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Motivated perception – Discovering emotional bias in mood judgements using the mood-of-the-crowd paradigm

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List of Scientific Publications of the Publication-Based Dissertation

Manuscript 1

Bucher, A., & Voss, A. (2018). Judging the mood of the crowd: Attention is focused on happy faces. *Emotion*. https://doi.org/10.1037/emo0000507

Manuscript 2

Bucher, A., Voss, A., Spaniol, J., Hische, A., & Sauer, N. (2019). *Age differences in emotion perception in a multiple target setting: An eye-tracking study*. Manuscript submitted for publication.

Manuscript 3

Lerche, V., Bucher, A., & Voss, A. (2018). *Processing emotional expressions under fear of rejection: Findings from diffusion model and eye-tracking analyses.* Manuscript submitted for publication.

Manuscript 4

Bucher, A., Hepp, J., Voss, A., & Hische, A. (2019). *Happy crowds are pretty crowds: The influence of attractiveness on mood perception*. Manuscript submitted for publication.

1 Introduction

From an evolutionary perspective, emotional expressions represent a product of natural selection and facilitate the adaptability to novel situations and challenges in interpersonal contexts (Nesse & Ellsworth, 2009). To communicate their emotions to others, humans use facial signals that are thought to be basic and culturally largely invariant (Ekman, 1992). Positive emotional expressions, like happiness, signal approachability and the will to engage in cooperative or pleasurable social interactions whereas negative emotions, like anger, indicate a warning signal of possible physical or psychological threat (Scherer & Wallbott, 1994). There is evidence that an automatic perception of emotions is possible even under high cognitive load (Tracy & Robins, 2008). Moreover, neurocognitive models postulate that the processing of emotional expressions takes place in specialized brain circuits and that the onset of attentional control for human faces is highly automatized (Lueschow et al., 2004). Already in the earliest stages in human life, newborns preferentially track human faces rather than other objects of comparable complexity, contrast, and spatial structure (Johnson, Dziurawiec, Ellis, & Morton, 1991). An efficient perception of emotional expressions thus seems to be of high importance, as it provides an adaptive advantage to immediately evaluate and react to emotional cues in other individuals or groups of people.

Given the significance of emotion perception in human functioning, the question whether specific emotions have a perceptual advantage was the focus of a multitude of research projects over the last decades. As different emotions serve different functions, many researchers were interested in figuring out, which emotions are perceived more efficiently. From a theoretical point of view, it is reasonable to postulate a facilitated perception for both negative (i.e., fearful or angry) and positive (i.e., happy) facial expressions (Nummenmaa & Calvo, 2015). The perception of anger or fear in other human beings indicates interpersonal conflict or threat (Lundqvist, Esteves, & Öhman, 1999), whereas happiness informs an individual about the possibility to approach another person or a group of people in order to receive support or cooperation (Johnston, Miles, & Macrae, 2010). A fast and efficient response to threat brings an evolutionary advantage (e.g., Pratto & John, 1991); however, the same argument is valid for positive stimuli (i.e., chances to improve a current situation). Therefore, the immediate perception of all action relevant stimuli is equally important (Wentura, Rothermund, & Bak, 2000).

In the literature targeting perceptual advantages of specific emotional expressions over others, there are significant inconsistencies between the findings. While some authors found support for an anger superiority effect in emotion perception (Hansen & Hansen, 1988; Öhman, Lundqvist, & Esteves, 2001; Pinkham, Griffin, Baron, Sasson, & Gur, 2010), other findings indicated a facilitated perception of happiness (Becker, Anderson, Mortensen, Neufeld, & Neel, 2011; Leppänen & Hietanen, 2004; Leppänen, Tenhunen, & Hietanen, 2003; Savage, Lipp, Craig, Becker, & Horstmann, 2013). There is evidence that perceptual biases highly depend on the employed stimulus material. The anger superiority effect seems to be limited to schematic stimuli whereas individuals perceive happy expressions faster and more accurately in studies using realistic photographs or computer-generated material (Becker et al. 2011). A common disadvantage of the above-mentioned empirical studies is the fact that all of them applied single-target visual search paradigms. These have the major drawback that it is entirely unclear whether the results are traceable to a fast perception of the target itself or a rapid identification of the distractor faces surrounding the target. It is possible that attention is immediately directed towards the target emotion. However, another explanation would be that individuals manage to detect the target quickly because only little time is necessary to identify the valence of the distractor faces. Up to this point, the interpretation of the results of previous experiments – supporting both the anger superiority effect and the happiness superiority effect – is highly ambiguous.

Thus, the aim of this dissertation was to create a paradigm that allows for disentangling target and distractor effects to clarify the interpretation of results. The newly developed mood-of-the-crowd paradigm (Bucher & Voss, 2018) differs in one particular respect from the most often used face-in-the-crowd paradigm. Instead of deciding whether there is a deviating face in a crowd of distractors, this novel paradigm uses multiple target emotions, eliminating the differentiation between target and distractors. The participant's task is to judge the overall mood of the crowd (e.g., whether there are more happy or angry faces present in the crowd). Therefore, the search task ("find a divergent face in the crowd") is changed into a judgement task ("assess the overall mood of the crowd"). In addition to investigating general biases in emotion perception with this new paradigm, I used it to examine the stability of perceptual biases over the life span and to study how individual differences and stimulus characteristics influence emotion perception. In all studies, I implemented eye-tracking procedures to further illuminate the individual's search processes when using the novel mood-of-the-crowd paradigm.

2 The Emotional Attentional Capture Account

At every moment, a wide variety of different information reaches our senses, but only a minority of stimuli is selected for further processing (Ruz & Lupiáñes, 2002). It is impossible to process all available information simultaneously due to limited processing and storage capacities, and individuals thus only attend to a small proportion of the stimuli present in their environment. With regard to the question how individuals selectively attend to stimuli, there exist two versions of the attentional capture hypothesis (Yantis, 1993). The stimulus-driven capture hypothesis proposes that characteristics of the stimulus itself drive attention regardless of the current motives or goals of the observer. In this assumption, “bottom up” or “exogenous” processes describe attentional control. In the context of emotion perception, this would indicate that particular emotional expressions have adopted specific features in human evolution to attract attention and ensure fast processing by the perceiver (Becker & Srinivasan, 2014). The other version – the contingent capture hypothesis – emphasizes that attentional capture is contingent on the observer’s attentional set. “Top down” or “endogenous” processes best describe attentional control in this case (Theeuwes, Olivers, & Belopolsky, 2010). Following this account, selection critically depends on the current goals and motives of the observer. Studies investigating these two accounts support both, the stimulus-driven capture hypothesis as well as the contingent capture hypothesis. While there is unequivocal evidence that irrelevant stimuli influence an individual’s selection mechanisms (Theeuwes, 1991; Theeuwes, 1992; Yantis & Egeth, 1999), other studies support the influence of top-down control on visual attention (Folk, Remington, & Johnston, 1992; Folk, Remington, & Wright, 1994, Gibson & Amelio, 2000; Remington, Folk, & McLean, 2001).

In the context of the association between selective attention and emotion, a variety of studies investigated whether some emotions capture attention to a greater extent than others. The most often used paradigm in this field is the single-target visual search task in which individuals have to scan a crowd of stimuli and report whether a target stimulus is present or absent (Treismann & Gelade, 1980; Wolfe, 1992). Hansen and Hansen (1988) were the first to implement this task to investigate whether anger or happiness has a perceptual advantage. In their seminal studies, participants were faster and more accurate when searching for an angry target surrounded by happy faces in comparison to the opposite scenario. Although some later studies replicated these original findings (Öhman et al., 2001; Pinkham et al., 2010), other authors raised criticism particularly regarding methodological confounds in those studies. The anger superiority effect seems to be limited to schematic stimuli, thus questioning the ecological validity of the previous findings (Becker et al., 2011). Moreover, using schematic stimuli inevitably leads to extremely homogeneous crowds of distractor faces, thus rendering it highly possible that single perceptual features (like the shapes of the eyebrows or the mouth) drive attention rather than the emotional expression itself (Becker et al., 2011). Lastly, there is often an exaggerated contrast between the schematic stimuli and the background of those pictures reducing the ecological validity of these laboratory tasks (Purcell & Stewart, 2010).

