowd or neutral-people-crowd, herewith the higher number of fixations and slower dwell time observed for all-angry crowd indicated the influence of negative favoring attentional hold.

Although the previous *Face in the Crowd Effect* studies revealed inconsistent results, such contradictions could be a consequence of distinct stimuli type and set that was employed. Although some of the leading studies preferred to use schematic faces to control perceptual differences between facial expressions (e.g. Fox, et al., 2000; Horstmann, et al., 2010; Lipp, et al., 2009; Öhman, et al., 2001), use of schematic faces has been criticized for lacking heterogeneity in a crowd, as they were identical; and ecological validity, as they were not real faces. Others that real faces were used (e.g. Hansen and Hansen, 1988; Horstmann and Bauland, 2006; Lipp, et al., 2009) were also criticized for not controlling low-level perceptual properties of faces, or for lacking heterogeneity in the crowd (i.e. using the same person’s facial expressions as target and distractor). In the current study, faces of different individuals were used as stimuli. Thus the ecological validity and heterogeneity of the crowd were satisfied. In an attempt to reduce low-level perceptual properties of the stimuli, luminance and contrast levels of hair-removed, grayscale pictures of individuals were equated.

One important issue that should be considered about the selection of stimuli was that both of the happy and angry faces were all open-mouthed. The reason behind this selection was that close-mouthed happy and angry faces were not generally evaluated as expressive for the emotion that they carried. Therefore, more expressive open-mouthed faces were used as emotional stimuli.

Although it could be argued that exposed teeth would be confounding, it was not an issue for the current study since all the to-be-compared angry and happy faces included exposed teeth feature. In other words, exposed teeth feature was balanced out through the faces.

Following the indication of anger superiority effect, and negative favoring attentional hold as well, the second phase of the research aimed to investigate whether there was a hemispheric asymmetry for the processing of *face in the crowd effect*.

CHAPTER 3

EXPERIMENT II

In the previous phase of the study, the results revealed detection superiority for facial targets with angry expression, and a negative favoring attentional hold, which made the angry faces more distractive. The second phase of the study aimed to investigate whether there was a hemispheric asymmetry for the processing of the *face in the crowd effect*. Divided visual field methodology was adopted to reveal whether there would be a visual bias for detecting emotional target faces in crowds, and neutral target faces in emotional crowds. The results were evaluated on the basis of two prominent hypotheses on differential hemispheric specializations in the processing of facial emotions: The Right Hemisphere hypothesis and the Valence-Specific hypothesis.

Divided visual field (DVF) paradigm is an alternative method for studying hemispheric lateralization in healthy people without expensive and strictly available brain imaging equipment. The functional principles of DVF methodology are contingent upon the transfer of visual input through retinas to the brain (Figure 2.1).

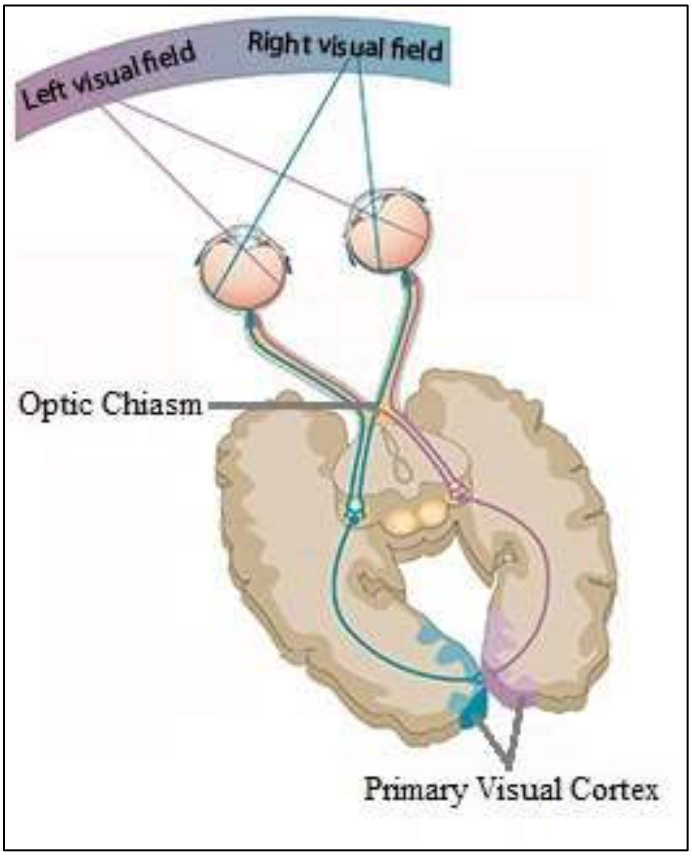

Figure 2.1. The route of visual input to the two hemispheres of the brain.

Visual information from the right visual field reaches into the left half of retina of both eyes; whereas the information from the left visual field reaches into the right half of the retina of both eyes. Left halves of the each retina that receive visual input from the right half of the environment are connected to the left hemisphere. The opposite pattern is applied for the right hemisphere that it is connected to the right halves of the each retina that receive information from the left half of the environment. At the optic chiasm, axons from the right half of the left retina cross to the right hemisphere, and axons from the left half of the right retina cross to the left hemisphere. As a result, visual information from the right visual field is initially processed by the left hemisphere, and visual information for the left visual field is initially processed by the right hemisphere. Thus, brief unilateral presentations of stimuli within certain angles of the visual half field will be projected to and processed by the contralateral hemisphere. Therefore, any visual field effects observed can be attributed to the early hemispheric processing.

In the current study, methodological considerations that Bourne (2006) provided were taken into account. Unilateral presentations were carried out within a 10.5^0 width from the central fixation, with a 2. 9^0 distance between the inside edge of visual stimuli and the fixation; and recommendation of maximum exposure to stimuli (i.e. 180ms) was regarded as stimulus duration, followed by a backward masking to reduce after-images. Within these conditions, unilateral left visual field presentations were projected to the right hemisphere, and vice versa.

Method

Participants

Fifty-five undergraduate and graduate students of Izmir University of Economics were recruited in the experiment voluntarily or for course credit. Participants were right-handed (scored higher than 60 in the Edinburgh Handedness Inventory (Oldfield, 1971)), displayed mild levels of anxiety or none (scored less than 15 from the Beck Anxiety Inventory (Ulusoy et al, 1998)), had normal or corrected vision, and no clinical diagnosis that would indicate an existing psychopathology, or any neurological impairment. The data of seven participants, who behaved improperly during the experiment such as moving the head or body, and failed following instructions, were eliminated. The data from 24 female and 24 male participants was regarded as viable for further analysis. The age of participants ranged between 19 and 28, with a mean of 21.21 years.

Stimuli, Apparatus and Material

Pictures of two females and two males with the highest expressiveness ratings were selected among the pictures of nine individuals, which were used in the Experiment I. There were no significant difference between the mean expressiveness ratings of angry (M = 5.94, SE = 0.46), happy (M = 5.69, SE = 0.27), and neutral faces (M = 6.21, SE = 0.11), F (2, 14) = 1.13, p > .05. The dimensions of the 12 pictures (four models x three expressions) were resized as the height was to 120 pixels, and the pictures were inserted on the center of 120*120 pixels black background.

The same adjacent rooms, one for running the experimental program (i.e. the control room) and the other for displaying the stimuli (i.e. the experimental room), were used to carry out the experimental sessions (see Figure 1.1 for the general view of the experimental setup) as in Experiment I. The experimental programs was run on a personal computer (Intel® Pentium® D, CPU 2.80 GHz 2.81 GHz, 2 GB of RAM) in the control room, which was connected to a 22" stimulus presentation monitor settled in the experimental room. The screen resolution was 1680*1050 pixels, and refresh rate was 59 MHz. The viewing distance was 50 cm. A chin rest was used to stabilize the viewing distance and subject's head.

Experimental presentations, randomization and response recording were designed and controlled by E-Prime® (Psychology Software Tools, Inc., version 2.0.10.182). Table 2.1 represents the eight different experimental programs, which were prepared in accordance with the experimental conditions and counterbalancing procedures.

Procedure

A FFiC task with trial-corresponded faces of four models was developed. Faces were presented in a 2x2 matrix, with a fixed horizontal and vertical distance between the adjacent faces (see Figure 2.2 for a sample stimulus-set of bilateral presentations). Stimulus-sets covered 220*275 pixels area of 1680*1050 pixels black background. For the visual half field presentations, the sets were displayed either on the left or the right side of the screen that the distance of their inside edge from the central fixation was 2.9^0, and that the distance of their outside edge from the central fixation was 9.9^0.

Table 2.1. *Experimental Programs*

Program	First Block	Second Block	Keyboard Label
1	Neutral Crowd Target Angry in Neutral Crowd	Angry Crowd Target Neutral in Angry Crowd	F: SAME K: DIFFERENT
2	Neutral Crowd Target Angry in Neutral Crowd	Angry Crowd Target Neutral in Angry Crowd	K: SAME F: DIFFERENT
3	Angry Crowd Target Neutral in Angry Crowd	Neutral Crowd Target Angry in Neutral Crowd	F: SAME K: DIFFERENT
4	Angry Crowd Target Neutral in Angry Crowd	Neutral Crowd Target Angry in Neutral Crowd	K: SAME F: DIFFERENT
5	Neutral Crowd Target Happy in Neutral Crowd	Happy Crowd Target Neutral in Happy Crowd	F: SAME K: DIFFERENT
6	Neutral Crowd Target Happy in Neutral Crowd	Happy Crowd Target Neutral in Happy Crowd	K: SAME F: DIFFERENT
7	Happy Crowd Target Neutral in Happy Crowd	Neutral Crowd Target Happy in Neutral Crowd	F: SAME K: DIFFERENT
8	Happy Crowd Target Neutral in Happy Crowd	Neutral Crowd Target Happy in Neutral Crowd	K: SAME F: DIFFERENT

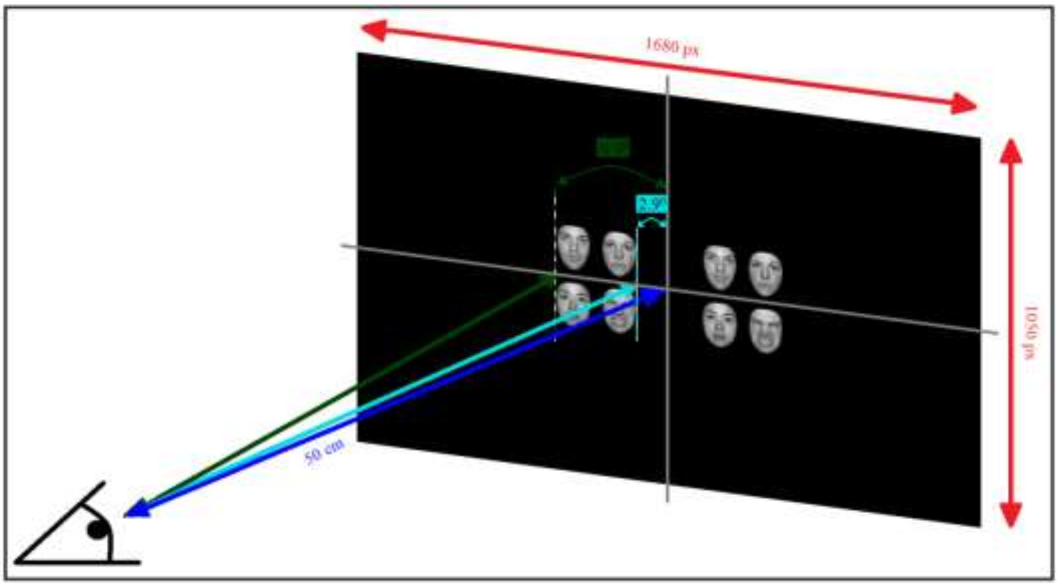

Figure 2.2. A sample stimulus-set of bilateral presentation. Sets were displayed either on the left side of the screen, on the right side of the screen, or on the both sides. The distance of their inside edge from the central fixation was 2.9^0, and that the distance of their outside edge from the central fixation was 9.9^0. The viewing distance was 50cm.

For the bilateral presentations, the same stimulus-sets were displayed both on the left and the right visual sides with their inside edge of 2.9^0 and their outside edge of 9.9^0 from central fixation.

As in the Experiment I, the target-present trials consisted of presentations of angry target face among neutral distractors, happy target face among neutral distractors, neutral target face among angry distractors, and neutral target face among happy distractors. The target-absent trials included presentations of crowd of angry faces, crowd of happy faces, and crowd of neutral faces. In the current experiment, the target-present sets were consisted of three distractors and a target, whereas the target-absent sets included crowd of four faces. Sets were presented in a 2x2 matrix. Thus, for the target-present sets, targets appeared in four different locations. Each face became a target once for each target-present trial type; thus each face was used as target four times. To-be-target faces, locations of the targets and the locations of the distractors that were the remaining three faces after the selection of the target, were determined pseudo-randomly, with the restriction that the same face would be a target in a target-present trial type just once, the same target would never appear in the same location, and overall, each face would appear as a distractor in each location three times. In total 16 sets of target-present trials (four locations x four faces) were prepared. Those sets were presented either on the left side, on the right side or on the both sides of the screen. Consequently, each target-present trial type included presentations of 12 sets (four targets x three visual sides). In the target-absent sets, faces of trial-corresponded emotion were pseudo-randomly inserted into the 2x2 matrix, with the restriction that the same face would never appear on the same location for the particular trial type.

Twelve sets of presentations (four faces x three visual sides) were prepared for each trial type.

Participants were assigned into one of the two main experimental conditions: Angry condition and happy condition. The assignment was pseudo-random that the number of females and males assigned into each condition was equal. In angry condition, two blocks of experimental presentations were carried out. The first block consisted of presentations of neutral crowd and angry targets presented among neutral distractors, whereas in the second block angry crowd and neutral targets among angry distractors were presented. Comparable blocks were also arranged for happy condition. Here, the first block included presentations of neutral crowd and happy targets among neutral distractors, whereas the second block included presentations of happy crowd and neutral crowd among happy distractors. The order of the blocks was counterbalanced for each condition (see Table 2.1 for different experimental programs that were run for each condition and order of the blocks). Nevertheless, each participant received 24 random condition-corresponding trials (12 of target-present and 12 of target-absent trial types) during each block. Overall, participants received 48 trials. Before each block, condition-corresponding practice tasks were completed. Practice tasks consisted of random presentation of 12 sets (two trial types x three visual sides x two times) generated by using grayscale schematic faces.

The participants, who filled out the informed consent form (see Appendix C), a questionnaire consisted of personal questions that might had been related to their performance, Edinburgh Handedness Inventory (Oldfield, 1971), and Beck Anxiety Inventory in Turkish standardized by Ulusoy et al. (1998) (see Appendix B), were taken to the experimental room. Participants adjusted the height of the experimental chair, put their chins on the chinrest in the position that they would be comfortable during the experimental session, and put on a headphone. Participants were instructed that they would see sets of emotional faces briefly, and their task was to decide as quickly and accurately as possible whether all the faces on the set displayed the same expression. They needed to press the "SAME" button on the keyboard, if the expressions were the same; or if there was a face with a discrepant emotion, they were required to press the "DIFFERENT" button. Participants were also informed that they would hear a warning sound at the beginning of each trial and they were supposed to focus on the fixation cross, which would be displayed on the center of the screen just before the presentation of facial stimuli. Before each block, participants were instructed about the type of trials that they would be administered.

Participants were administered a series of practice trials, which were consisted of schematic faces, before the start of main experimental trials (see Figure 2.3 for a typical trial). Each trial started with the presentation of a 1500ms-blank screen followed by a 500ms-warning sound, a 100ms-blank screen, and a 500ms-fixation cross; then each visual stimulus set was presented for 180ms and a 5000ms-mask covered the area where the stimulus set had been presented.