Contrary to the findings supporting an anger superiority effect, studies using realistic photographs or computer-generated faces found evidence for a faster and more accurate perception of happiness in the classic face-in-the-crowd paradigm (Becker et al., 2011; Juth, Lundqvist, Karlsson, & Öhman, 2005; Savage et al., 2013). In their study, Becker et al. (2011) found support for the happiness superiority effect when carefully eliminating perceptual confounds, for example when only showing the upper part of the face (eradicating the influence of exposed teeth in smiling faces) or presenting computer-generated faces controlling for emotional intensity, lighting and contrast. Although these studies erase previous problems of schematic stimuli, it remains an open question whether the perceptual advantage for happy faces is attributable to a quick and direct focus on the target or a fast evaluation of the distractors surrounding the target face. Therefore, the findings remain ambiguous. It is possible that individuals find the happy (or angry) face quickly because only a short amount of time is necessary to identify its valence. However, the same explanation applies to the surrounding distractor faces because it is possible that they capture less attention and therefore participants quickly detect the target emotion.

In addition to the problem of the confound of target and distractor effects, other limitations arise when using single-target visual search paradigms. First, the search for a deviating face in a crowd is less likely to occur in everyday life, thus limiting the representativeness of such experimental scenarios (Isaacowitz, Livingstone, & Castro, 2017). Judging the overall mood of a crowd (e.g. at a sporting event, concert or in class) therefore seems more representative of real-life situations. Moreover, single-target paradigms do not allow for a naturalistic visual search as the search process in this task is determined by the location of the target face. Although there is already evidence for a happiness superiority effect when using crowds with multiple target faces (Elias, Dyer, & Sweeney, 2017), Elias et al. (2017) investigated dynamically changing emotional expressions while not systematically testing the difference in perception between happy and angry crowds.

Hence, a major aim of the present dissertation was to introduce a new paradigm that overcomes the limitations of single-target visual search paradigms. I developed the mood-of-the-crowd paradigm, in which participants' task is to judge the overall mood of the crowd instead of deciding whether a specific target is present or absent in the array of faces. This leads to an elimination of confounds between target and distractor effects because all faces are targets and inform the correct response. Another benefit of this paradigm is that it is highly suitable for eye-tracking analysis because the search process does not stop abruptly as soon as participants detect the target emotion. The analysis of eye movements is a great merit for investigating biases in emotion perception. The next section will discuss these advantages.

3 Eye-tracking Analyses – Underlying Processes in Emotion Perception

When investigating perceptual biases in visual search paradigms, the sole analysis of response times and error rates does not provide full information about the underlying processes that led to the judgement. These measures do not contain information about how many stimuli participants focused on or how long they needed to fixate the targets to uncover their valence. Therefore, further measures are necessary to better disentangle why participants chose a specific response. The additional analysis of eye movements provides an opportunity to pinpoint the locus of search asymmetries. The most obvious advantage of eye-tracking analyses is that eye movements are directly observable or more specifically, recordable by the eye-tracker (Zelinsky, 2008). Typically, eye-trackers combine a highly specialized video camera and an image analysis software that enable differentiation between saccades, fixations and blinks. Saccades represent rapid eye movements with a characteristic duration of 30 to 80 ms (Holmqvist et al., 2011). Individuals typically perform 3 to 4 saccades per second and researchers argue that no information acquisition is possible during the execution of a saccade (Findlay & Gilchrist, 2003). Fixations, on the other hand, usually last longer than saccades and vary mostly between 50 and 250 ms. However, other authors suggest that a temporal threshold of 100 ms is necessary to effectively discriminate fixations from other oculomotor activity (Manor & Gordon, 2003).

Once the eye-tracker has recorded and identified the saccades and fixations that participants performed during the visual search task, it is possible to compute a variety of different variables that can shed light on the visual search process. However, in this section I only discuss those eye-tracking measures that I employed in the experimental studies of this thesis, namely the number of fixations, fixation duration, and the proportion of fixations. The number of fixations an individual performs during a task is an indicator of visual search efficiency (Zelinsky & Sheinberg, 1997). Specifically, the combination of the number of fixations and the response latencies captures the individual's information acquisition per time and captures how conservative participants are when reaching their decision. Fixation durations, in turn, reflect the depth of visual processing, assuming a more elaborate processing of a stimulus the longer the fixation duration on that stimulus (Just & Carpenter, 1980). However, there are also other possible explanations for longer fixations on a stimulus. In contrast to a more elaborate visual processing, attentional preferences (Roelofs et al., 2010) or processing deficits in specific target groups (Sullivan & Ruffman, 2004) can be responsible for longer fixations on the stimulus. Lastly, the proportion of fixations is the fixation duration for a specific target divided by the total fixation durations during a trial. This variable directly targets biases in visual perception. In brief, these eye-tracking variables allow for a deepened understanding of the efficiency and depth of information acquisition as well as underlying biases in visual search paradigms.

In the typical visual search paradigm in the field of emotion perception, the face-in-the-crowd paradigm, participants have to decide as accurately and fast as possible whether the crowd contains a target face or not. In this paradigm and in single-target visual search tasks in general, the target stimulus highly influences the search process, because individuals immediately stop scanning the crowd as soon as they detect the discriminant face. In contrast, the presentation of multiple target emotions and thus eliminating the differentiation between target and distractor faces brings some major advantages. First, individuals are able to decide freely how many faces they want to inspect until they decide to make their judgment. This is not possible in tasks with only one target emotion as the search process should stop immediately as soon as the individual focuses on the target. This difference is highly valuable when using gaze movement analyses.

Another advantage of the combination of eye-tracking and the mood-of-the-crowd paradigm (eliminating target and distractor faces) is that it is easier to investigate search asymmetries as it becomes possible to contrast the number of fixations between, for example, happy and angry faces within a trial. When there is only one target emotion in the crowd of faces, a comparison of the number of fixations between distractors and the target is not possible. Lastly, the interpretation of the findings is less ambiguous because when combining behavioral (response latencies and accuracy rates) and eye-tracking data, it is easier to locate the source of the observed effect. In terms of general biases or moderating factors in emotion perception research, it often remains unclear whether the postulated effect is attributable to the perceptual or the processing level. With regard to the evaluation of the mood of a presented crowd, for example, it is possible that the happiness superiority effect is due to a higher fixation rate on happy in comparison to angry faces. This, in turn, would indicate that perceptual preferences guide attention and therefore influence the final judgement. If the participant's attention shifts towards the happy faces in a crowd, this of course affects the later evaluation of the perceived mood. For instance, Roelofs et al. (2010) argue that individuals preferentially focus on happy compared to angry expressions and that this preference serves the individuals' emotion-regulation goals to retain their well-being. However, there is also the possibility that although participants retrieve the same information (equal numbers and duration of fixations on the different kinds of presented stimuli) when inspecting the crowd of faces, the final judgment is nevertheless biased. This would indicate that differences occur during the evaluation phase (e.g., a positive reappraisal of the retrieved information in case of a happiness superiority effect). Therefore, the additional application of gaze analyses helps contrasting both alternatives and reaching a deepened understanding of the causes of the observed results patterns.

In the following manuscripts, I aimed to combine the benefits of the mood-of-the-crowd paradigm (higher ecological validity, higher suitability for eye-tracking analyses, elimination of confounds between target and distractor effects) and eye-tracking procedures (clarification of underlying processes in emotion perception). In the first manuscript, my aspiration was to test the happiness superiority effect in a multiple target setting when using the mood-of-the-crowd paradigm. In the second manuscript, I applied this paradigm to an age-stratified sample. In Manuscripts 3 and 4, I intended to test the influence of individual-level (fear of rejection) and stimulus-level (stimulus attractiveness) moderators on emotion perception in the newly developed multiple target setting.