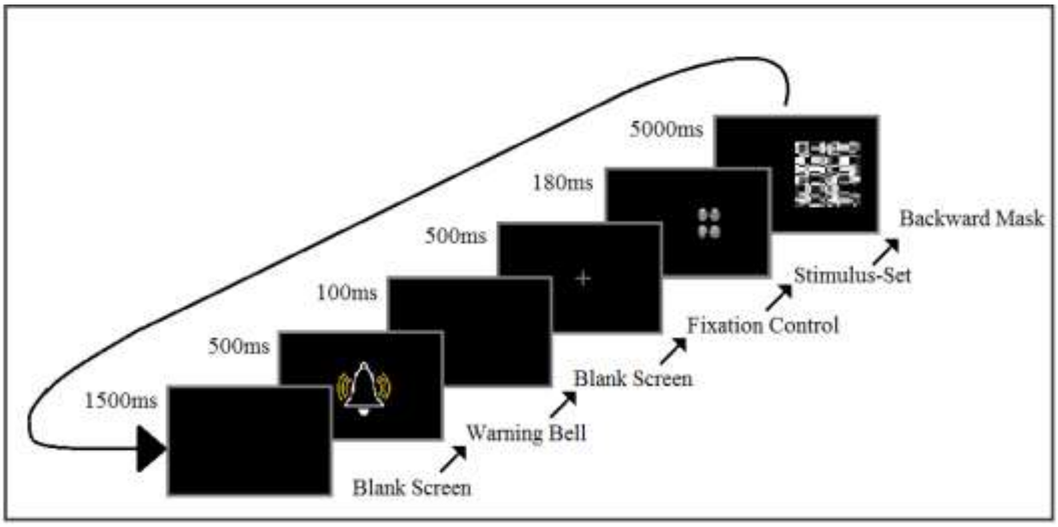

Figure 2.3. The sequence of stimuli through a trial. Each trial started with a 1500ms of blank screen, followed by a 500ms of warning sound, a 100ms of blank screen, and a 500ms of fixation cross, sequentially. Stimulus-sets were presented 180ms, and a 5000ms-mask covered the area where the stimulus-set had been presented until the participants responded. Upon the responding of the participant, the next trial started. If the participant did not respond during 5000ms of the mask, the next trial began, and the response was recorded as missing.

Participants were instructed to determine whether all of the faces in the set had the same facial expression or different by pressing the preassigned buttons (label of SAME was attached on F button and label of DIFFERENT was attached on K button, respectively) on the keyboard as quickly and accurately as possible. The locations of the “SAME” and “DIFFERENT” labels on the keyboard were counterbalanced across participants. The response of the participant during the 5000ms decision period were automatically recorded for its accuracy and latency. If the participant failed to respond or omit it, the procedure continued with the next trial, and it was recorded as a missing response.

In order to control whether the participants have paid their duty in the study in accordance with the experimental terms and conditions, experimental sessions were monitored and recorded by a closed-circuit video system. In such instances that a participant altered his/her body posture out of acceptable range, moved his/her head, or gazed away from the screen, the data collected from this particular participant were excluded from further analyses.

After the experimental session was completed, the participants were asked to express their impressions about the experiment and their performance; then they were debriefed and dismissed.

Statistical Analyses

Throughout the experiment, reaction times and accuracy scores were recorded for analyses. It was aimed to investigate the influence of the type of emotional target (angry vs. happy) and the visual field of presentation (left, right or bilateral) on detection time during the search for emotional targets.

A 2x3 mixed design ANOVA was conducted to compare main effects of the type of target and the visual field of presentation on detection time. During the search for neutral targets among emotional distractors, it was investigated whether the type of emotional distractors (angry vs. happy) and the visual field of presentation (left, right or bilateral) had an effect on response time. A 2x3 mixed design ANOVA was conducted to compare main effects of the type of emotional distractors and the visual field of presentation on detection time. Search performance was also investigated for the target-absent trials. The effect of the type of emotional crowd (angry vs. happy) and visual field of presentation (left, right or bilateral) on detection time of the absence of a target face was taken into account. A 2x3 mixed design ANOVA was conducted to compare the conditions.

The data of 13 participants, whose percentage of correct answers for each block were below the chance level, was excluded from the analysis. Analyses were conducted with the remaining data from 35 participants. The distributions of reaction times for each participant across conditions were normal, after the extreme scores from three participants were removed for the corresponding condition.

Results

Search for emotional target.

Analysis revealed that there was a significant main effect of visual field on detection time of targets, $F(2,54) = 4.59$, $p < .05$, $\eta^2 = .15$. Post-hoc comparisons revealed that the faster detection time of targets, which were displayed on the left visual field, than of targets, which were displayed on the right visual field (*MD* = 151.67, $p < .06$) was close to significance (see Figure 2.4).

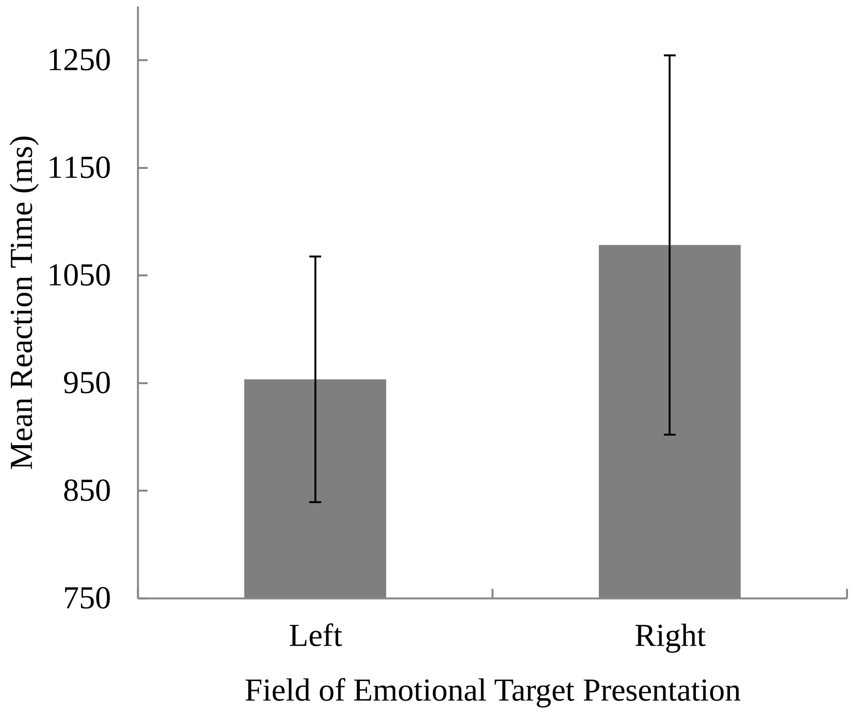

Figure 2.4. Mean (with 95% CI) reaction time by the field that the emotional target presented among neutral distractors.

Detection time was similar for bilateral and unilateral presentations (for the left visual presentations, *MD* = 8.66, $p > .05$; for the right visual field presentations, *MD* = 143.01, $p > .05$). Neither the main effect of the target type on detection time, $F(1, 27) = .01$, $p > .05$; nor the interaction between the target type and the visual field of presentation, $F(2, 54) = 1.65$, $p > .05$, was found to be significant.

Search among emotional distractors.

The visual field that the stimulus sets were presented indicated a significant effect on detection time of neutral targets among emotional distractors, $F(2, 58) = 5.5$, $p < .05$, $\eta^2 = .16$. The follow up comparisons indicated that the detection time was significantly longer for the trials that the stimulus sets were presented on the left visual field in comparison to the trials that the stimulus sets were presented on the right visual field (*MD* = 226.04, $p < .05$) (see Figure 2.5). For the bilateral and unilateral presentations, detection time was similar (for the left visual field presentations, *MD* = 132.46, $p > .05$; for the right visual field presentations, *MD* = 93.58, $p > .05$). The main effect of the distractor type was not significant, $F(1, 29) = 1.61$, $p > .05$. There was no significant interaction between the distractor type and the visual field of presentation, $F(1, 58) = .34$, $p > .05$.

Search performance during target-absent trials.

Analysis indicated that there were no significant main effects of the type of the condition (angry vs. happy), $F(1, 22) = 1.82$, $p > .05$, of visual field that the crowd presented (bilateral, left, right), $F(2, 50) = .07$, $p > .05$, nor of the interaction, $F(2, 44) = 1.20$, $p > .05$, on reaction times to the neutral crowd. No significant interaction was observed between the visual field of presentation and condition, $F(2, 44) = .22$, $p > .05$, on differential detection time.

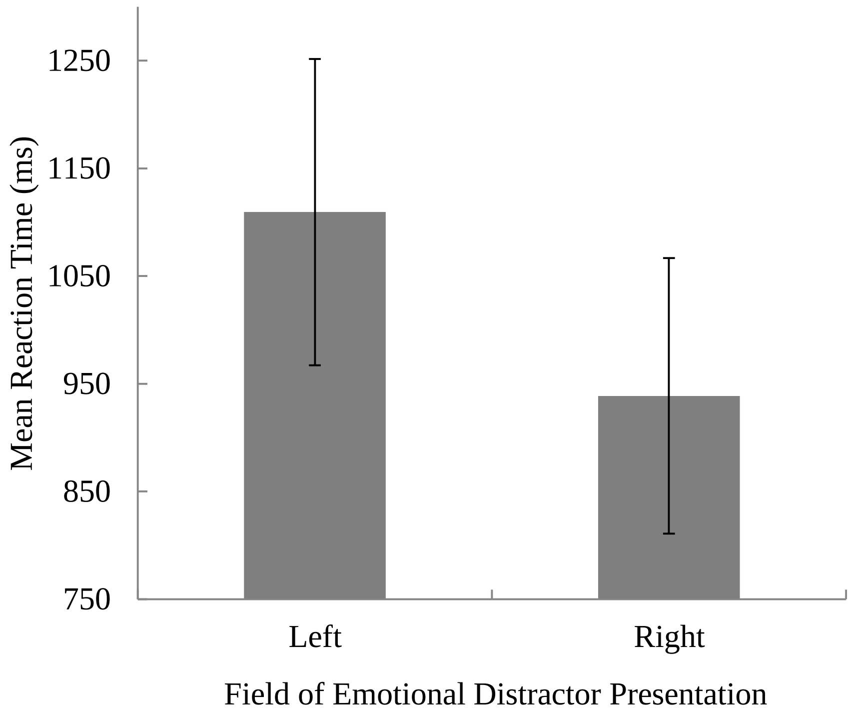

Figure 2.5. Mean (with 95% CI) reaction time by the field that the neutral target presented among emotional distractors.

Discussion

Following the indication of anger superiority effect, and negative favoring attentional hold as well, in the *Finding the Face in the Crowd* task, the second phase of the research aimed to investigate the existence of a hemispheric bias in the detection of threatening targets among crowd of distractor faces, and in the distraction of threatening faces around the neutral target faces. Results indicated a right hemisphere bias in the detection of emotional target faces. When presented to the right hemisphere, emotional targets were detected faster, irrespective of the emotional valence. A significant right hemisphere bias was also observed for the emotional distractors, in which the distractors played their role better at the left visual field. Regardless of the emotional valence of the distractors, detection time of neutral targets among the distractors was slower, when they were presented to the right hemisphere. It was also observed that when presented as crowd, reaction times to angry faces were slower than the happy faces, which indicated a strong negative favoring attentional hold, without recourse to visual field that they were presented.

Those results pointed out attraction superiority, and a longer attentional hold of emotional faces in the right hemisphere, which could be inferred as a support to the Right Hemisphere Hypothesis. Right Hemisphere Hypothesis asserts that the right hemisphere is specialized for processing all emotions, irrespective of the affective valence; whereas the Valence-Specific hypothesis states that the right hemisphere is involved in processing of negative emotions and the left hemisphere is involved in processing of positive emotions.

A left visual field bias in the processing of emotional facial stimuli might explain the present findings on emotional targets that were detected faster and that emotional distractors resulted in slower detection of neutral targets, regardless of their emotional valence. Emotional valence did not have a significant effect on detection times in both visual half fields, which contradicted with Valence-Specific hypothesis. It could be a valid argument that the left visual field bias in detection times of emotional faces might be resulted from the specialized processing of faces in the right hemisphere, but it could not explain the contradicted findings with the Valence-Specific hypothesis. From a Valence-Specific vantage point, the right hemisphere specialization in face processing might be resulted in the left visual field bias in detection times of emotional faces.
If it was the case, then it would be expected that the target faces with emotional content of anger would be processed faster in the left visual field, or that the distractor faces with emotional content of anger would have been processed slower, when presented to the right hemisphere. However, results did not support those expectations. Regardless of the valence, the right hemisphere bias was observed for the processing of facial expressions.

On the other hand, the current study was far from representing conclusive results. Both comments from participants on their performance and low percentage of accurate responses (see Appendix IV for the error percentage of each participant across conditions) indicated that the *Finding the Face in the Crowd* task was highly complicated as a divided visual field study.
As a result, evaluating the existence of visual field bias in the processing of emotional facial stimuli would be more prominent with further findings.

CHAPTER 4

EXPERIMENT III

In the present study, flicker paradigm was used to investigate whether the detection time of changes in crowd of faces would differentiate across different emotional content and across visual half field that the change appeared. Consequently, flicker version of *Finding the Face in the Crowd* task was developed, which consisted of attraction trials that the expression of the target face changed from neutral into an emotional content (i.e. anger or happiness), while the rest stayed neutral; and distraction trials that the expression of the target face changed from an emotional content (i.e. anger or happiness) into neutral, while the rest stayed emotional. The results of behavioral responses and eye movements were evaluated on the basis of Right Hemisphere hypothesis and Valence-Specific hypothesis.

Method

Participants

Participants with right-hand dominancy and mild levels of anxiety (i.e. scored higher than 60 in the Edinburgh Handedness Inventory (Oldfield, 1971) and less than 15 from the Beck Anxiety Inventory (Ulusoy et al, 1998)) were recruited in the experiment. Normal or corrected vision and no clinical diagnosis of an existing psychopathology or neurological problems were pre-requirements of participating. Eighty-five undergraduate/graduate students and workers of Izmir universities participated in the study voluntarily or for course credit. The data of five participants, who failed following instructions or behaved improperly during the experiment, were excluded from further analyses. The data from 40 female and 40 male participants were regarded as viable for further analysis. The age of participants ranged between 18 and 46, with a mean of 23.01 years.

Stimuli, Apparatus and Material

Stimulus-sets, which were presented in the experimental trials, were constructed by using the eight of the faces (four females) that were selected for and used in Experiment I. The ninth face was used to construct sets for practice trials. The dimensions of the 24 pictures (eight models x three expressions) were resized as the height was to 150 pixels, and the pictures were inserted on the center of 150*150 pixels black background.

The general settlement of experimental setup with eye-tracking technology was the same as of Experiment I (see Figure 1.1 for details).

E-Prime® (Psychology Software Tools, Inc., version 2.0.10.182) was used for designing and controlling of experimental presentations, randomization, behavioral response recording and triggering iViewX® (SensoMotoric Instruments, Inc., version 2.6.20) to record eye movements during the presentations of stimulus-sets with a sampling rate of 120Hz. A chin rest was used to stabilize the viewing distance and subject's head. The viewing distance was 60cm.

Procedure

In the experimental trials, pairs of two stimulus-sets were presented: Original and modified sets (see Figure 3.1). In the original sets, each model expressed the same facial emotion, whereas in the modified sets the emotional content of one face (i.e. the target face) was changed. Starting with an original set, pairs of original and modified sets were presented alternately. The study consisted of two main experimental conditions (i.e. angry condition and happy condition) and the additional two control conditions, in which the angry and happy condition trials were presented upside-down (i.e. angry-inverted condition and happy-inverted condition). In all conditions, two types of experimental trials were presented. In order to investigate the attraction effect, the experimental trials were generated by using crowd of neutral faces as the original set and a change of the target face into an emotional expression as the modified set (i.e. neutral crowd-emotional target pairs); whereas the distraction effect was measured by using crowd of emotional faces as the original set and a change of the target face into a neutral face as the modified set (i.e. emotional crowd-neutral target pairs).