4 Judging the Mood of the Crowd: Attention is Focused on Happy Faces (Manuscript 1)[1]

The fast identification of relevant information is the core function of attentional processes and allows individuals to react immediately to changes in the environment. Specifically, the selective attention to emotional expressions allows judging other people's intentions and behavior (Calvo & Marrero, 2009). For example, the perception of anger serves as a signal to keep distance from other persons, and a smiling face is an indicator of approachability (Juth et al., 2005). So far, most empirical studies implemented single-target paradigms to shed light on the question whether there is a perceptual advantage for happy or angry facial expressions (e.g., Becker et al., 2011; Hansen & Hansen, 1988; Öhman et al., 2001; Pinkham et al., 2010). Due to the previously mentioned limitations of single-target visual search paradigms, our focus was to develop and implement the mood-of-the-crowd paradigm in the first manuscript to investigate the relation of attentional processes and decision-making.

In the mood-of-the-crowd paradigm, participants have to judge the overall mood of the crowd instead of deciding whether there is one deviating face in a crowd of distractor faces. For example, participants' task is to judge whether more happy or angry expressions are displayed in the crowd of faces (Figure 1). The crowds typically consist of 20 faces. The number of – in this case – happy faces varies in four steps (seven, nine, 11, 13 out of 20 faces), to introduce different levels of difficulty and to ensure the existence of a correct response.[2] The task is more complex, requiring the processing of several stimuli and has a higher ecological validity as in every-day situations typically crowds with more than one target are prevalent.

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[1] Bucher, A., & Voss, A. (2018). Judging the mood of the crowd: Attention is focused on happy faces. *Emotion*. https://doi.org/10.1037/emo0000507

[2] For a more detailed explanation of the mood-of-the-crowd task and the concrete experimental design please refer to the method sections of the respective manuscripts.

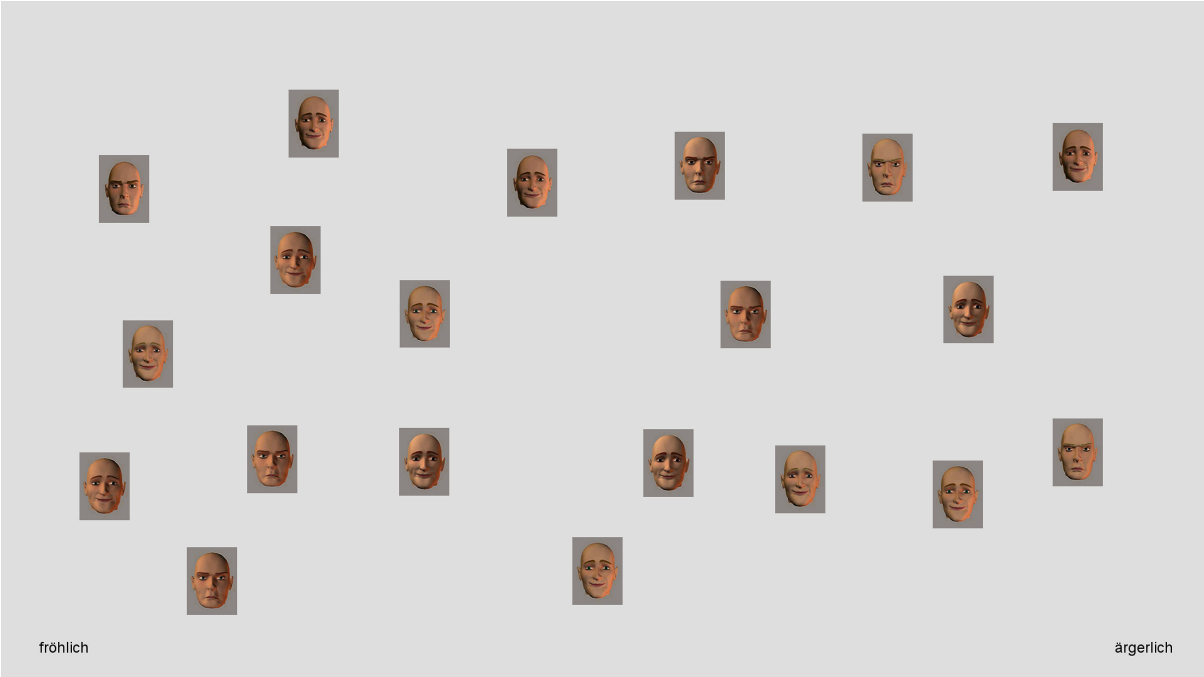

Figure 1. Example trial of the mood-of-the-crowd task ("fröhlich" = "happy", "ärgerlich" = "angry"). In this trial, "happy" is the correct response. The computer-generated faces were derived from Becker et al. (2011).

There is also previous evidence that judging a mood instead of single emotional targets leads to a perceptual advantage for happy crowds of faces. In the studies by Elias et al. (2017), participants inspected crowds of happy, angry, and fearful faces that changed dynamically within the trials. Each face presented in the crowd displayed one emotion from the same category. In each trial, the mean emotion of the crowd was randomly chosen from uniformly distributed intensity values (Elias et al., 2017). As outlined above, every face was dynamically changing in emotional intensity within the same emotion category. Participants' task was to evaluate the average emotional intensity of the displayed faces. The authors found more precise intensity estimates for happy in comparison to angry and fearful faces. Derived from the experiments by Elias et al. (2017) and other studies supporting a happiness superiority effect in emotion perception (Becker et al., 2011; Savage et al., 2013), we hypothesized that happy faces attract more attention, and therefore we expected happy crowds to be judged more efficiently compared to angry crowds. As outlined earlier, in addition to the investigation of emotional biases at the behavioral level, we aimed to deepen the understanding of the visual search process itself. In order to do this, we decided to use the analysis of gaze movements, which provides a window into how participants reach their decisions. At the attentional level, we expected a higher number of fixations on happy faces compared to angry faces. This assumption was based on previous findings on search asymmetry favoring happy faces (Becker et al., 2011; Craig, Becker, & Lipp, 2014). Moreover, we assumed shorter fixation durations on happy compared to angry faces, indicating a faster processing of happy expressions (McKelvie, 1995). This idea was previously supported by Miyazawa and Iwasaki (2010), who found evidence that happy faces capture less attention compared to angry expressions, which was underlined by a smaller attentional blink effect for happy faces. Hence, the following experiments of Manuscript 1 aimed to test the stability of the happiness superiority effect when using a different setup that presents multiple emotional target faces in a crowd of deviating expressions.

In the first two experiments of the first manuscript, several happy or angry faces appeared in a crowd of neutral distractors whereas the third experiment presented happy and angry expressions together. Participants judged whether more faces showed a neutral or emotional expression (Exp. 1 and Exp. 2) or whether the crowds contained more happy or angry faces (Exp. 3). The major benefit of this mood-of-the-crowd paradigm is that all faces inform about the correct response and that distractor and target effects are no longer confounded. To address previous issues regarding the stimulus material, we used realistic photographs in the first experiment and computer-generated facial expressions in experiments 2 and 3. We used a random allocation of stimuli because arranging the pictures in a specific pattern (e.g., a matrix or a circle) might bias participants' gaze movement (e.g., row-wise or clockwise) and would also undermine the realistic presentation of a crowd. Thus, we were able to analyze participants' eye movements to gain more insight into the attentional processes that influence the final decision.

In the first experiment using the realistic facial expressions, we found evidence for a faster and more accurate identification of happy crowds. Regarding the eye-tracking data, happy faces were fixated more frequently and shorter. These findings clearly speak in favor of a happiness superiority effect. When presenting the computer-generated faces in Experiment 2, there were again higher accuracy rates for happy crowds and fixation rates were higher for happy compared to angry expressions. As participants rated the computer-generated faces as less emotionally intense than the realistic face pictures (Becker et al., 2011; Goeleven, Raedt, Leyman and Verschuere, 2008), we believe it to be possible that emotional intensity differences of the stimulus material between the first two experiments might be a reason for the non-replicable speed advantage in the second experiment. In the last experiment, presenting happy and angry faces together, participants showed longer fixations on happy faces. An explanation for this finding might be an avoidance tendency towards negative information when the crowd consists of both happy and angry expressions (Roelofs et al., 2010). Individuals preferentially focus on happy expressions and avoid focusing on angry faces to retain their well-being (Roelofs et al., 2010).

The results corroborate a large body of previous experimental findings suggesting a happiness superiority effect. We were able to generalize the findings from previous studies to an experimental setting that uses multiple targets and thus overcomes confounds of target and distractor effects. Additionally, using gaze analyses, we found evidence that happy faces show a detection advantage already in the early stages of perception. Although we largely replicated the happiness superiority effect in a multiple target setting, it remained an open question whether this effect is constant over the lifespan or changes during aging. Manuscript 2 addressed this question.

5 Age Differences in Emotion Perception in a Multiple Target Setting: An Eye-Tracking Study (Manuscript 2)[3]

The perceptual advantage for happy in comparison to angry facial expressions was shown in many empirical studies using different material and diverse experimental settings. It was found when using realistic face pictures (Becker et al., 2011; Juth et al., 2005; Savage et al., 2013) and computer-generated emotional expressions (Becker et al., 2011; Bucher & Voss, 2018) as well as when using single emotional targets (Leppänen & Hietanen, 2004; Leppänen et al., 2003) and multiple emotional faces (Bucher & Voss, 2018; Elias et al., 2017). However, it remains unclear whether these findings extrapolate to the entire life span.

The socioemotional selectivity hypothesis suggests that aging, and the intensified perception of a shrinking time horizon, lead to an increase of relative salience of emotion- instead of knowledge-focused goals (Figure 2; Carstensen, 1992; Carstensen, 1999; Carstensen, Isaacowitz, & Charles, 1999). Older individuals report a greater focus on emotionally meaningful relationships whereas people from younger age cohorts spend more time making new contacts (Fredrickson & Carstensen, 1990; Fung, Carstensen, & Lutz, 1999). Furthermore, aging is associated with a decreased frequency and duration of negative emotions (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000). According to the

[3] Bucher, A., Voss, A., Spaniol, J., Hische, A., & Sauer, N. (2019). *Age differences in emotion perception in a multiple target setting: An eye-tracking study*. Manuscript submitted for publication.

socioemotional selectivity theory, one would expect a positivity effect in older adults that translates into an increased bias towards positive compared to negative information (Mather & Carstensen, 2005). Empirical findings regarding the association between aging and emotion perception are also in line with this theory, predominantly showing a preferential focus on happy targets in older cohorts (Allard & Isaacowitz, 2008; Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Mather & Carstensen, 2003). However, there is also evidence of a more efficient perception of anger in older age cohorts (Hahn, Carlson, Singer, & Gronlund, 2006; Mather & Knight, 2006) and of a reduced positivity effect when older adults' cognitive resources are constraint (Reed, Chan, & Mikels, 2014).

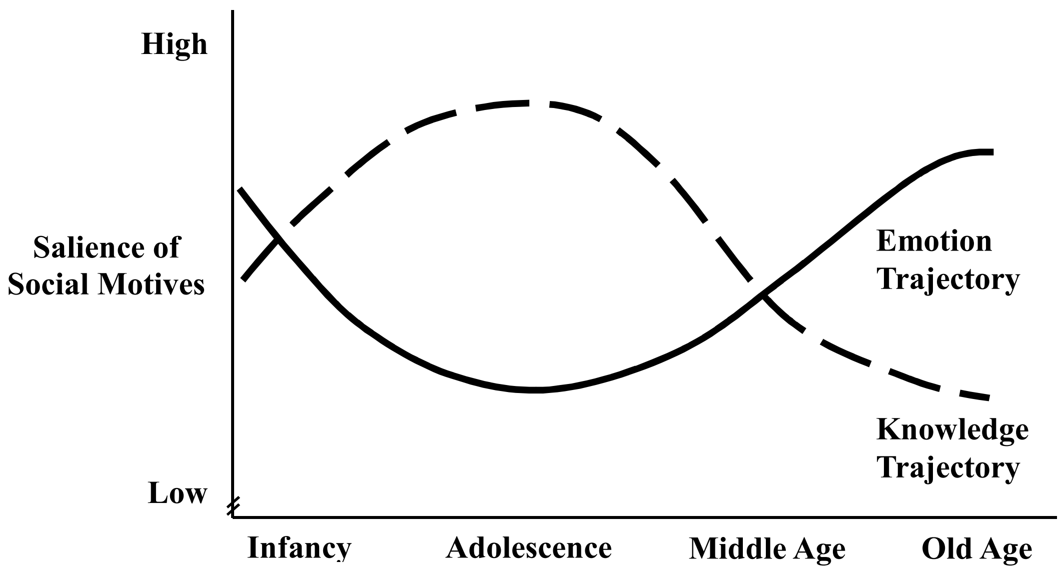

Figure 2. Visualization of the socioemotional selectivity theory by Carstensen (1999) displaying the relative change of emotional and knowledge trajectory during the life span.

In a recent meta-analysis, Isaacowitz, Livingstone and Castro (2017) raised critique about the use of single emotional targets in experimental paradigms, arguing that such tasks lack ecological validity and reduce the motivation to successfully solve the task, especially for older individuals. Moreover, the findings from studies applying the face-in-the-crowd paradigm are also limited due to the afore-mentioned confounds of target and distractor effects and lower suitability for gaze analyses. Therefore, the key intention of Manuscript 2 was to combine the mood-of-the-crowd paradigm with eye-tracking analyses as this combination enables a more superior understanding of differences in emotion-cognition interactions between younger and older individuals. It is possible that the positivity effect translates into a preferential focus on positive faces in the crowd or occurs during the evaluation phase. Moreover, because the socioemotional selectivity theory supposes a gradual change in emotion-directed goals during aging (Löckenhoff & Carstensen, 2007), it is necessary to empirically test whether this shift starts abruptly in the latest stage of life or already during mid-life. The theory proposes that due to a perception of a gradually diminishing time horizon, individuals preferentially focus on emotion-directed compared to knowledge-focused goals. However, previous investigations mostly compared young adults with individuals of high age and therefore cannot make an assumption about the beginning of changes in emotion perception across the life span. The current manuscript therefore investigated three different age cohorts (young, middle-aged, and old), aiming to pinpoint the commencement of changes in emotion perception and processing across the life span. We used the mood-of-the-crowd paradigm and the participants' task was to decide as accurately and fast as possible whether there were more happy or angry faces in a crowd of faces. We hypothesized that individuals from the oldest age group would fixate happy expressions with a longer duration and a higher frequency. This shift in emotion perception should then translate into a higher proportion of classifications as "happy" when evaluating the mood of the crowd for older adults.

Contrary to the assumptions derived from the socioemotional selectivity theory, the oldest age cohort predominantly judged the crowd of emotional faces to be angry compared to the young and middle-aged group. Additionally, whereas especially the young cohort fixated happy faces longer in comparison to angry expressions, there was no difference in the oldest age group. Generally, these findings contradict the age-related positivity effect found in previous empirical investigations. A possible explanation for these findings might be a decline in inhibitory functions with increasing age (Hasher & Zacks, 1988; Kane, Hasher, Stoltzfus, & Zacks, 1994). The ability to ignore or suppress negative information might decline with increasing age and thus translate into a higher proportion of negative judgments in older participants. Furthermore, it is possible that because of the higher difficulty of the mood-of-the-crowd task, more cognitive control is necessary to solve the task successfully which might impair a spontaneous emotion regulation in older adults. Reed et al. (2014) found that the positivity effect in older individuals is more prevalent in low-demand tasks, thus, the absent positivity bias might be due to characteristics of the paradigm itself. Finally, two recent meta-analyses found that older participants were less effective in identifying most of the basic emotional expressions compared to their younger counterparts and that this difference was even more pronounced with respect to angry compared to happy faces (Gonçalves et al., 2018; Ruffman, Henry, Livingstone, & Phillips, 2008). The disappearance of the happiness superiority effect might therefore be due to increased problems in the perception of anger. To conclude, as older adults retrieve the same information when inspecting the crowd (same fixation durations and fixation rates on happy and angry faces), the judgmental bias favoring the negative response speaks in favor of a biased processing of emotional expressions.