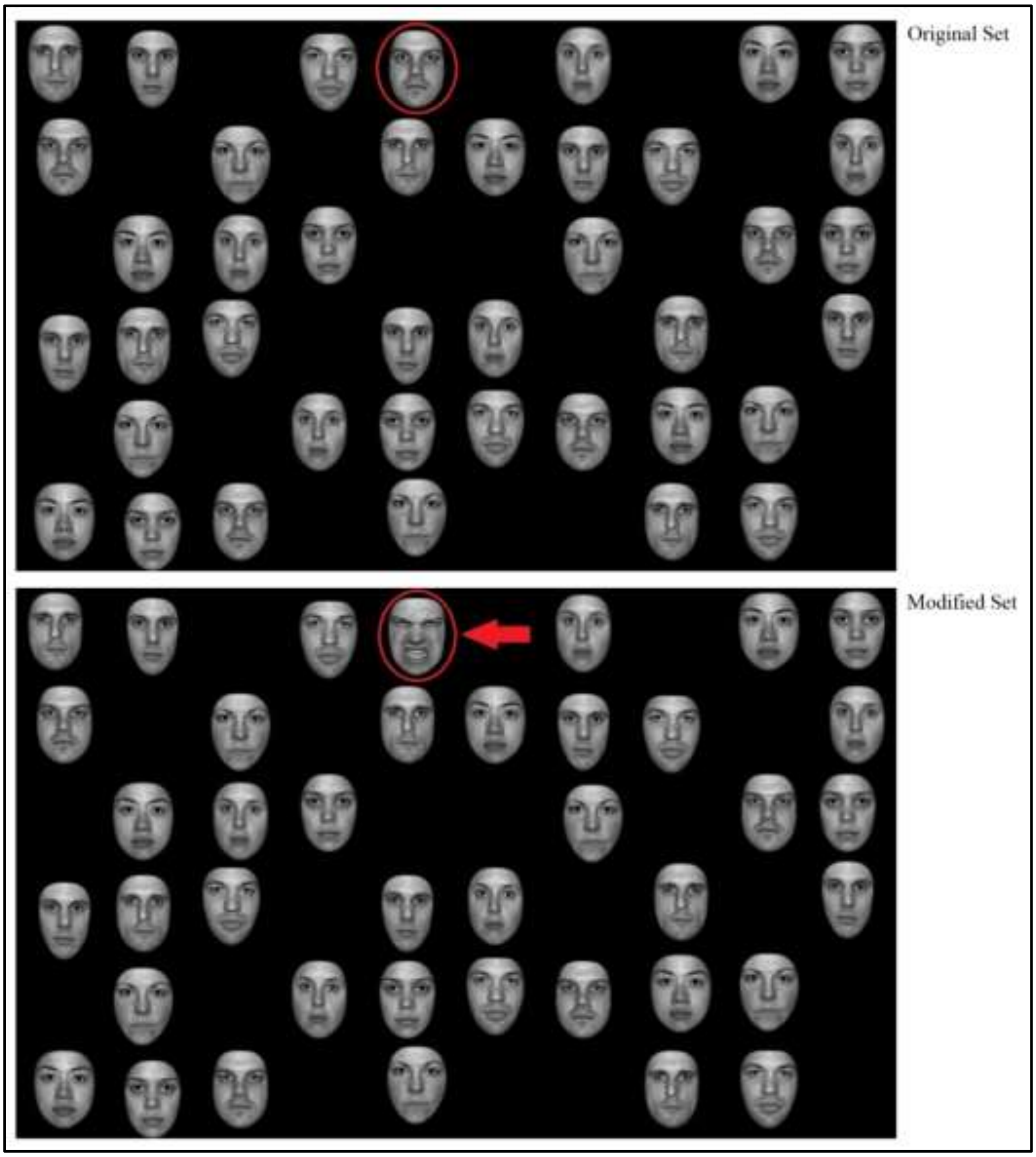

Figure 3.1. A sample pair of stimuli-set. In the original sets, each model expressed the same facial emotion, whereas in the modified sets the emotional content of one face (i.e. the target face) was changed. Here, the appearance of an angry target face in the neutral crowd was presented for illustration.

For instance, in angry condition, attraction effect was measured by the detection of the change in the target face from neutral into the angry expression while the rest stayed neutral; and the distraction effect was measured by the detection of the change in the target face from angry into neutral expression, while the rest stayed angry.

For each experimental trial, an original set and a modified set, in which the emotional content of the target face was changed, were generated. The stimulus-sets were presented on a 1680*1050 pixels of area. The area was consisted of 15 different 336*350 pixels sized locations and four sub-locations of each, in which the facial stimuli were inserted into (see Figure 3.2). The alignments of the 150*150 pixel sized facial stimuli within 168*175 pixels sized sub-locations were made randomly. Pictures of eight faces were used five times to enlarge the size of crowd. For each trial, 40 facial stimuli (eight facial stimuli x five places) were displayed on the total of 60 sub-locations (15 locations x 4 sub-locations). The placement of facial stimuli was pseudo-random. In each location, either two or three facial stimuli were inserted in. In each stimulus-set, the number of facial stimuli was equal for the left visual half (i.e. locations of 1, 2, 6, 7, 11, and 12) and for the right visual half (i.e. locations of 4, 5, 9, 10, 14, and 15). The gender of faces was also counterbalanced across visual halves. Throughout an experimental session, emotional change of faces in each location was tested two times, with the following restrictions for each corresponding trial type: In each location, a male and a female model presented as target, the same target would never appear in the same location, and a target would appear in the same sub-location only once.

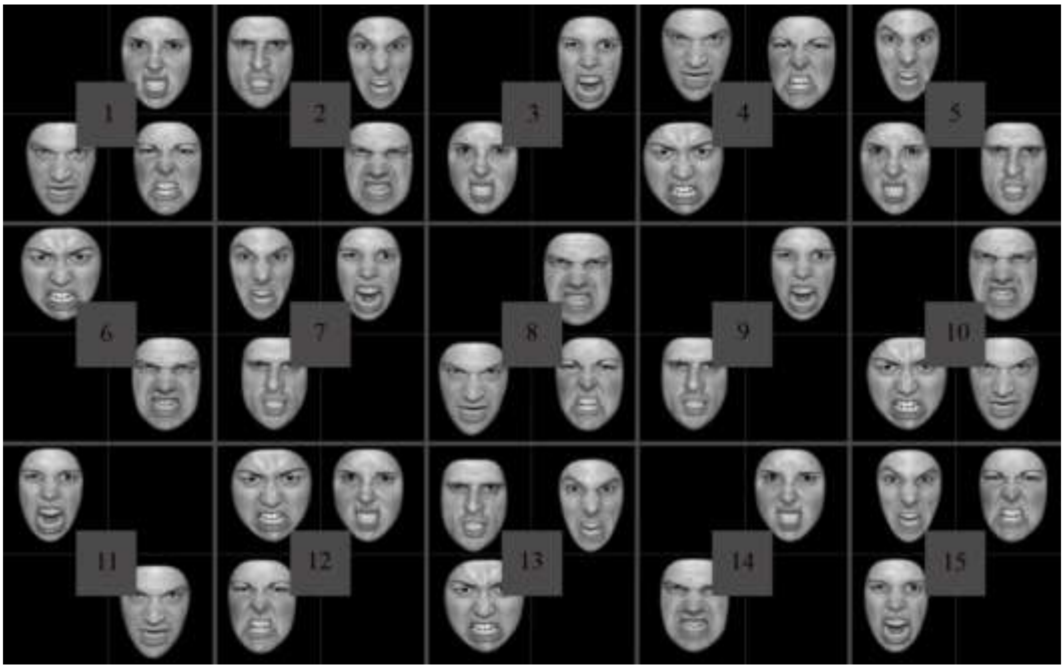

Figure 3.2. A sample of original set of stimulus. Stimulus-sets covered 1680*1050 pixels of area and consisted of 15 different locations. Each location divided into 2x2 matrix, in which the facial stimuli were inserted in. For illustration, locations were separated from each other with thicker lines, whereas the sub-locations were divided by thinner lines.

Mirror images of sub-locations in the right visual field presentations were used as the left visual field presentations, in order to keep the distributions of facial stimuli comparable and to ensure that the change detection differences, if any, were due to stated variables, rather than the distribution of stimuli on the field. Besides the distributional control of visual halves of field, emotional content was also controlled, in which the same stimuli distributions were used for to-be-compared changes in emotional content. For the neutral crowd-emotional target pairs, the original sets of neutral crowd were similar across conditions, but the target faces were changed into either angry or happy condition-corresponding expression. For emotional crowd-neutral target pairs, the sub-locations of condition-corresponding emotional facial stimuli were kept constant in the original sets, and the target faces were changed into a neutral expression.

Participants were pseudo-randomly assigned into one of the four conditions: Angry, angry-inverted, happy, or happy-inverted condition. The number of females and males assigned into each condition was equal. Participants were administered total of 60 experimental trials throughout the experimental session in random order: 30 condition-corresponding trials (15 locations x two targets) of neutral crowd-emotional target pairs and 30 trials of emotional crowd-neutral target pairs. Before the experimental sessions, participants completed practice trials and gained experience on the experimental procedures and their tasks. Eight practice trials (two types of experimental trials x two emotions x two visual halves of the field) were generated by the remaining model that was used in Experiment I.

The participants filled out the informed consent form (see Appendix V), and a questionnaire consisted of personal questions that might had been related to their performance, Edinburgh Handedness Inventory (Oldfield, 1971), and Beck Anxiety Inventory in Turkish standardized by Ulusoy et al. (1998) (see Appendix II). For the experimental session, they were taken to the experimental room. After participants adjusted the height of the experimental chair in the position that they would be comfortable during the experimental session, and put their chins on the chinrest, they were informed about the experimental procedures, the task, and calibration procedures. The participants were instructed that they would be presented crowd of faces with the same emotional content, and then the emotional content of one of those faces would begin to change throughout the corresponding trial and their task was to detect as quickly and accurately as possible the changing face (i.e. the target), and then to press the space bar on the keyboard. They were also informed that, when they pressed space bar, the faces would be gone and the target location screen, which was a black screen divided into 15 different locations by a 5x3 matrix, would appear. They were instructed to point out the location that the target was displayed by clicking the area with the mouse. Finally, in an attempt to prevent attention deficits and fatigue that would result in performance decrement, the participants were informed that at the beginning of each trial they would see a fixation cross on the screen, so they could rest their eyes and focus their attention, and when they were ready to continue, they would start the trial by pressing the space bar.

After the instructions, a 5-point-calibration was completed by using gray points which were displayed on a black background, since the stimuli used were monochrome and presented on a black background. If the visual gaze deviated more than 1° of visual angle for any point, calibration and validation procedure was repeated.

Before the start of main experimental trials, the participants completed a series of practice trials, and received feedback for their performance on response accuracy. The practice trials were identical across conditions, thus participants had seen samples of all type of trials. However, in experimental trials, participants received only condition-corresponding neutral crowd-emotional target and emotional crowd-neutral target pairs of trials.

Each trial started with a presentation of mini-instruction, which reminded participants to focus on fixation cross and press the space bar to start to trial and disappeared in 5000ms, and followed by the fixation cross (see Figure 3.3 for a typical trial). The fixation cross stayed on the center of the screen until the participant pressed space bar. Starting with the original set, 300ms of original sets and 300ms of modified sets were presented alternately with 80ms of gray blanks between them, until the participant detected the change in the expression of the target face and pressed the space bar. Upon the responding of the participant, a 500ms-gray blank and the target location screen were presented. When participants clicked on the location that the target appeared, the next trial with the presentation of mini-instruction began.

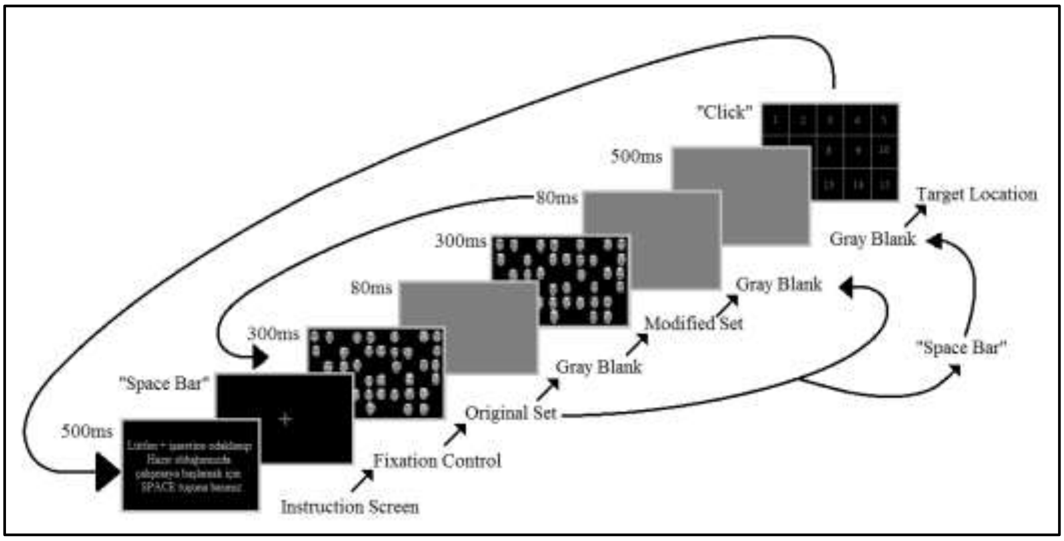

Figure 3.3. The sequence in a typical experimental trial. Each trial started with a presentation of 5000ms-mini-instruction, followed by the fixation cross until the participant pressed space bar. 300ms of original sets and 300ms of modified sets were presented in a sequential cycle with 80ms of gray blanks between them, until the participant detected the change and pressed the space bar. Upon the responding of the participant, a 500ms-gray blank and the target location screen were presented. Target location screen disappeared when participant clicked the location of target face by using the mouse; the next trial with the presentation of mini-instruction began.

Experimental sessions were monitored and recorded by a closed-circuit video system. In such instances that the participants did not paid their duty in the study in accordance with the experimental terms and conditions, for instance altered the body posture out of acceptable range, moved the head, or gazed away from the screen, the data collected from this particular participant were excluded from further analyses.

Statistical Analyses

Reaction times, accuracy and eye tracking data recorded for analyses throughout the experimental sessions. Only the left eye movements were used for analysis as a standard measure (Lykins et al., 2011).

Reaction time analyses. For each experimental trial, the time interval between the first presentation of the original set and the time that the participant pressed space bar to indicate the detection of target face was recorded as reaction time. Reaction time analyses included only correct answers, in which the target location was pointed out accurately. Reaction time outliers were defined as ±2 *SD*s from the participant's mean reaction time and calculated for attraction trials and distraction trials separately. Outliers that violated the normality of the distribution were excluded (2.7% of correct responses). For each corresponding trial type, reaction times of participants were averaged by each field of presentation, and recorded as their RT scores. Distributions of those calculated mean RT scores were also tested. For the attraction trials, the left visual field score of one participant, who assigned into angry-inverted condition, violated the normality of distribution and was excluded from further analyses.

For the distraction trials, the left visual field score of four participants, two of angry-inverted, one of angry and one of happy conditions, were excluded from analyses.

The stated research interest handled the processing of emotional content presented in different field of presentations. In order to compare the performance of detecting changes in the left and right visual halves, reaction times for the trials that the targets were displayed on the left (i.e. 1, 2, 6, 7, 11, and 12) and on the right visual half (i.e. 4, 5, 9, 10, 14, and 15) for each emotional content were averaged (see Figure 3.2).