Up to now, the dissertation addressed the happiness superiority effect using a novel paradigm and testing it with respect to an age-stratified sample. In addition to the research on general perceptual biases, a further avenue is to investigate moderators at the individual level that can account for differences in emotion perception and processing. Thus, in Manuscript 3, we addressed the role of individual differences in the affiliation motive when evaluating emotional crowds of faces.

6 Processing Emotional Expressions under Fear of Rejection: Findings from Diffusion Model and Eye-Tracking Analyses (Manuscript 3)[4]

Human beings are confronted with crowds of faces in a variety of situations, for example, when giving a speech in front of a class or when performing as a comedian in a theatre. In these situations, the verbal and non-verbal signals of the audience serve as a feedback for the performing person. In case of the comedian, a predominantly smiling and laughing crowd would suggest a successful and humorous performance whereas a predominantly frowning and serious crowd would point towards a rather boring show. The newly developed mood-of-the-crowd paradigm (Bucher & Voss, 2018) is able to simulate such a situation in a laboratory setting. So far, we tested for general perceptual biases and the influence of aging on emotion perception, indicating a happiness superiority effect in younger participants that manifested in a more accurate and faster evaluation of happy in comparison to angry crowds. This happiness advantage was no longer present when examining

[4] Lerche, V., Bucher, A., & Voss, A. (2018). *Processing emotional expressions under fear of rejection: Findings from diffusion model and eye-tracking analyses.* Manuscript submitted for publication.

individuals of higher age. What was not part of the previous studies is the question whether there are other moderators at the individual level that can influence crowd perception.

A possible moderator regarding emotion perception displays the affiliation motive. According to the motive disposition theory (MDT; e.g., McClelland, 1985), the need for affiliation emphasizes an individual's need for belonging and involvement with other human beings or a social group. Furthermore, the affiliation motive is a fundamental psychological motive that drives behavior and influences how individuals react in specific social contexts. For example, individuals high in fear of rejection, one of the two main aspects of the affiliation motive, perceive ambiguous faces more negatively compared to participants with a lower motive score (Nikitin & Freund, 2015). The authors found a reduced happiness superiority effect for individuals higher in fear of rejection (Nikitin & Freund, 2015). In further studies, authors found evidence that the manipulation of social exclusion enhances an individuals' speed of identifying happy faces in a crowd of distractor faces (DeWall, Maner, & Rouby, 2009). Moreover, individuals who experienced a threat of social exclusion fixated on happy expressions more frequently in comparison to persons who did not experience a threat of social exclusion (DeWall et al., 2009). In addition, following social exclusion, participants showed a preference for working on a task together with other individuals rather than solving the task alone by themselves (Maner, DeWall, Baumeister, & Schaller, 2007). A possible explanation might be that after experiencing a threat of social exclusion individuals seek compensation (DeWall et al., 2009). These findings underline the importance of investigating the affiliation motive in the context of emotion perception.

From these previous findings, it remains unclear which underlying processes are accountable for the influence of fear of rejection or the threat of social exclusion on emotion perception. It is possible that individuals who experienced a threat of social exclusion shift their prior response criterion to the positive information (prior bias) or that the speed of information accumulation (dynamic bias) increases compared to individuals who did not experience a frustration of the need for affiliation. To shed light on these questions, we applied the diffusion model (Ratcliff, 1978), which allows disentangling prior from dynamic biases. The model assumes that relevant information is collected continuously and that this accumulation of information proceeds until an upper or lower threshold is reached and individuals initiate their corresponding response (Voss, Rothermund, & Voss, 2004). In general, the diffusion model differentiates between several different parameters that influence the response time distribution and accuracy rates (Figure 3). The distance between the thresholds (*a*) is a measure of conservatism with higher values indicating that individuals take more time or prefer collecting more information until making their decision. The drift rate (*v*) captures the speed of information accumulation, namely the individual's relative amount of information uptake per time. The starting point (*z*) refers to a prior bias in information processing. If the starting point is closer to one of the two thresholds, fewer information is necessary to reach this threshold and individuals reach the corresponding decision more often and with shorter decision times. The last parameter is the non-decision time (t_0) that indicates the duration of processes additional to the decision process (e.g., encoding of information and motoric response execution). There are also other parameters that are, however, not part of the present study.

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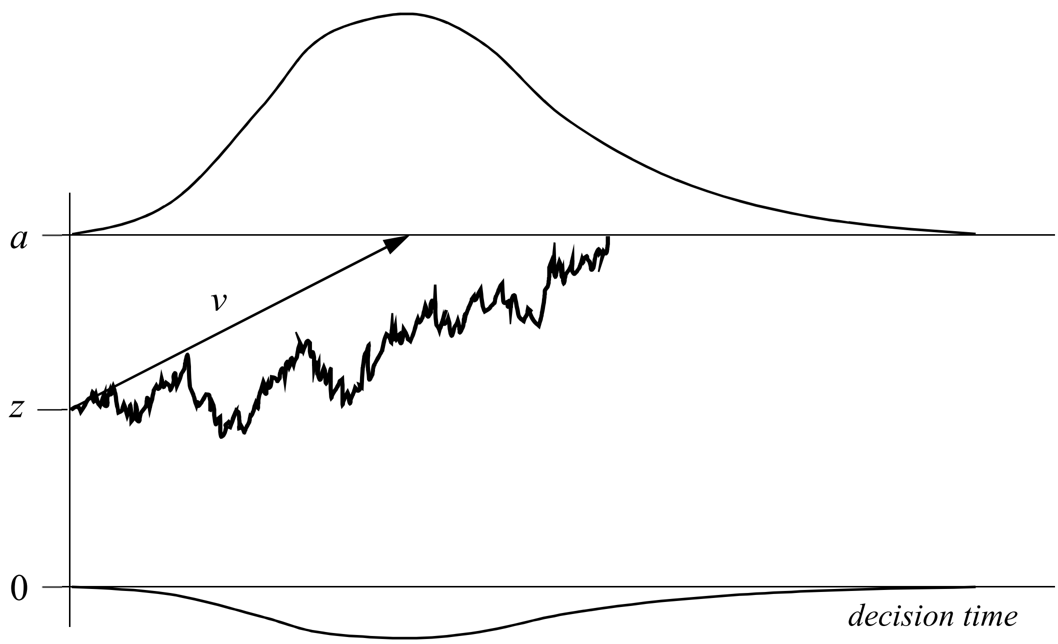

Figure 3. Illustration of the diffusion model with the two thresholds associated with correct and erroneous responses. The main diffusion model parameters are threshold separation (*a*), starting point *z* (here situated in the center between the two thresholds), non-decision time (t_0, not depicted in the figure) and drift rate *v*.

In the current study, we used the future-alone manipulation introduced by Twenge, Baumeister, Tice, and Stucke (2001) to induce a threat of social exclusion and thus create a frustration of the affiliation motive. Participants filled out explicit and implicit measures of the affiliation motive. Afterwards, representing the future-alone manipulation, participants answered a personality questionnaire and received individual feedback of the scores of all five personality traits, but a false and randomized feedback regarding their belongingness with significant others in the future. In the frustration condition, participants received negative feedback about their future relationships (e.g., reduced likelihood of a steady relationship with a romantic partner in the future, increased probability of dissolving friendships) whereas in the satisfaction group, participants received a positive feedback (e.g., increased likelihood of a steady relationship with a romantic partner in the future, increased probability of long-lasting and close friendships). After receiving the feedback, individuals performed the mood-of-the-crowd task.

This is, to our knowledge, the first study that examined the influence of threat of social exclusion on emotion perception and additionally investigated a potential moderating role of the affiliation motive. Furthermore, we applied the diffusion model as well as eye-tracking analyses to examine the underlying processes of the effects of psychological motives on emotion perception. First, we replicated the findings by Bucher and Voss (2018) who found – generally – longer fixation durations for happy compared to angry faces when both emotions were presented together. This effect was even more pronounced for participants who received a positive feedback about their future social relationships and for individuals with low levels of fear of rejection. Furthermore, we found evidence that individuals who were more fearful of rejection accumulated information in crowds dominated by negative emotional expressions more quickly compared to their less fearful counterparts (drift rate of the diffusion model; dynamic bias). Moreover, individuals scoring lower on fear of rejection who received negative feedback regarding their future belonging showed a prior bias (i.e., shifted starting point of the diffusion model) for the positive in comparison to the negative mood judgement. This indicates that individuals low on fear of rejection attempted to restore the thwarted motive by shifting a criterion (e.g., a more positive perception of an ambiguous situation). The present study underlines the fact that diffusion modeling adds important information about which cognitive processes are responsible with regard to the influence of the affiliation motive on emotion perception.

In the present manuscript, we were able to outline several novel avenues in terms of the application of the mood-of-the-crowd paradigm. First, we demonstrated that, besides the investigation of general biases in emotion perception, the paradigm is also suitable for the examination of possible moderators on the individual (affiliation motive) and situational level (threat of social exclusion) and their interaction. Second, as the paradigm is a binary classification task (upper and lower thresholds associated with the “angry” and “happy” response) it also enables the use of diffusion model analyses to gain a deeper understanding of the processes accountable for the effects. We found evidence that top-down processes influence selective attention, showing that emotion perception depends on the current goals and motives of the observer. In addition to the study of individual level moderators, we aimed to manipulate stimuli characteristics in the last manuscript. We investigated whether the attractiveness of the presented faces influences how individuals perceive the mood of the crowd.

7 Happy Crowds are Pretty Crowds: The Influence of Attractiveness on Mood Perception (Manuscript 4)[5]

Alongside research on general biases in emotion perception and the influence of individual differences, there is also evidence that social cues of the stimuli themselves influence how participants perceive the respective emotion. In visual search paradigms, the gender of the presented face has been found to play an important role and is one of the most thoroughly investigated moderators. There is consensus that the happiness superiority effect is more pronounced in female faces or female crowds (Becker et al., 2007; Bucher & Voss, 2018; Craig & Lipp, 2017; Hugenberg & Sczesny, 2006; Lipp, Craig, & Dat, 2015). Moreover, other social cues, like race, are important with regard to the research on emotion perception. Empirical studies revealed – for example – that own-race faces reached a more positive evaluation compared to other-race faces (Bijlstra et al., 2010; Craig, Mallan, & Lipp, 2012). What remained an open question was whether these findings are attributable to stereotype or evaluative congruence effects. In detailed studies, Hugenberg (2005) and Hugenberg and Sczesny (2006) compared both accounts – systematically manipulating race and gender – while the participants' task was to discriminate happy versus sad and happy versus angry expressions. According to the stereotype account, there should be a strong link between females and sad expressions (Plant, Kling, & Smith, 2004) whereas anger should be associated more closely with males and other-race males (Devine, 1989). As race and gender showed the same influence on emotion perception – with a faster evaluation of happy female and happy own-race faces – the authors found evidence for the evaluative congruence

[5] Bucher, A., Hepp, J., Voss, A., & Hische, A. (2019). *Happy crowds are pretty crowds: The influence of attractiveness on mood perception*. Manuscript submitted for publication.

account. The theory predicts a faster and more accurate perception of a respective emotion when it matches the evaluation (positive or negative) of a social cue.

In a recent study, Lindeberg, Craig and Lipp (2018) tested this account investigating the influence of attractiveness on emotion perception. Although attractiveness does not represent an invariant social cue, there is high conformity about what is attractive in other people and what is not (Langlois et al., 2000). Face attractiveness is an important variable to study because perceived attractiveness is associated with many positive outcomes, for example a higher attributed intelligence (Jackson, Hunter, & Hodge, 1995), more positively evaluated personality traits (Borkenau & Liebler, 1992; Borkenau & Liebler, 1995; Smits & Cherhoniak, 1976), and a higher likelihood of getting a job (Watkins & Johnston, 2000). With regard to emotion perception, the detection of happiness is more efficient in attractive faces (Lindeberg et al., 2018; Mueser, Grau, Sussman, & Rosen, 1984). However, according to the evaluative congruence account, there should also be a more efficient perception of anger in unattractive faces, which previous studies did not reveal.

In the current manuscript, we aimed to replicate the findings by Lindeberg et al. (2018) using the mood-of-the-crowd paradigm. This task is especially suited for gaze analysis, because the search process does not stop abruptly as soon as participants detect the respective target. Analyzing eye-tracking data allows for pinpointing the locus of the attractiveness effect on emotion perception. If the effect manifests at the attentional level (e.g. higher fixation rates on happy attractive and angry unattractive faces), it is most likely that perceptual preferences guide perception. If the attractiveness effect emerges in the evaluation phase (e.g. a response bias towards happiness in attractive crowds and towards anger in unattractive crowds), this would indicate a biased evaluation of faces. Moreover, the paradigm is characterized by much higher cognitive demands that manifest in lower accuracy rates. Thus, the task leaves more room for emotion perception biases and might enable testing the evaluative congruence account also for unattractive faces.

In two studies, we systematically manipulated the attractiveness of the crowds and participants had to judge as fast and accurately as possible whether the presented crowd consisted of more happy or angry targets. Moreover, participants rated the presented faces on attractiveness and emotional intensity. In the first experiment, stimuli were selected using the same criteria that Lindeberg et al. (2018) used, selecting the most and least attractive Caucasian faces from the Chicago Face Database (Ma, Correll, & Wittenbrink, 2015). However, as this led to attractiveness differences between attractive female and male faces, we matched attractiveness between female and male faces when choosing the material in Experiment 2. Across both experiments, there was consistent evidence for a response bias towards happiness in attractive crowds and towards anger in unattractive crowds (Figure 4).

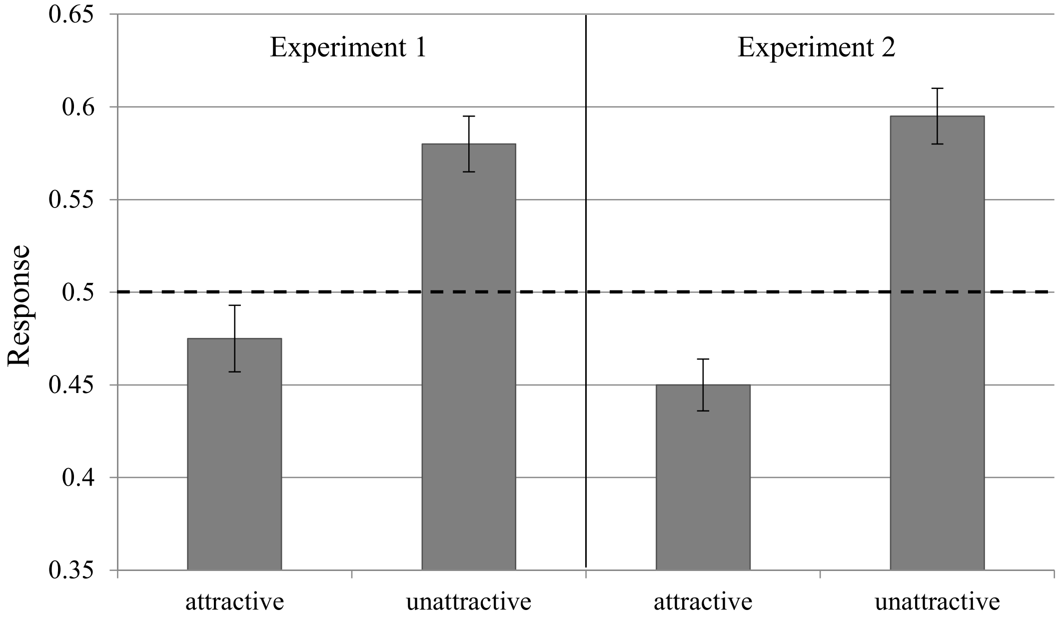

Figure 4. Main effect of attractiveness on response tendency (0 = happy, 1 = angry) in Experiment 1 (left panel) and Experiment 2 (right panel). Error bars indicate standard errors.