As mentioned in the procedure section, participants were assigned into one of the four conditions (angry, angry-inverted, happy, happy-inverted) and presented trials of neutral crowd-emotional target and emotional crowd-neutral target pairs. For each type of experimental trials, 2 (presentation: upright vs. inverted) x 2 (emotional expression: anger vs. happiness) x 2 (visual half field: left vs. right) mixed design factorial ANOVA, with the last variable measured repeatedly, was conducted to compare the detection time of the change in the facial expression of the target.

Eye-tracking analyses. Eye tracking data were attained from correct responses. Moreover, the gaze data of reaction time outliers (described in the *reaction time analysis* section) were also excluded from the analyses.

Two areas of interest were determined for gaze data comparisons: One of them covered the left visual field of presentations (i.e. locations of 1, 2, 6, 7, 11, and 12) and the other covered the right visual field of presentations (i.e. locations of 4, 5, 9, 10, 14, and 15).

Scores of entry time of first fixation (i.e. the time that the first fixation occurred in that AIO), average fixation time (i.e. mean of the durations of the fixations), number of fixations, and dwell time (i.e. the total duration of all fixations and saccades in that AIO) were averaged for each visual side of presentations and recorded as scores of participants. The normality of distributions was tested for each dependent variable, with regard to the type of experimental trial and the condition that the participants were assigned into. For the attraction trials entry time scores of three participants, dwell time scores of two participants, and number of fixation scores of one participant violated the normality of distribution and were excluded from further analyses. For the distraction trials entry time scores of four participants, dwell time scores of three participants, and number of fixation scores of two participants were excluded.

For each dependent variable, 2 (presentation: upright vs. inverted) x 2 (emotional expression: anger vs. happiness) x 2 (visual half field: left vs. right) mixed design factorial ANOVA, with the last variable measured repeatedly, was conducted to compare the scores of condition-corresponding change in the facial expression of the target. In order to investigate the independent effects of attraction and distraction, analyses for each type of experimental trials were carried out separately.

Results

Attraction trials. Results indicated that the main effect of visual field of presentation on detection time of emotional changes among neutral crowd was statistically significant, $F(1, 75) = 19.94$, $p < .05$, $\eta^2 = .21$.

When presented on the left visual side (*M* = 5714.12, *SE* = 216.67), the change in target's facial expression was detected faster, compared to the presentations on the right visual field (*M* = 6709.23, *SE* = 237.33) (see Figure 3.4). Emotional content was a closely-significant predictor of the difference between detection time of changes, $F(1, 75) = 3.73$, $p < .06$, $\eta^2 = .05$. When the target face changed from neutral into an angry expression (*M* = 5864.23, *SE* = 249.64) the detection time was faster, in comparison to the changes into a happy expression (*M* = 6532.62, *SE* = 307.80) (see Figure 3.5). The main effect of condition on detection time was also significant, $F(1, 75) = 29.06$, $p < .05$, $\eta^2 = .28$, that the changes in the inverted faces (*M* = 7131.48, *SE* = 299.44) were detected more slowly than the changes in the upright faces (*M* = 5297.06, *SE* = 178.40) (see Figure 3.6). No significant interactions were observed between detection time scores of field and condition, $F(1, 75) = 1.23$, $p > .05$; field and emotion, $F(1, 75) = .03$, $p > .05$; field, condition, and emotion, $F(1, 75) = .06$, $p > .05$; and condition and emotion $F(1, 75) = 2.53$, $p > .05$.

Eye-tracking analyses revealed pattern of findings consistent with the reaction time analyses. The results for analyses of each dependent variable were represented in the Table 3.1. Results revealed that the entry time of the first fixation was significantly different across visual halves of presentation, $F(1, 73) = 59.99$, $p < .05$, $\eta^2 = .45$, in which participants preferred to look at the left visual half (*M* = 1219.28, *SE* = 51.6) earlier than the right visual half (*M* = 2029.36, *SE* = 82.32) (Figure 3.7).

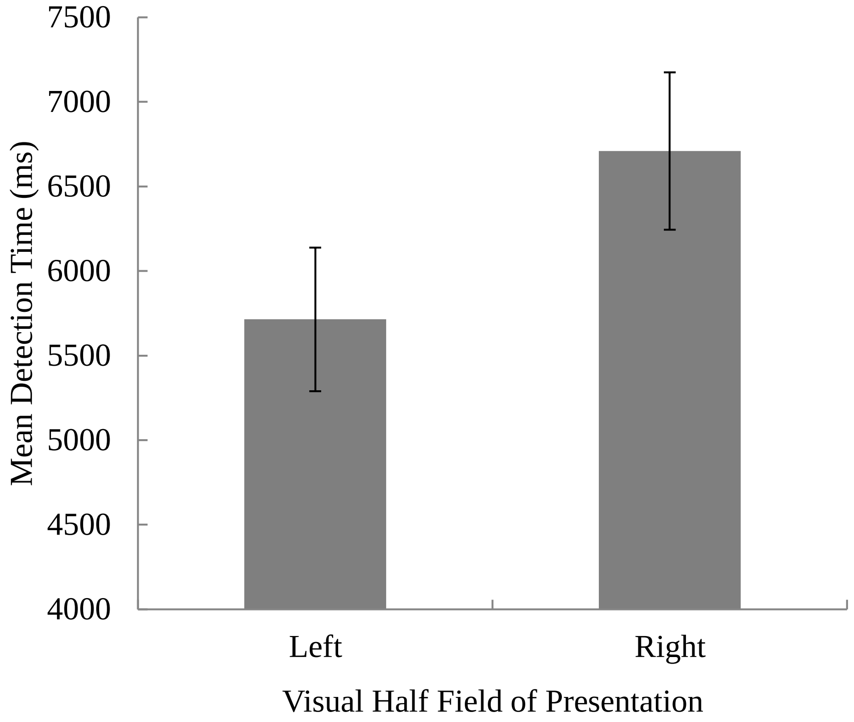

Figure 3.4. Mean (with 95% CI) detection time of the emotional change in target's face by visual half field of the presentation.

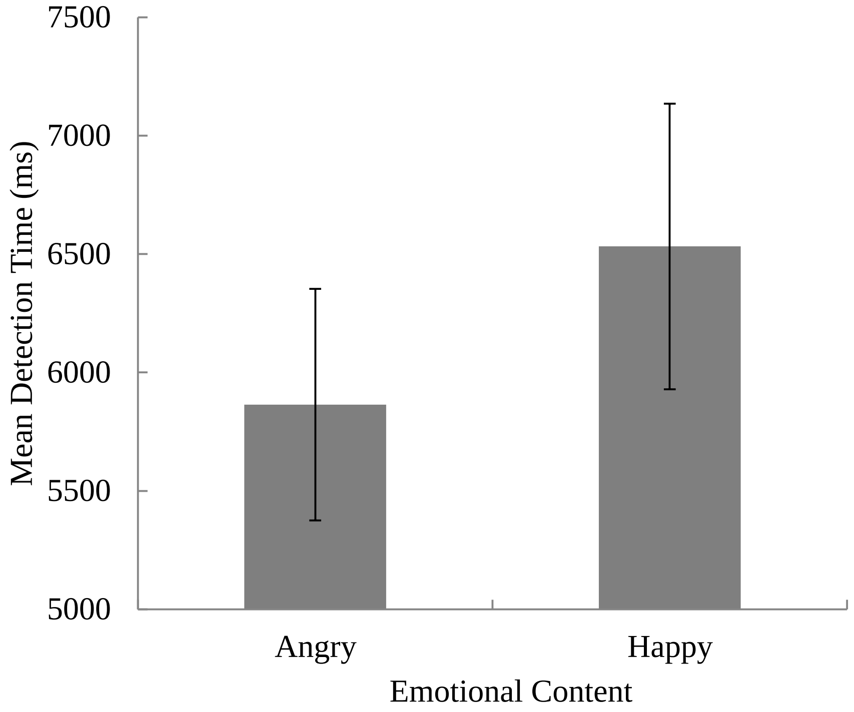

Figure 3.5. Mean (with 95% CI) detection time of the emotional change in the face of the target displayed among neutral crowd by the emotional content.

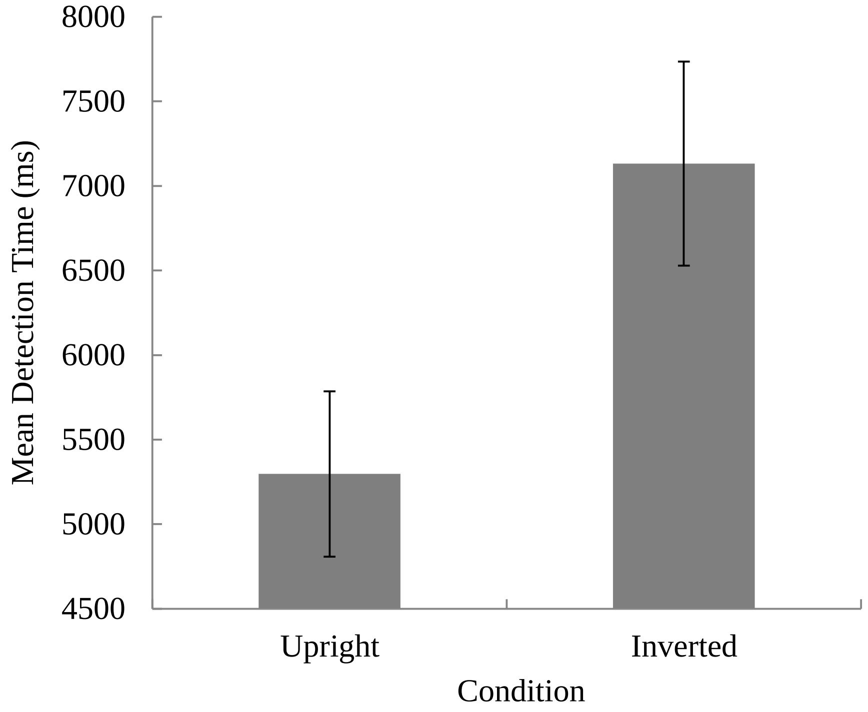

Figure 3.6. Mean (with 95% CI) detection time of the emotional change in the face of the target displayed among neutral crowd by the condition of presentation.

Table 3.1. *The ANOVA Test Statistics of 2x2x2 Mixed Design for Eye-Tracking Scores of Attraction Trials.*

	Entry Time $F(1, 73)$	Dwell Time $F(1, 74)$	Mean Fixation Duration $F(1,76)$	Number of Fixations $F(1, 75)$
Field	59.99*	7.04*	2.86	18.18*
Condition	3.68*	18.72*	.15	19.18*
Emotion	2.58	3.26	.00	3.52
Field x Condition	.03	.00	.77	.85
Field x Emotion	2.52	.95	.30	.50
Emotion x Condition	1.30	.90	.65	1.16
Field x Condition x Emotion	.01	.10	.16	.08

* $p < .05$

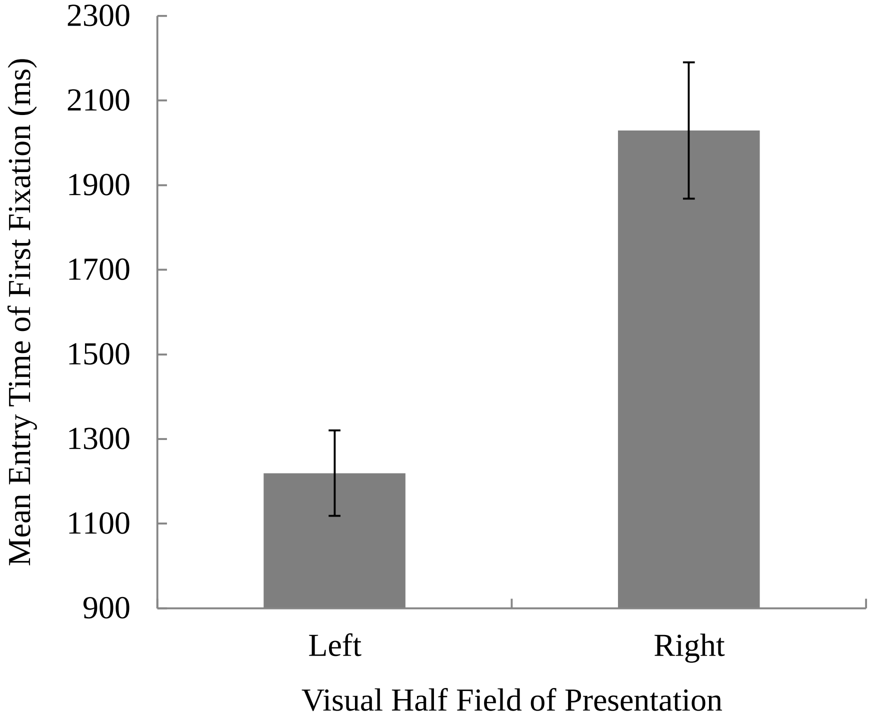

Figure 3.7. Mean (with 95% CI) entry time measures of the first fixation for attraction trials by the visual half field of the presentation.

When the faces were presented upright (M = 1466.24, SE = 48.83), participants looked at the areas of interest earlier, compared to the trials that the faces were presented inverted (M = 1651.94, SE = 65.05), $F(1, 73) = 3.68$, $p < .06$, $\eta^2 = .05$ (Figure 3.8). No significant effect of emotion was observed for entry time. There were no significant interaction between entry scores of field and condition; field and emotion; condition and emotion; and field, condition and emotion.

It can be seen in Figure 3.9 that the total duration of saccades and fixations was significantly higher for the left visual field (M = 2540.08, SE = 83.63) than for the right visual field (M = 2349.55, SE = 79.15), $F(1, 74) = 7.04$, $p < .05$, η^2 = .09. When the faces were presented inverted (M = 2738.70, SE = 104.19), participants looked at the areas of interest longer, compared to the trials that the faces were presented upright (M = 2168.89, SE = 83.36), $F(1, 74) = 18.72$, $p <$ .05, $\eta^2 = .20$ (Figure 3.10). The effect of emotion was not significant for dwell time. There was no significant interaction between dwell time scores of field and condition; field and emotion; condition and emotion; and field, condition and emotion.

The total number of fixations was significantly higher for the left visual field (M = 9.75, SE = .32) than for the right visual field (M = 8.81, SE = .30), $F(1, 75) = 18.18$, $p < .05$, $\eta^2 = .20$ (Figure 3.11). More fixations were observed when the faces were presented inverted (M = 10.45, SE = .40) in comparison to upright presentation (M = 8.22, SE = .34), $F(1, 75) = 19.18$, $p < .05$, $\eta^2 = .20$ (Figure 3.12).

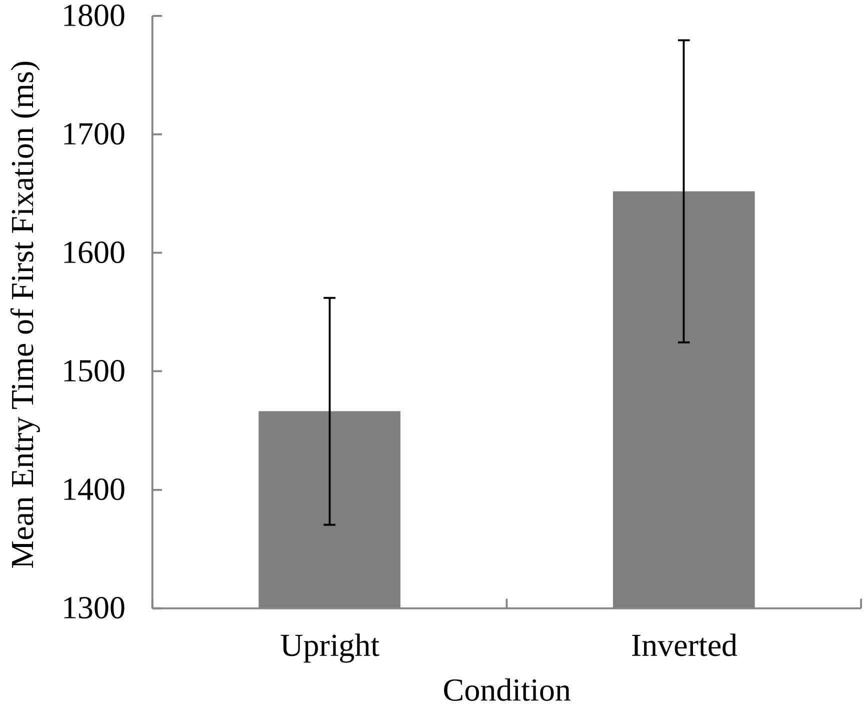

Figure 3.8. Mean (with 95% CI) entry time measures of the first fixation for the attraction trials by the condition of presentation.

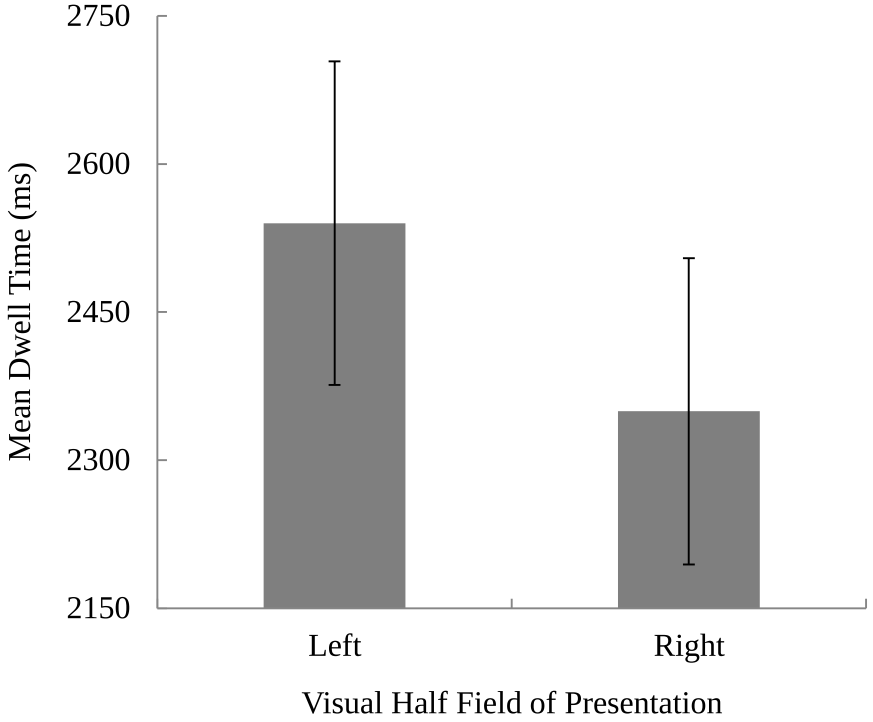

Figure 3.9. Mean (with 95% CI) dwell time measures for attraction trials by the visual half field of the presentation.

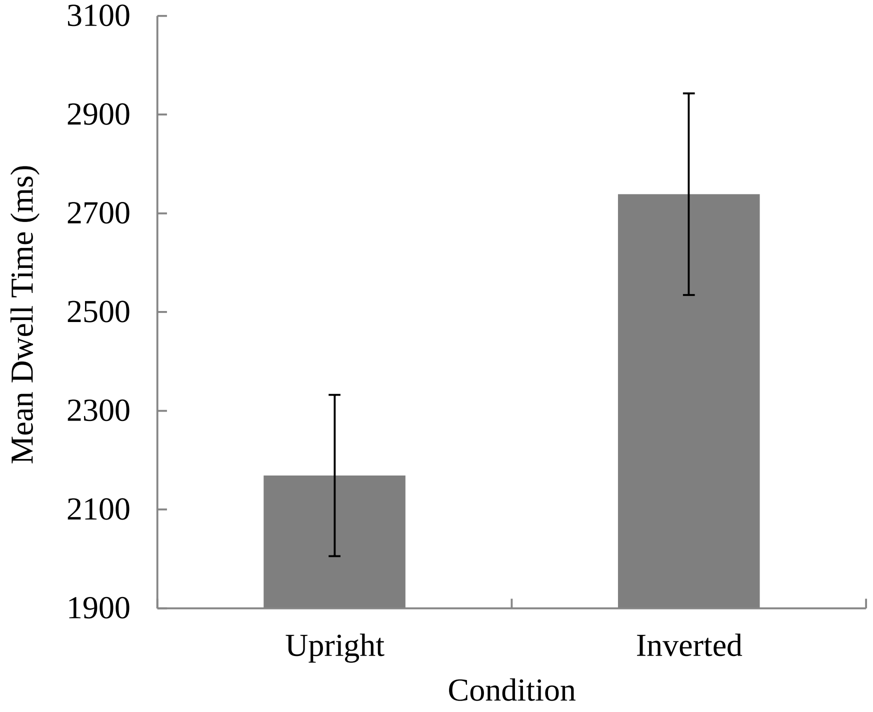

Figure 3.10. Mean (with 95% CI) dwell time measures for the attraction trials by the condition of presentation.

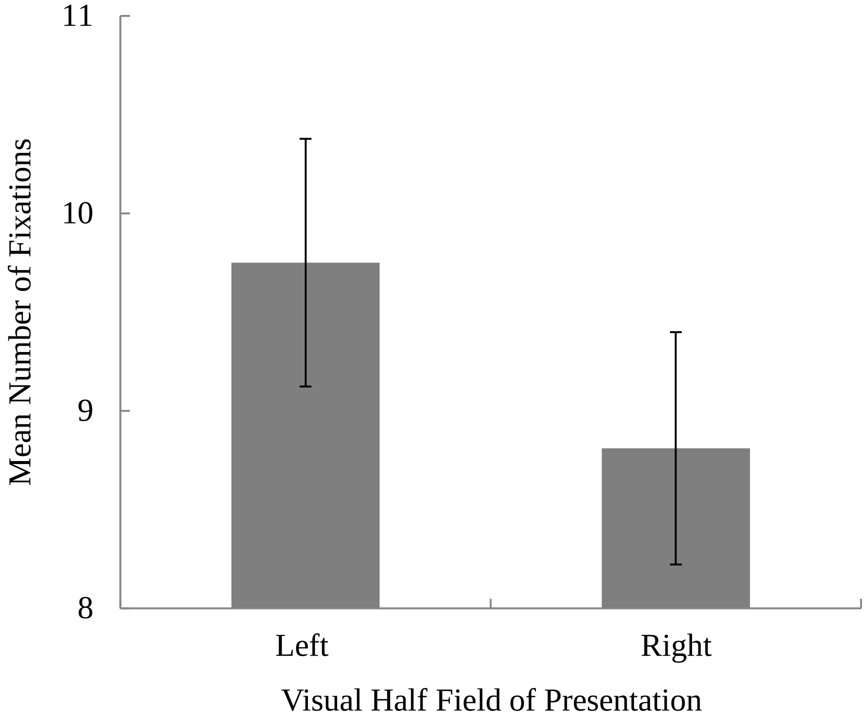

Figure 3.11. Mean (with 95% CI) number of fixations for attraction trials by the visual half field of the presentation.

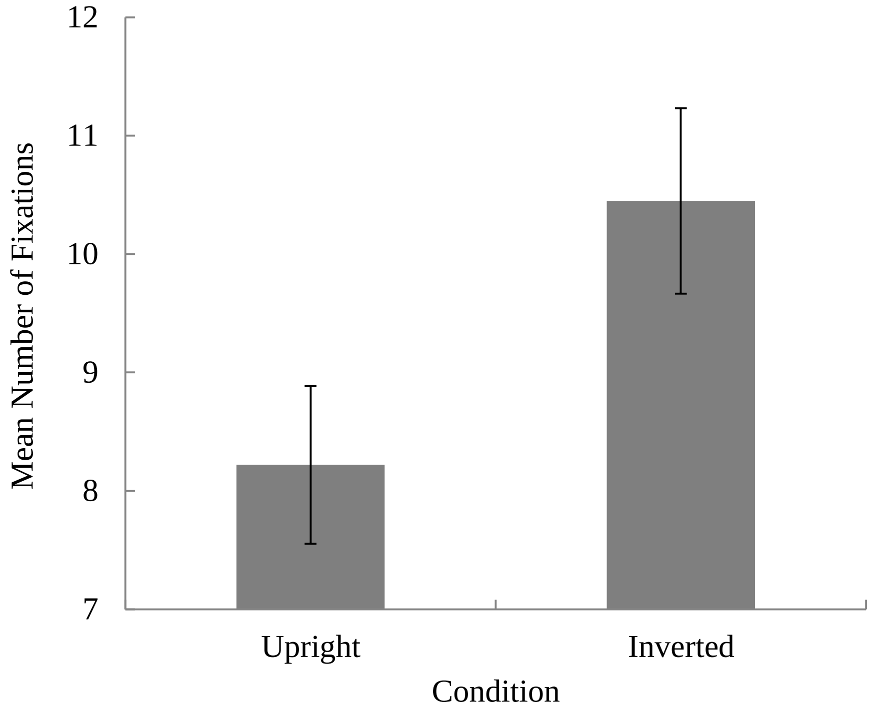

Figure 3.12. Mean (with 95% CI) number of fixations for the attraction trials by the condition of presentation.

No significant effect of emotion was observed for the number of fixations. There were no significant interaction between fixation amounts of field and condition; field and emotion; condition and emotion; and field, condition and emotion.

For the mean fixation duration, the scores were similar across visual halves of field, condition, or emotion. Interactions between mean fixation duration of field and condition; field and emotion; condition and emotion; and field, condition and emotion were not significant.

Distraction Trials. Analysis revealed a significant main effect of visual field of presentation on detection time of changes among emotional crowd, $F(1, 72) = 8.32$, $p < .05$, $\eta^2 = .10$. When presented on the left visual side (M = 111080.27ms, SE = 379.52), the change in target's facial expression was detected faster, compared to the presentations on the right visual field (M = 12323.75, SE = 430.80) (see Figure 3.13). The main effect of emotional content of the distractors on detection time was not significant, $F(1, 72) = .04$, $p > .05$; nor the main effect of condition, $F(1, 72) = .37$, $p > .05$. Interaction effects were not significant for the detection times of field and condition, $F(1, 72) = .57$, $p > .05$; of field and emotion, $F(1, 72) = .01$, $p > .05$; and of field, condition, and emotion, $F(1, 72) = 2.95$, $p > .05$. However, there was a significant interaction between detection scores of condition and emotion, $F(1, 72) = 14.27$, $p < .05$, $\eta^2 = .17$. Follow-up comparisons revealed that when faces were presented upright, detection of target face among angry crowd (M = 12738.99, SE = 730.93) was significantly slower compared to detection of target face among happy crowd (M = 10113.13, SE = 578.93), $t(36) = 2.82$, $p < .05$, $r = .42$.

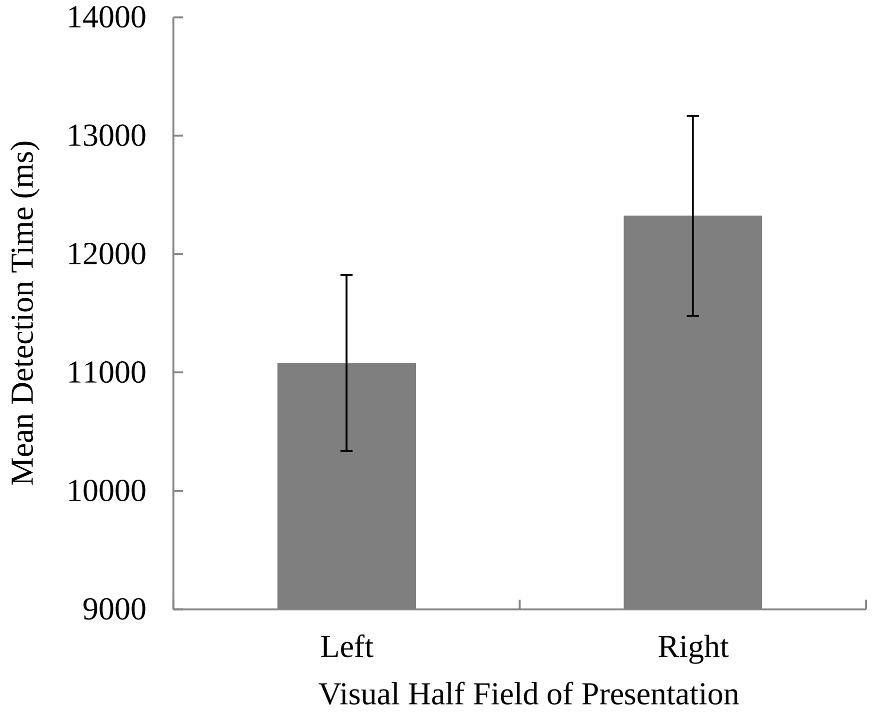

Figure 3.13. Mean (with 95% CI) detection time of the change in the face of the target displayed among emotional crowd by the visual half field of presentation.

On the other hand, when the faces were inverted, detection time of target faces among angry crowd (*M* = 10646.54, *SE* = 549.03) was faster than the detection of target faces among happy crowd (*M* = 13010.57, *SE* = 737.11), $t(34.17) = 2.57$, $p < .05$, $r = .40$ (see Figure 3.14).

Analyses of eye-tracking data provided further findings to evaluate the phenomena. The results for analyses of each dependent variable were represented in the Table 3.2. The entry time of the first fixation was significantly different across visual halves of presentation, $F(1, 72) = 15.33$, $p < .05$, $\eta^2 = .18$, in which participants preferred to look at the left visual field (*M* = 1725.29, *SE* = 80.35) earlier than the right visual field (*M* = 2208.92, *SE* = 801.76) (Figure 3.15). No significant effect of condition was observed for entry time. The effect of emotion on entry time was not significant. There were no significant interaction between entry scores of field and condition; field and emotion; condition and emotion; and field, condition and emotion.

The effect of visual field of presentation was also significant for dwell time, $F(1, 74) = 23.38$, $p < .05$, $\eta^2 = .24$. The total duration of saccades and fixations on the left visual field (*M* = 4560.78, *SE* = 78) was higher than on the right visual field (*M* = 4029.52, *SE* = 146.84) (Figure 3.16). The main effects of condition and emotion on dwell time were not significant. No significant interactions were observed between dwell time scores of field and condition; and field and emotion. On the other hand, the interaction between dwell time scores of condition and emotion was statistically significant, $F(1, 74) = 5.89$, $p < .05$, $\eta^2 = .07$.

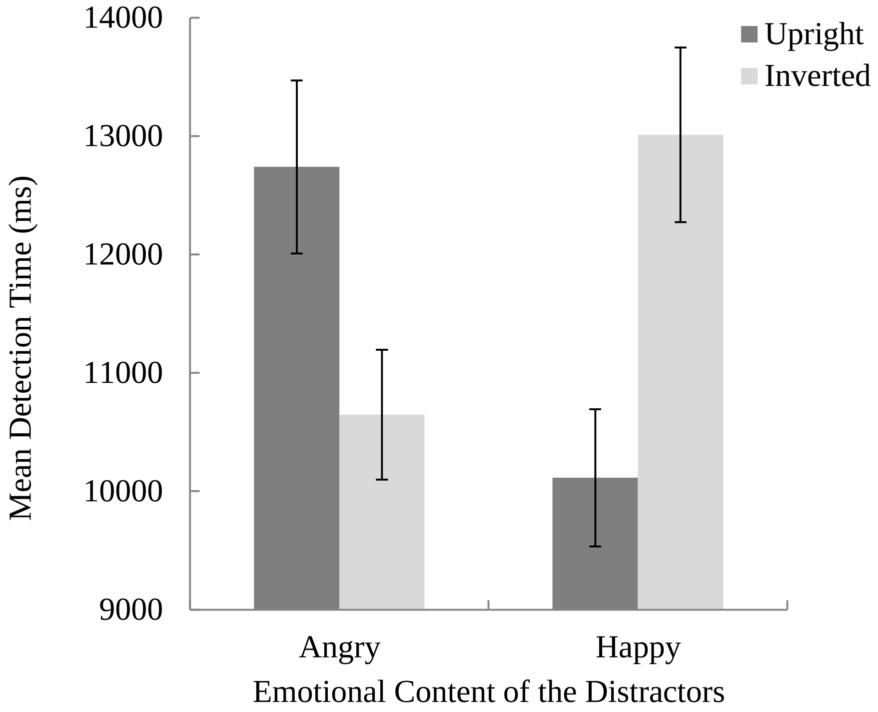

Figure 3.14. Mean (with 95% CI) detection time of the change in the face of the target displayed among emotional crowd by the emotional content of the crowd and by the condition of presentation.