Participants evaluated attractive crowds faster and with a higher accuracy when crowds consisted of a higher number of happy expressions, whereas the reverse pattern was true for unattractive crowds of faces. Results thus supported the evaluative congruence account. Additionally, in Experiment 1, participants fixated longer and more frequently on happy attractive targets. However, the second experiment did not replicate these findings. As attractiveness differences between the attractive and unattractive faces were smaller in the second experiment (due to the change in selection criteria), this might have resulted in a reduced attention grabbing power of the attractive smiling faces. This, in turn, might have led to a similar allocation of attention to the happy and angry attractive and unattractive faces.

Although we used different stimuli sets in both experiments, participants consistently rated happy attractive and angry unattractive faces as more emotionally intense compared to angry attractive and happy unattractive faces. It is most likely that the attractiveness effect found in the mood-of-the-crowd paradigm also occurs with regard to the emotional intensity rating. However, it is also possible that – coincidentally – happiness was expressed more strongly in attractive faces and anger in unattractive faces in both experiments. Future investigations should therefore use computer-generated emotional expressions matched for attractiveness, gender, and emotional intensity to ensure equal emotional intensities of the facial expressions. Overall, both experiments emphasize the importance of researching attractiveness in visual search paradigms as it highly influences emotion perception. It is necessary to control for visual attractiveness in future investigations that aim to investigate other social cues (like race or gender) in order to prevent confounds of different stimulus characteristics.

8 Discussion

8.1 Summary of Key Findings

The main goal of this doctoral thesis was to develop a novel visual search paradigm that helps to better localize the causes of perceptual processes in visual search tasks. The most widely used task in the field of emotion perception in human faces is the face-in-the-crowd paradigm. It is a single-target visual search task (Treismann & Gelade, 1980; Wolfe, 1992) which aims to uncover perceptual advantages for specific emotions (e.g., happiness or anger superiority effect). However, as outlined earlier, search paradigms using only one target emotion have received criticism (Isaacowitz et al., 2017). Besides the limited ecological validity of the face-in-the-crowd paradigm, it also creates ambiguous results that are not clearly traceable to target or distractor effects. Moreover, it is less suited for the examination of self-directed search patterns that are not determined by the location of a single target emotion. By developing the mood-of-the-crowd paradigm, we aimed to overcome these limitations. We presented multiple target emotions within crowds and thus eliminated the ambiguity of target and distractor effects as well as enabled a higher suitability for the investigation of eye movements.

In the first manuscript, we successfully replicated the happiness superiority effect from previous studies (Becker et al., 2011; Elias et al., 2017; Leppänen & Hietanen, 2004; Leppänen et al., 2003; Savage et al., 2013) when the participants' task was to judge the overall mood of the crowd instead of deciding whether there is a deviating face in a crowd of distractor faces. Across two experiments – using realistic facial expressions and computer-generated material – participants judged happy crowds with a higher accuracy and they fixated a higher number of happy expressions compared to angry expressions. Thus, we were able to translate previous findings into a multiple target setting. As only young undergraduate students took part in the experiments, we strove to apply the mood-of-the-crowd paradigm to an age-stratified sample in the second manuscript. According to the socioemotional selectivity theory (Carstensen, 1992, Carstensen, 1999), we expected a more strongly pronounced happiness superiority effect for the oldest age group. However, we found evidence that older individuals tended to judge the mood of the crowd as being angry more often compared to the youngest age cohort. Furthermore, while the youngest age group fixated longer on happy compared to angry faces, this was not the case for the oldest age group. Although we were able to replicate the findings from the first manuscript in the youngest age group, we did not confirm an increased perceptual advantage for happy crowds in older adults. Higher cognitive demands of this new paradigm (Reed et al., 2014) as well as a possible decline of inhibitory functioning with increasing age (Hasher & Zacks, 1988; Kane et al., 1994) might serve as explanations for these results.

In addition to investigating general perceptual biases towards specific emotions, we aimed to focus on possible moderators at the individual level and in terms of stimulus characteristics that influence emotion perception in the mood-of-the-crowd paradigm. In Manuscript 3, we investigated the influence of fear of rejection in terms of emotion processing. We found evidence for an increased drift rate (speed of information processing; see Voss, Nagler, & Lerche, 2013) for angry-dominated crowds for individuals with higher levels of fear of rejection. Therefore, individuals scoring high in fear of rejection accumulated information faster from crowds dominated by negative faces. Furthermore, individuals with a lower fear of rejection who were frustrated showed a prior bias (i.e., shifted starting point of the diffusion model) for the positive rather than negative mood in contrast to the more fearful individuals. With this study, we were able to combine the newly developed task with diffusion modelling. These findings emphasize that although the happiness superiority effect assumes a general perceptual advantage for happy facial expressions – suggesting that stimulus characteristics drive perception – individual motives can also have the power to influence emotion perception.

In the last manuscript, we manipulated the attractiveness of the presented faces, as this factor is mostly neglected in visual search experiments with human faces; however, it has an essential influence on emotion perception (Lindeberg et al., 2018). In two carefully controlled experiments, we tested the evaluative congruence account (Hugenberg, 2005; Hugenberg & Sczesny, 2006) and found faster and more accurate judgements in attractive crowds dominated by happy faces and unattractive crowds dominated by angry faces. Individuals perceived attractive crowds as happy more frequently whereas they judged unattractive crowds as angry more often. With these four studies, we were able to underline the fact that both bottom-up (stimulus-driven) processes (Yantis, 1993) as well as top-down (observers' motives) mechanisms (Theeuwes et al., 2010) influence mood perception.

8.2 The Importance of Multiple Target Paradigms and Future Research

One major goal of developing the mood-of-the-crowd paradigm was to create an experimental setting that closely resembles everyday situations and thus entails a higher ecological validity. However, although using multiple target emotions enhances the representativeness of the paradigm, there are other possibilities for further increasing the generalizability of this paradigm. Embedding faces in a physical context (e.g., the background scene; Noh & Isaacowitz, 2013) or presenting dynamically changing facial expressions instead of static faces (Isaacowitz & Stanley, 2011) would further increase the ecological validity of the crowds. Moreover, it is necessary to test this paradigm using different set-sizes and sources of stimulus material. Although we already tested the paradigm with faces from different sources – like the realistic faces from the KDEF (Lundqvist, Flykt, & Öhman, 1998) and Chicago Face Database (Ma et al., 2015) as well as the computer-generated material by Becker et al. (2011) – it is essential to further test the robustness of the findings with other stimulus material.

Another advantage of using multiple target paradigms is that target and distractor effects are separable and that such tasks are more suitable for gaze analysis as the search process is not affected by the location of a single target emotion – thus leading to naturalistic and self-regulated eye movements. The combination of behavioral measures and eye-tracking analysis helps to understand the locus of perceptual biases in such paradigms more thoroughly. As previously stated, it is possible that effects manifest in gaze movements (e.g., an increased probability of fixations on positive emotional expressions), thus indicating that a preferential focus on specific emotions guides emotion perception. This would suggest, for example, that individuals efficiently detect happy faces because happy expressions attract attention to a stronger degree compared to negative emotions. Because individuals seek to retain an emotional well-being, this approach tendency towards positive emotions might explain differences at the early stages of emotion perception (Roelofs et al., 2010). However, when no difference is observable in gaze movements (equal number of fixations on different types of emotions), but the final judgement is nevertheless biased towards one emotion; this would suggest a bias in the evaluation phase – indicating a reappraisal of the inspected faces. To conclude, using multiple target emotions and thus enabling to additionally implement gaze analyses, helps to gain a deepened understanding of where to pinpoint effects in visual search paradigms.