Table 3.2. *The ANOVA Test Statistics of 2x2x2 Mixed Design for Eye-Tracking Scores of Distraction Trials.*

	Entry Time $F(1, 73)$	Dwell Time $F(1, 74)$	Mean Fixation Duration $F(1,76)$	Number of Fixations $F(1, 75)$
Field	15.33*	23.38*	7.03*	20.39*
Condition	1.12	.36	.02	.00
Emotion	.00	1.06	.16	.70
Field x Condition	.09	.31	.54	.02
Field x Emotion	.82	2.46	.03	4.65*
Emotion x Condition	.57	5.89*	.19	1.46
Field x Condition x Emotion	2.55	4.02*	.74	4.65*

* $p < .05$

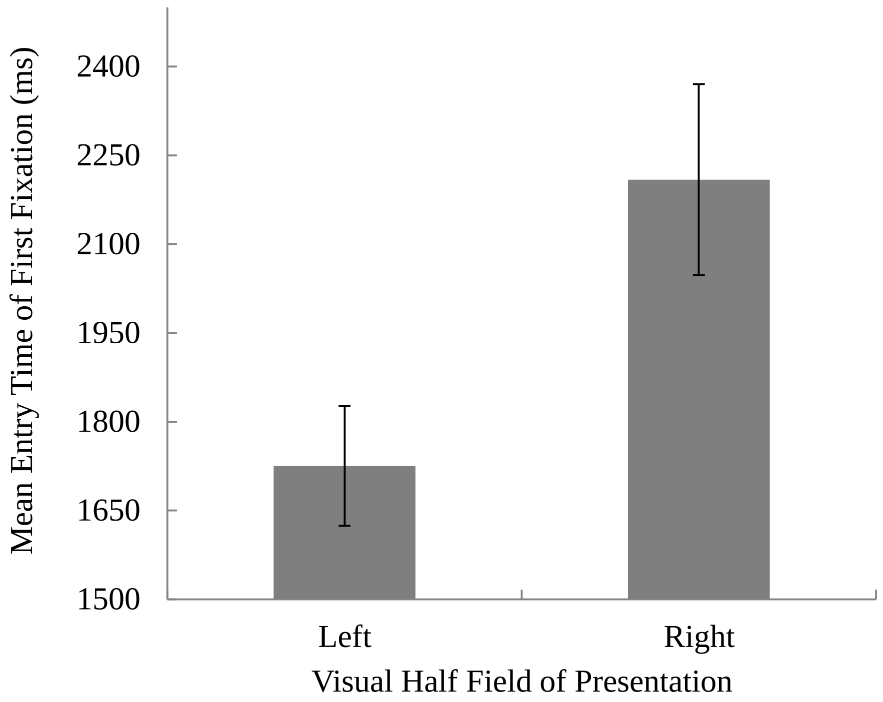

Figure 3.15. Mean (with 95% CI) entry time measures of the first fixation for distraction trials by the visual half field of the presentation.

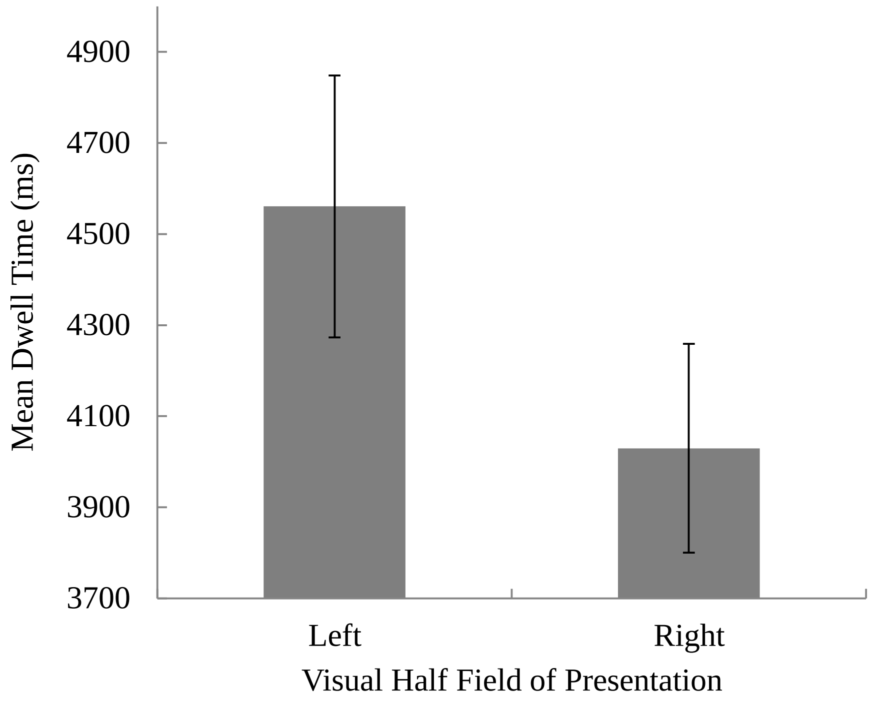

Figure 3.16. Mean (with 95% CI) dwell time measures for distraction trials by the visual half field of the presentation.

Follow-up comparisons revealed that when faces were presented upright, the total duration of saccade and fixations were longer when the neutral target face was changing among angry crowd (*M* = 4782.93, *SE* = 267.31) compared to change of neutral target face among happy crowd (*M* = 3960.47, *SE* = 208.28), $t(38) = 2.43$, $p < .05$, $r = .37$ (Figure 3.17). However when the faces were inverted, the total duration of saccade and fixations in response to the neutral target faces among angry crowd was similar to the neutral target faces among happy crowd, $t(36) = .98$, $p > .05$. There was a significant interaction between field, condition and emotion, $F(1, 74) = 4.02$, $p < .05$, $\eta^2 = .05$. Follow up tests were conducted for upright faces and inverted faces separately. When faces were presented upright (see Figure 3.18), the total duration of saccade and fixations were longer in the left visual half field (*M* = 4654.02, *SE* = 235.71) compared to the right visual half field (*M* = 4064.80, *SE* = 158.23), $F(1, 38) = 12.11$, $p < .05$, $\eta^2 = .24$. Moreover, when the neutral target face was changing among angry crowd (*M* = 4782.93, *SE* = 267.31), longer dwell time was observed, compared to the change of neutral target face among happy crowd (*M* = 3960.47, *SE* = 208.28), $F(1, 38) = 5.68$, $p < .05$, $\eta^2 = .13$. The interaction between dwell time scores of field and emotion was also significant for upright faces, $F(1, 38) = 5.38$, $p < .05$, $\eta^2 = .12$. When the faces were presented on the left visual side, the dwell time for the neutral target faces among angry crowd (*M* = 5254.31, *SE* = 355.51) was longer than for the neutral target faces among happy crowd (*M* = 4053.72, *SE* = 252.52), $t(38) = 2.75$, $p < .05$, $r = .41$. When the faces were presented on the right visual side, the dwell time for the neutral target faces among angry crowd and for the neutral target faces among happy crowd were similar, $t(38) = 1.34$, $p > .05$.

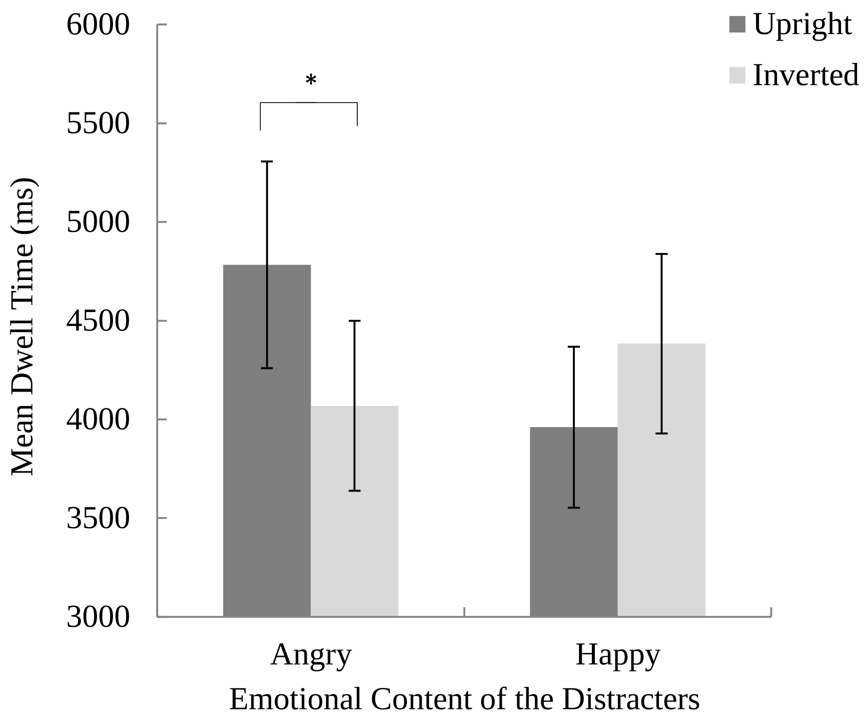

Figure 3.17. Mean (with 95% CI) dwell time measures for the emotional content of the crowd by the condition of presentation. (* $p < .05$)

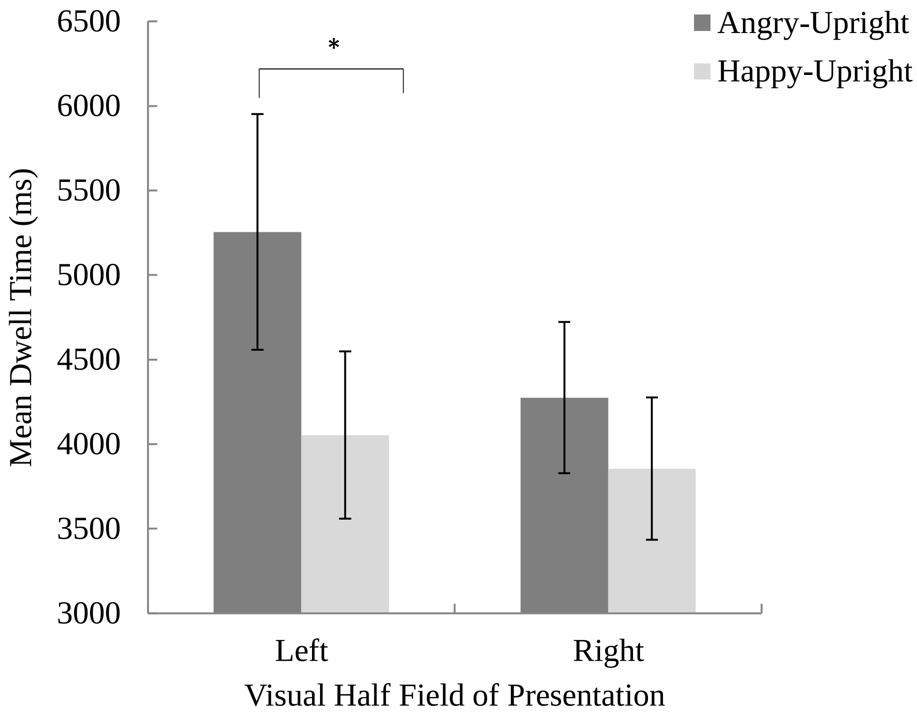

Figure 3.18. Mean (with 95% CI) dwell time measures for each the emotional content of the crowd and by the visual field, while presentation of stimuli was upright. (* $p < .05$)

When faces were presented inverted (see Figure 3.19), the total duration of saccade and fixations were longer in the left visual half field (*M* = 4462.63, *SE* = 173.09) compared to the right visual half field (*M* = 3992.38, *SE* = 175.26), $F(1, 36) = 11.83$, $p < .05$, $\eta^2 = .25$. The effect of emotion on dwell time was not significant, $F(1, 36) = 1.04$, $p > .05$. No significant interaction was observed between dwell time scores of field and emotion, $F(1, 36) = .12$, $p > .05$.

Consistent with the dwell time scores, the total number of fixations was significantly higher for the left visual field (*M* = 17.64, *SE* = .58) than for the right visual field (*M* = 16.05, *SE* = .49), $F(1, 75) = 20.39$, $p < .05$, $\eta^2 = .21$ (Figure 3.20). The main effects of condition and emotion on number of fixations were not significant. The interaction between field and condition was not significant in terms of their number of fixations. Although there was a significant interaction between number of fixation scores of field and emotion, $F(1, 75) = 4.65$, $p < .05$, $\eta^2 = .06$, follow up tests indicated no significant difference between fixation scores in response to the neutral target faces among angry crowd and to the neutral target faces among happy crowd, neither for the left visual field presentations, $t(77) = 1.42$, $p > .05$, nor for the right visual field presentations, $t(77) = .09$, $p > .05$. Another significant interaction was observed between fixation amounts of condition and emotion, $F(1, 75) = 4.65$, $p < .05$, $\eta^2 = .06$. When the faces were presented upright, more fixations were observed in response to the neutral target faces among angry crowd (*M* = 18.39, *SE* = .87) in comparison to the neutral target faces among happy crowd (*M* = 8.22, *SE* = .34), $t(38) = 2.46$, $p < .05$, $r = .37$ (Figure 3.21).

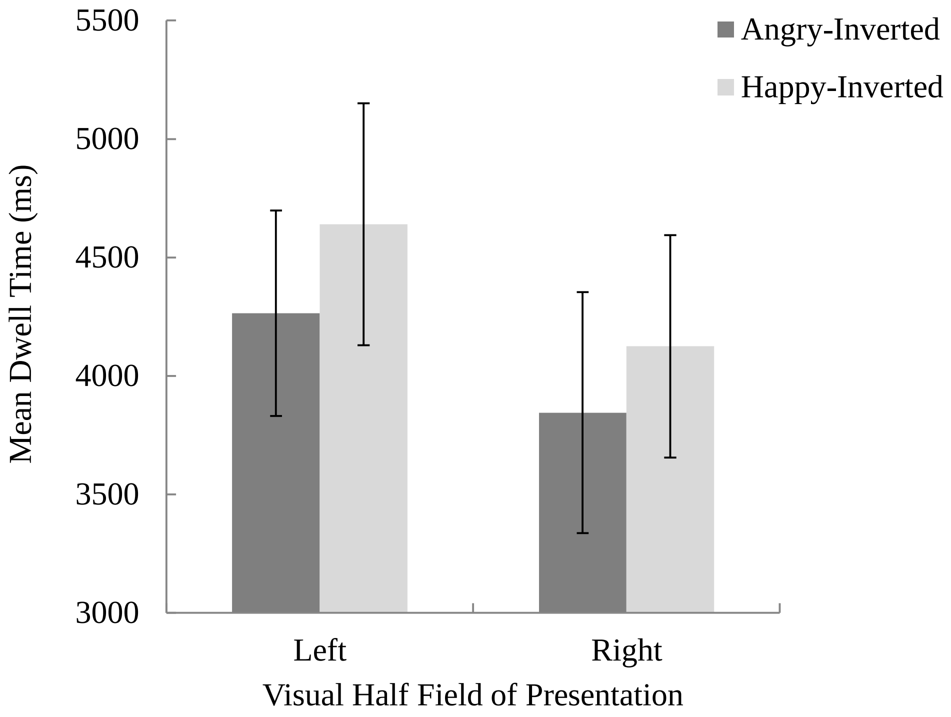

Figure 3.19. Mean (with 95% CI) dwell time measures for each the emotional content of the crowd and by the visual field, while presentation of stimuli was inverted.

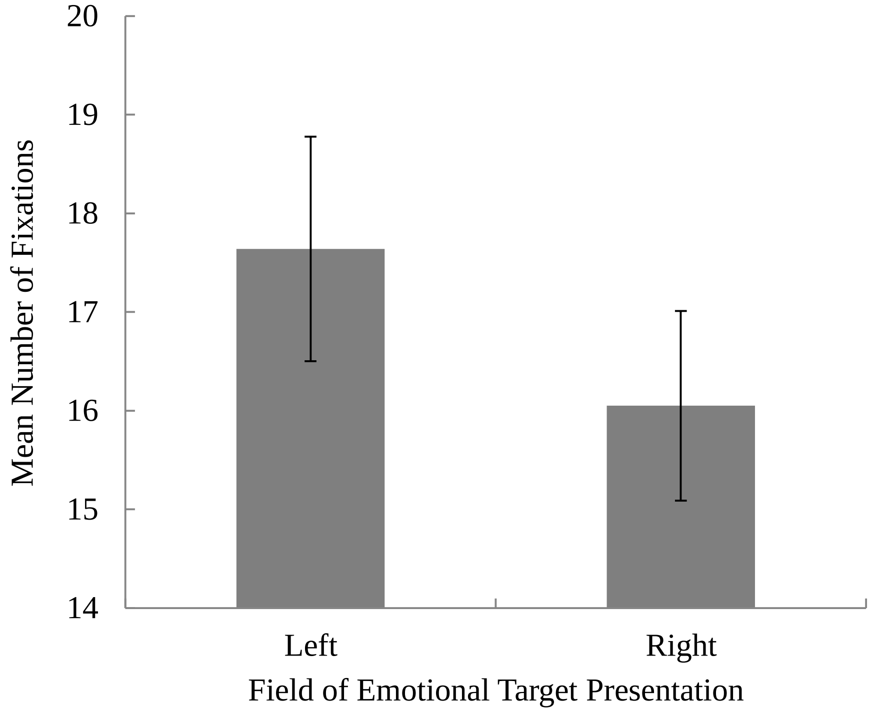

Figure 3.20. Mean (with 95% CI) number of fixations for distraction trials by the visual half field of the presentation.

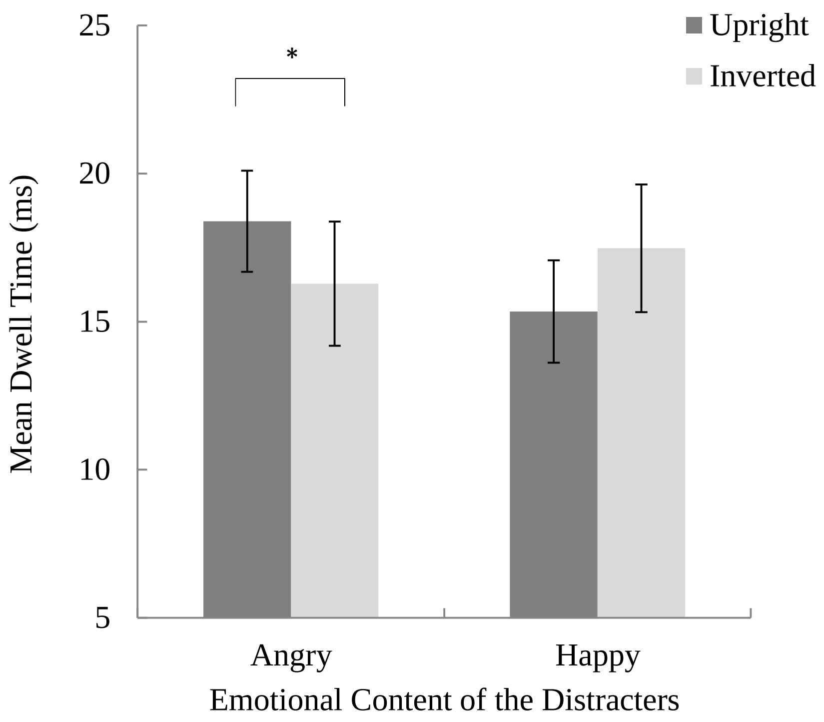

Figure 3.21. Mean (with 95% CI) number of fixations for the emotional content of the crowd by the condition of presentation. (* $p < .05$)

No emotional differences was observed in total number of fixation when the faces were presented inverted, $t(37) = .77$, $p > .05$. There was no significant interaction between fixation amounts of field, condition and emotion.

For the mean fixation duration, scores were different across visual halves of field, $F(1, 76) = 7.03$, $p < .05$, $\eta^2 = .09$, in which the mean fixation duration was longer in the left visual field ($M = 224.60$, $SE = 4.71$) in comparison to the right visual field ($M = 217.39$, $SE = 4.15$) (Figure 3.22). No significant effects of condition or emotion on mean fixation duration were observed. Interactions between mean fixation duration of field and condition; field and emotion; condition and emotion; and field, condition and emotion were not significant.

Discussion

In the current study, flicker paradigm was adopted to initialize a *finding the face in the crowd* task to investigate the differentiation in the detection of changes in crowd of faces across visual halves of field that the change appeared. In Experiment I, crowd of faces manifested two distinct effects on detection time: When presented among neutral crowds, angry target faces attracted more attention, and when presented as crowd, angry faces distracted the detection of neutral target faces more. In regard to these findings, two sets of trials were generated: Trials that aimed to measure attraction effect and trials that aimed to measure distraction effect. In attraction trials, the crowd was neutral, and the expression of the target face changed from neutral into an emotional content (i.e. anger or happiness), while the rest stayed neutral.

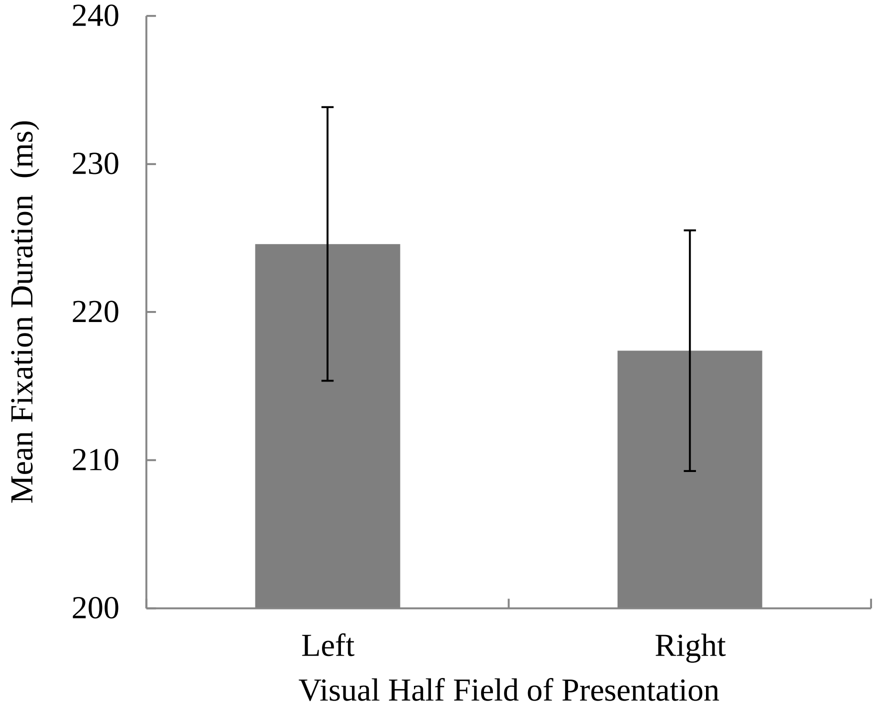

Figure 3.22. Mean (with 95% CI) fixation duration for distraction trials by the visual half field of the presentation.

On the other hand, the distraction trials consisted of emotional crowds (i.e. angry or happy), and the expression of the target face changed from emotional into a neutral content, while the rest stayed emotional. Therefore, results were evaluated on the basis of attraction and distraction effects.

One of the prominent findings obtained from flicker version of “finding the face in the crowd” task was the support for anger superiority effect for both attentional capture and attentional hold. In the attraction trials, it was observed that the detection was faster when the expression of the neutral target face changed into an angry expression, regardless of the visual field of presentation. In the endeavor of investigating the distraction effect, a negative favoring attentional hold were evident when the faces were presented upright. People spend more time to detect the change of the expression of the target face changed from the angry into a neutral content, in a crowd of angry faces. Moreover, total duration of fixations and saccades was longer for the trials when the target face changed from angry into neutral expression, only when the faces were presented upright. These findings suggest that the emotional system might have a role in attentional capture of threatening changes in the facial expression, and in attentional hold of threatening faces that distracted the detection of change.

In regard to the examination of a visual field bias during the detection of changes in the expression of faces, behavioral and eye tracking data implied a left visual field bias for both attraction and distraction trials, in which the changes were detected faster in the left visual field. It should be mentioned, however, that people preferred to start searching for change from the left visual field, as the occurrence of the first fixation was faster in the left area of interest.

It could be argued that the faster detection of change in the left visual side might be related to the preference to start searching for the change from the left visual side. It was also observed that the number of fixations and the total duration of fixations and saccades were higher for left visual side. The left visual field bias prevailed regardless of the behavioral effect under investigation, and asserted right hemisphere hypothesis for the processing of changes in emotional expression of facial stimuli. On the other hand, the pattern of eye-movements was similar for upright and inverted presentations, suggesting that the observed left visual field bias might be independent of the emotional content of the target or crowd. Altogether, it was reasonable to assume that early beginning and higher amount of eye movements in the left visual side might be resulted in faster detection of changes.

CHAPTER 5

CONCLUSION

The present study aimed to investigate the underlying cognitive and emotional mechanisms of visual search for emotional facial stimuli. Three main experiments were conducted to examine the effects of emotional content conveyed by the faces. Classical *finding the face in the crowd* task was applied as the heading experiment with the efforts for compensating the shortcomings of previous studies: Multiple identities were used as discrepant target faces and distractors to increase ecological validity; facial stimuli were similar in perceptibility and expressiveness across emotional expressions; low-level visual confounds were attenuated; neutral faces were used as distractors while comparing the effects of valence bare by target faces and as discrepant target faces while comparing the effects of valence bare by distractor faces. It has been reported that anger superiority effect is enhanced with high levels of anxiety (Ashwin et al., 2012; Matsumoto, 2010). Anxiety is also found associated with lateralization for facial emotion processing (Bourne and Vladeanu, 2011).

Therefore, the anxiety level of the participants has been assessed and only the ones whose anxiety scores were below the maximum of mild level have been recruited in the experiments. After the investigation of performance asymmetries for the visual search for faces with threatening and friendly expressions, the existence of hemispheric bias, which contributed the search performance, was examined.

As hemispheric specialization is demonstrated repeatedly for processing of facial expressions, similar mechanisms were hypothesized to be involved in the detection of facial expressions. Visual search method for detecting emotional faces was assumed as an ecologically valid tool for investigating the existence of a visual field bias that the detection of emotional faces is superior; because visual search performance closely reflects everyday searching experiences of individuals. In addition, by comparing the search performance for faces with distinct affective content, one could provide support for the present hypotheses on processing of facial emotions. In this regard, visual search task paradigm was combined with divided visual field methodology to investigate hemispheric bias in the processing. The divided visual field methodology provides opportunity to project visual input to one hemisphere that is unilateral left visual field presentations are projected to the right hemisphere, and vice versa. The results were evaluated on the basis of the Right Hemisphere hypothesis and the Valence-Specific hypothesis. As the second experiment, visual search task was combined with the divided visual field methodology to investigate whether the detection advantage or distraction would differentiate across fields of presentation and across specific facial expressions.

For example, one could find evidence for the Right Hemisphere hypothesis, if the search for emotional discrepant faces has been more efficient in the left visual field, regardless of the valence of the facial expression. On the other hand, finding that the lateralization of processing has differed for negative and positive emotional expressions, in which the happy discrepant faces have been detected faster in the right visual field, whereas the angry discrepant faces have been detected faster in the left visual field, it would be a support for the Valence-Specific hypothesis.

The involvement of emotional system in the detection of threatening changes in the visual environment. Monitoring for and rapidly detecting the presence and motion of animate objects, which would be signaled by visual change, is crucial for human survival, especially when the change signals potential threat, such as an approaching predator. Indeed, it was observed that changes in neutral facial expression into the angry expression has been detected faster, when the model was male and probably perceived as more threatening, or have more potential for committing violence (Amado et al., 2011). The existence of hemispheric asymmetries in emotion processing has been demonstrated in many studies; however the question of whether the detection of changes in the facial emotion would be asymmetric on the left and right visual fields has been yet unanswered. In the final experiment, the integration of visual search task and flicker paradigm was conducted. Flicker paradigm consisted of repeated presentations of an original image and a modified image alternately, with brief blank screens following each image.

The presentation of blank screen attenuates the motion signal, eliminates low-level cues that attract attention to the location of change, and assures that the detection of change will depend on focal attention to objects in the display. With the flicker version of *finding the face in the crowd* task, it was aimed to examine the involvement of emotional system in the detection of changes across specific emotional content of faces and across distinct visual fields of presentation. As a result of the stated experiment, one could find support for the Right Hemisphere hypothesis if the detection of change of the facial expression would be faster in the left visual field, regardless of the valence of the facial expression; whereas the faster detection of change from neutral into the angry expression on the left visual field, while the faster detection of change from neutral into the happy expression on the right visual field might indicate processing in line with the Valence-Specific hypothesis.

When the shortcomings of previous visual search studies discussed above were compensated, anger superiority effect was observed during the visual search for emotional faces and visual search among emotional faces. Angry faces were detected faster than happy faces, and held attention more than happy faces, suggesting that the emotional system might enhance the processing for threat-related stimuli. The involvement of attentional processes was examined by eye-movement patterns. Early attentional capture for angry faces was evident as the timing of first fixation was faster for angry faces than happy faces. However, post-attentive processing was similar for the discrepant emotional targets. These findings connoted the preattentive processing that took part and guided attention to the threat-related stimuli.

Longer attentional hold for angry faces revealed itself in the search for discrepant neutral faces displayed among emotional distractor faces as longer duration and occurrence of eye-movements for angry distractor faces and latency of the first fixation to the discrepant neutral faces among angry rather than happy distractors faces. Post-attentive processing for discrepant neutral faces was similar regardless of the distractor valence. It should be mentioned, however, that the assessment for post-attentive processing (i.e. the time difference between the first fixation to the target face and response time) might not reflect the measurement, which it supposed to compute. Response time might not represent the end of post-attentive processing, or the first fixation might not represent the start. Moreover, the involvement of preattentive and post-attentive processing in visual search for real emotional faces should be examined by using different set sizes in the future studies. The comparison of search slopes will provide further insights on attentional processing.

Integration of visual search paradigm with divided visual field methodology indicated that visual search for/among emotional faces was lateralized to the right hemisphere. Results suggested that the detection of discrepant emotional faces was faster when presented to the right hemisphere, regardless of the valence. Moreover, the distraction effect of crowd of emotional faces was more powerful on the left visual field. Altogether, results supported the Right Hemisphere hypothesis. On the other hand, low levels of accurate responses indicated that the visual search was complex and compelling task when combined with the divided visual field paradigm. Thus, Valence-Specific hypothesis was not subjected to complete rejection with the findings from this experiment.

Replicating the experiment with simple schematic facial stimuli may provide more accurate responses and more conclusive results; on the other hand, still suffers from problems of ecological validity and distractor homogeneity. Thus, reducing the set size of faces may be ecologically valid solution for simplification of the task. It could be speculated that using set size of two might not be a representative of “crowd”; on the other hand, one can find studies in the literature that implemented search tasks with the set size of two (e.g. Becker et al., 2011).

Further support for the anger superiority effect for both attentional capture and attentional hold was observed in the final experiment. Detection was faster when the expression of the neutral target face changed into an angry expression in comparison to the changes into a happy expression; but slower when the target face changed from angry into the neutral content, compared to the changes from happy into the neutral content. Total duration of fixations and saccades was longer for the trials when the target face changed from angry into neutral expression, in comparison to the trials that the faces changed from happy to the neutral content. Altogether, the findings supported the notion that emotional system might have a role in attentional capture and hold of threatening changes in the facial expression. In the endeavor of investigating a visual search bias in the detection of changes, behavioral data and eye-movement patterns were evaluated. Results suggested a left visual field bias for attraction and distraction trials, as the change was detected in the left visual field faster, without recourse to the emotional content of target or crowd.

These findings seemed to support the Right Hemisphere hypothesis, and were consisted with the previous studies in the literature that provide evidence for the role of right hemisphere during the detection of changes (Beck et al., 2005; Beck et al., 2001; Iyilikci et al., 2011; Spotorno and Faure, 2011). However, the left visual field was preferred to start searching, and received more fixations and longer dwell time. Therefore, it was reasonable to assume that the early beginning and higher amount of eye movements in the left visual side might be resulted in faster detection of changes, rather than the involvement of emotional system. Indeed, the pattern of eye-movements observed for upright and inverted presentations promoted the assumption. For both upright and inverted presentations of faces, people preferred to start search from the left visual side, looked and fixated on the left visual side more, and as a result, detected the change faster on the left visual side. Thus, the observed left visual field bias might be independent of the emotional processing of emotional faces. To test this assumption, the task may be conducted with the participants who would prefer to start searching from the right visual field. The right visual field preference, or search strategy, may be observed naturally for people whose native language has the writing system of right-to-left direction (e.g. Hebrew or Arabic), or may be produced in the laboratory settings with training. In all conditions, if the right visual field preference to start searching result in faster detection of changes in the right visual side, then it may be concluded that the observed left visual field bias is independent of the emotional processing of emotional faces.

In contrast, if one will find evidence of faster detection of changes in the left visual field, despite the preference of starting searching from the right visual field, it may provide further evidence for the involvement of emotional system and support the Right Hemisphere hypothesis.

Taken together, in the current thesis, angry superiority effect was observed for attentional capture and attentional allocation with an indication of preattentive guidance of attention to the threatening facial expression. Similar results were observed during the detection of changes in the facial expressions of individuals. In this regard, the current thesis performed its service in the pursuance of investigating the attentional processing during visual search for emotional faces. By preventing the previous shortcomings and limitations of previous studies, varying the set size and comparisons of search slopes calculated for specific categories of emotional targets should be the course of action for the future studies of visual search for emotional faces. Investigations for other variables that may have a moderating influence on the performance, such as the gender of the model and the gender of the observers, should be regarded to explain the phenomena more comprehensively.

The examination of hemispheric lateralization and visual field biases is on the way of fruition, but not conclusive. Regardless of the emotional valence, in the left visual field, visual search for emotional faces was more efficient and visual search among emotional faces was more distractive. Further studies that demand simpler and easier visual search performance may provide more conclusive perspectives to understand the underlying emotional and cognitive mechanisms for processing and search of emotional facial stimuli.

In regard to the visual field bias observed during the detection for the changes in facial expressions, one should eliminate, or control, the possibility that the observed left visual field bias is a result of preference of searching for changes from the left visual side. Further studies may manipulate the preference of field to start searching for changes.

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APPENDIX A

Informed consent form that was used in the Experiment I.

İZMİR EKONOMİ ÜNİVERSİTESİ PSİKOLOJİ LABORATUVARI
KATILIMCI BİLGİLENDİRME FORMU

Değerli Katılımcı,

Bu çalışma, Araş. Gör. Buket Kara tarafından deneysel psikoloji yüksek lisans tezi kapsamında yürütülmektedir.

Çalışma boyunca, farklı bireylere ait nötr, öfkeli ya da mutlu yüzler bilgisayar ekranında sunulacak; katılımcılardan, ekrandaki yüzlerdeki duygu ifadelerinin aynı mı yoksa farklı mı olduğunu belirlemeleri istenecektir. Yüzler ekranda dört saniye boyunca görüntülenecektir. Bu süre zarfında yanıt verilmeyen denemeler geçersiz sayılacaktır. Bununla birlikte, mümkün olduğunca hızlı karar ve yanıt vermek, araştırmanın hipotezleri bakımından değerlidir.

Deney sonucunda elde edilecek katılımcı yanıtları toplu olarak analiz edilecek, kişisel bilgiler gizli tutulacaktır.

Deneye katılım gönüllülük esasına dayanmaktadır. Katılımcılar, deney öncesinde ya da deney sırasında, istedikleri takdirde deneyden ayrılma hakkına sahiptir. Böylesi bir durumda, katılımcıdan toplanmış veri iptal edilecektir.

Yukarıdaki bilgileri okudum ve deney hakkında bilgilendirildim. Sorularım araştırmacı tarafından açık bir biçimde yanıtlandı. Deneye katılmayı kabul ediyorum.

Ad- Soyad:

İmza:

Tarih:

Katılımcıya gerekli bilgiler aktarılmış, katılımcının soruları tarafımca cevaplanmıştır.

Buket Kara

APPENDIX B

Questionnaire and inventories that applied before experimental sessions.

İZMİR EKONOMİ ÜNİVERSİTESİ PSİKOLOJİ LABORATUVARI

KATILIMCI BİLGİ FORMU

CİNSİYET: .....

YAŞ: .....

BÖLÜM/ SINIF: .... / ......

Lütfen aşağıdaki soruları, durumunuzu en iyi yansıtan seçeneği işaretleyerek ve boşlukları doldurarak yanıtlayınız.

1. Yakın zamanda (son bir sene dahil) başka bir psikoloji deneyine katıldınız mı?
    - Evet, ... hafta/ay/yıl önce .... içerikli bir çalışmaya katıldım
    - Hayır
2. Herhangi bir psikolojik rahatsızlık geçirdiniz mi?
    - Evet (3. sorudan devam ediniz)
    - Hayır (5. sorudan devam ediniz)
3. Bir uzman tarafından rahatsızlığınıza tanı koyuldu mu?
    - Evet, ... hafta/ay/yıl önce .... tanısı koyuldu
    - Hayır
4. Rahatsızlığınızla ilgili kullandığınız ilaçlar var mı?
    - Evet, ... isimli ilaç(lar)ı kullandım/ kullanmaktayım
    - Hayır
5. Herhangi bir nörolojik rahatsızlık geçirdiniz mi?
    - Evet (6. sorudan devam ediniz)
    - Hayır (8. sorudan devam ediniz)
6. Bir uzman tarafından rahatsızlığınıza tanı koyuldu mu?
    - Evet, ... hafta/ay/yıl önce .... tanısı koyuldu
    - Hayır
7. Rahatsızlığınızla ilgili kullandığınız ilaçlar var mı?
    - Evet, ... isimli ilaç(lar)ı kullandım/ kullanmaktayım
    - Hayır
8. Düzenli olarak kullanmakta olduğunuz ilaçlar var mı?
    - Evet, ...isimli ilaç(lar)ı .... amacıyla kullanıyorum
    - Hayır

Questionnaire and inventories that applied before experimental sessions (cont.).

9. Herhangi bir görme bozukluğunuz var mı?

 Evet:

O Miyop Derece: .... Sol göz / .... Sağ göz

O Hipermetrop Derece: .... Sol göz / .... Sağ göz

O Astigmat Derece: .... Sol göz / .... Sağ göz

O Diğer ....

 Hayır (Edinburgh El Kullanım Envanteri'nden devam ediniz)

10. Aşağıdaki seçeneklerden hangisi sizin için uygun:

 Gözlük kullanıyorum

 Lens kullanıyorum

 Gözlük ya da lens kullanmıyorum

Edinburgh El Kullanım Envanteri

Lütfen aşağıda sayılan aktiviteler sırasında el kullanım tercihinizi ilgili kutunun içine işaret koyarak belirtiniz. Söz konusu aktivite sırasında her zaman tek elinizi kullanıyorsanız, o ele ait kutuya iki tane işaret koyunuz. Eğer söz konusu aktivite için iki elinizi birden ayırt edilemez biçimde kullanıyorsanız, iki kutuya birden birer işaret koyunuz.

	Sol El	Sağ El
Yazma		
Çizim yapma		
(Bir şey) fırlatma		
Makas kullanma		
Diş fırçası kullanma		
(Bıçak olmadan) çatal kullanma		
Kaşık kullanma		
Süpürge tutarken üstte olan el		
Kibrit çakma		
Kutu açma		

Puan: Sonuç:

Questionnaire and inventories that applied before experimental sessions (cont.).

<u>Beck Kaygı Envanteri</u>

Aşağıdaki belirtileri bugün de dahil olmak üzere son bir hafta içinde ne ölçüde yaşadığınızı göz önünde bulundurarak yanıt veriniz.

	Hiç	Hafif	Orta	Ağır
Bedeninizin herhangi bir yerinde uyuşma/karıncalanma				
Sıcak/ ateş basmaları				
Bacaklarda halsizlik, titreme				
Gevşeyememe				
Çok kötü şeyler olacak korkusu				
Baş dönmesi/ sersemlik hissi				
Kalp çarpıntısı				
Dengeyi kaybetme korkusu				
Dehşete kapılma				
Sinirlilik				
Boğuluyormuş gibi olma duygusu				
Ellerde titreme				
Titreklik				
Kontrolü kaybetme korkusu				
Nefes almada güçlük				
Ölüm korkusu				
Korkuya kapılma				
Midede hazımsızlık/ rahatsızlık hissi				
Baygınlık				
Yüz kızarması				
Terleme (sıcağa bağlı olmayan)				

Puan: Sonuç:

Questionnaire and inventories that applied before experimental sessions (cont.).

<u>Bu kısım araştırmacı tarafından doldurulacaktır</u>

Araştırmacının notları:

- Sözlü yönerge tam olarak aktarıldı:
  - ☐ Görecekleri yüz ifadeleri
  - ☐ "+" işaretine odaklanmaları gerektiği
  - ☐ Görevlerinin ne olduğu
  - ☐ Doğru ve hızlı cevap vermenin önemi

- Deney sırasında:
  - ☐ Katılımcı yönergeleri takip etti
  - ☐ Datanın geçerliğini tehlikeye atacak hareketlerden kaçındı

Deney sonrası katılımcı yorumu:

- Yorgunluk:

- Dikkat dağınıklığı:

- Refleks hataları:

- Sunum Hızı:

- Diğer:

APPENDIX C

A sample of informed consent form that was used in Experiment II.

İZMİR EKONOMİ ÜNİVERSİTESİ PSİKOLOJİ LABORATUVARI
KATILIMCI BİLGİLENDİRME FORMU

Değerli Katılımcı,

Bu çalışma, Araş. Gör. Buket Kara tarafından deneysel psikoloji yüksek lisans tezi kapsamında yürütülmektedir.

Çalışma boyunca, farklı bireylere ait nötr, öfkeli ya da mutlu yüzler bilgisayar ekranında sunulacak; katılımcılardan, ekrandaki yüzlerdeki duygu ifadelerinin aynı mı yoksa farklı mı olduğunu belirlemeleri istenecektir. Yüzler ekranda 180 milisaniye boyunca görüntülenecektir. Mümkün olduğunca hızlı karar ve yanıt vermek, araştırmanın hipotezleri bakımından değerlidir.

Deney sonucunda elde edilecek katılımcı yanıtları toplu olarak analiz edilecek, kişisel bilgiler gizli tutulacaktır.

Deneye katılım gönüllülük esasına dayanmaktadır. Katılımcılar, deney öncesinde ya da deney sırasında, istedikleri takdirde deneyden ayrılma hakkına sahiptir. Böylesi bir durumda, katılımcıdan toplanmış veri iptal edilecektir.

Yukarıdaki bilgileri okudum ve deney hakkında bilgilendirildim. Sorularım araştırmacı tarafından açık bir biçimde yanıtlandı. Deneye katılmayı kabul ediyorum.

Ad- Soyad:

İmza:

Tarih:

Katılımcıya gerekli bilgiler aktarılmış, katılımcının soruları tarafımca cevaplanmıştır.

Buket Kara

APPENDIX D

Percentage of errors of each participant across conditions.†

Participant No	Condition	Emotional Crowd	Neutral Crowd	Emotional Target	Neutral Target
1	Angry	42	17	50	42
2	Angry	33	8	83	42
3	Angry	17	33	67	58
4	Angry	17	8	17	33
5	Angry	42	75	25	50
6	Angry	58	8	42	100
7	Angry	100	17	67	58
8	Angry	75	75	17	0
9	Angry	50	33	42	33
10	Angry	67	92	8	17
11	Angry	92	50	33	8
12	Angry	50	0	33	33
13	Angry	42	33	42	58
14	Angry	42	17	33	17
15	Angry	67	33	50	33
16	Angry	25	33	33	33
17	Happy	8	25	33	67
18	Happy	58	42	58	25
19	Happy	0	8	75	58
20	Happy	8	8	83	67
21	Happy	100	42	25	33
22	Happy	75	83	8	17
23	Happy	17	33	58	50
24	Happy	50	8	42	50
25	Happy	67	17	50	0
26	Happy	17	67	33	58
27	Happy	50	33	42	33
28	Happy	42	33	33	50
29	Happy	42	8	25	50
30	Happy	83	50	25	0
31	Happy	0	75	8	100
32	Happy	50	33	50	50
33	Happy	100	58	33	33
34	Happy	8	42	33	58
35	Happy	33	33	50	42

† Missing and outlier data were also included as well as inaccurate responses.

APPENDIX E

A sample of informed consent form that was used in Experiment III.

İZMİR EKONOMİ ÜNİVERSİTESİ PSİKOLOJİ LABORATUVARI
KATILIMCI BİLGİLENDİRME FORMU

Değerli Katılımcı,

Bu çalışma, Araş. Gör. Buket Kara tarafından deneysel psikoloji yüksek lisans tezi kapsamında yürütülmektedir.

Çalışma boyunca, farklı bireylerin nötr ya da öfkeli yüz ifadelerinden oluşturulmuş setler bilgisayar ekranında toplu olarak sunulacaktır. Setteki yüzlerden birinin duygu ifadesi, deneme boyunca değişecektir. Katılımcılardan, değişen yüz ifadesini mümkün olduğunca hızlı ve doğru şekilde saptamaları istenecektir. Yüz seti, katılımcı cevap verene kadar ekranda kalacaktır. Değişimin saptanmasının ardından, katılımcıdan, değişimin gerçekleştiği bölgenin belirtilmesi istenecektir. Bu bakımdan, değişimi hızlı saptamanın yanında değişimin gerçekleştiği yeri doğru bildirmek, araştırmanın hipotezleri bakımından değerlidir.

Deney sonucunda elde edilecek katılımcı yanıtları toplu olarak analiz edilecek, kişisel bilgiler gizli tutulacaktır.

Deneye katılım gönüllülük esasına dayanmaktadır. Katılımcılar, deney öncesinde ya da deney sırasında, istedikleri takdirde deneyden ayrılma hakkına sahiptir. Böylesi bir durumda, katılımcıdan toplanmış veri iptal edilecektir.

Yukarıdaki bilgileri okudum ve deney hakkında bilgilendirildim. Sorularım araştırmacı tarafından açık bir biçimde yanıtlandı. Deneye katılmayı kabul ediyorum.

Ad- Soyad:

İmza:

Tarih:

Katılımcıya gerekli bilgiler aktarılmış, katılımcının soruları tarafımca cevaplanmıştır.

Buket Kara