Although we tested the newly developed paradigm in terms of general perceptual biases and regarding the influence of diverse moderators in different experimental settings, there are several directions that should be pursued in future investigations. In the first manuscript, we were able to find support for the happiness superiority effect but did not investigate state moderators. Participants' motivational or affective states need consideration in future projects. There is consistent evidence for a strong counter-regulation mechanism in human beings (e.g., Rothermund, Voss, & Wentura, 2008; Wentura, Voss, & Rothermund, 2009) that emphasizes a more efficient perception of happiness when in negative emotional or motivational states whereas the opposite reveals when individuals are in positive states. However, other empirical findings support the assumption that negative as well as positive mood induction leads to a preferred focusing of happy facial expressions (Sanchez, Vazquez, Gomez, & Joormann, 2014). To contrast both hypotheses, it would be interesting to use the mood-of-the-crowd paradigm to test the influence of a preceding mood induction on the happiness superiority effect. More generally, as we did not control for possible mood differences of the participants prior to our experiments, we cannot rule out the possibility that mood differences affected our results. Thus, it is necessary to statistically adjust for participants' general mood in prospective research projects.

Regarding the second manuscript, in which we investigated age differences in emotion perception, there are also several modifications that should be considered in future studies. First, the recruitment of participants of older age – especially for experiments using eye-tracking procedures – is a major challenge. Therefore, studies are often underpowered and this restricts the transferability to the general population. Although larger sample sizes require effortful and cost-intensive recruitment, a replication of the age study in the second manuscript would be desirable. A replication of this study with a larger sample would render it possible to test the stability of the findings, which were contrary to the assumptions of the socioemotional selectivity theory. Another important modification of the present mood-of-the-crowd task in the context of an age-stratified sample would be the use of young and old emotional target faces. Ebner, He and Johnson (2011) found that younger and older participants fixated longer on own-age faces, which in turn predicted a better emotion identification for pictures of the same age. This own-age effect in visual inspection – reflecting a higher social relevance of own-age individuals – might also play a role in the current study and might explain why we were not able to find a potentiated happiness superiority effect in older adults. Even though we presented possible explanations for our results (higher cognitive demands of the task, decreases in inhibitory processes in older adults), it is possible that the postulated positivity bias in older individuals is only apparent when using age-congruent emotional facial expressions, which should be of focus in future investigations.

In the third manuscript, the focus was to investigate the role of fear of rejection on emotion perception. Furthermore, we were interested in testing the counter-regulation approach (Rothermund et al., 2008; Wentura et al., 2009) by showing that a frustration of the need for affiliation leads to a bias towards happy expressions, whereas the satisfaction of the affiliation need should result in a biased perception towards angry faces. However, we only used two different conditions in our experiments and did not include a real baseline or control condition that enables testing differences of the experimental conditions against this baseline. In future studies, the inclusion of a further control group with no affiliation-relevant feedback (but, for example, competence-relevant feedback) or no feedback at all would be necessary to test the counter-regulation approach more concisely.

With regard to the last manuscript, that aimed to investigate the influence of attractiveness on emotion perception, we found consistent evidence of a biased perception towards happiness in attractive crowds and towards anger in unattractive crowds. Consistent across both experiments, happy attractive faces as well as angry unattractive faces received higher emotional intensity ratings compared to happy unattractive and angry attractive faces. Because it is possible that the difference in attractiveness not only affected the performance in the mood-of-the-crowd task but also the emotional intensity ratings of the face pictures, it is necessary to ensure equal emotional intensities in future experiments. One possibility would be to implement machine-learning approaches such as a *Generative Adversarial Network* (GAN; see e.g., Goodfellow et al., 2014) that can be trained to generate new faces. Moreover, these architectures cannot only be used to generate faces, but also to gradually change the intensity of emotional expressions (e.g., smile) or to convert specific emotional expressions from neutral faces in a standardized manner (Gauthier, 2014). Another interesting aspect that deserves consideration in future research projects would be the investigation of participants' self-perception of their own attractiveness. Sim, Saperia, Brown and Berinieri (2015) suggest that individuals' self-perceived own attractiveness influences the degree to which they perceive another person's attractiveness. It is possible that especially individuals who perceive themselves as highly attractive might judge attractive crowds more favorably compared to unattractive crowds whereas this effect might be reduced for persons who rate themselves as being less attractive. It would be interesting to examine the moderating role of participants' self-perceived own attractiveness in future studies examining attractiveness effects on emotion perception.

8.3 The Use of Eye-Tracking Data in Emotion Perception Experiments

In addition to the development of a new visual search paradigm incorporating multiple target emotions, another major goal of this thesis was to derive new insights into perceptual processes by the application of eye-tracking analyses in this paradigm. Response times and responses only show the final decision of the participant and the speed of decision-making but cannot expose underlying mechanisms that led to the eventual judgement. Although the use of eye-tracking allows for investigating these underlying mechanisms, the implementation of gaze analyses brings some main challenges with it. First, it is necessary to evaluate whether an eye-tracking procedure is suitable for a specific task. As outlined earlier in this thesis, single-target visual search paradigms are less suited for eye-tracking analyses as individuals cannot decide freely how much information (e.g., faces) they want to consider until they reach their final decision. In the face-in-the-crowd paradigm, for example, the position of the target emotion determines the search process most strongly. This is not the case in the mood-of-the-crowd task, where individuals can freely choose how many faces they inspect until they decide to judge the mood of the presented crowd. Another challenge in visual search tasks is the question of how to arrange the stimulus material. In the majority of previous experiments, the presented crowds were allocated in a circle or in a matrix (e.g., Hansen & Hansen, 1988; Juth et al., 2005; Pinkham et al., 2010; Savage et al., 2013). The reason behind this presentation was to ensure equal distances between the fixation cross (displayed in the center of the screen) and the surrounding face pictures. However, arranging the pictures in specific patterns (e.g., a matrix or a circle) guides participants' gaze movements (e.g., row-wise or clockwise) and, undermines a realistic presentation of a crowd. Based on this argument we used a random allocation of stimuli in all our experiments. A third challenge becomes evident when deciding which stimulus material to use. On the one hand, realistic face pictures enhance the generalizability of the experimental findings but do not always allow for comparability between the displayed emotional intensities of the different emotions (Goeloeven et al., 2008). On the other hand, when ensuring equal emotional intensity of the contrasted emotions, for example when implementing computer-generated material (Becker et al., 2011), this trades internal for external validity and impairs the representativeness of the crowd. Thus, it is highly necessary to compare perceptual biases when using different stimulus materials. Fourth, the selection of the eye-tracker itself needs to be considered. While older models are extremely cumbersome and require the participant to stay in a specific position during the completion of the experimental task, newer models are attachable on the lower part of the computer or laptop monitor. This creates a more naturalistic way to work on the task for participants and prevents from placing the focus on the eye-tracker in the experimental setting.

The above-mentioned challenges mainly refer to the selection of the paradigm, the stimulus material, and the experimental design. Additionally, the eye-tracking procedure itself also poses many challenges that require consideration. One major issue concerns the choice of suitable fixation criteria. There is no consensus about the exact duration of a fixation. Some researchers argue that fixations usually vary between 50 and 250 ms (Holmqvist et al. 2011). However, there is also evidence that a temporal threshold of 100 ms is necessary to effectively discriminate fixations from other oculomotor activity and to therefore reach a better classification of fixations (Manor & Gordon, 2003). Another difficulty lies in the determination of the areas of interest with regard to the face pictures. It is possible to allow a small tolerance around the pictures to avoid missing fixations on the pictures. This, on the one hand, can lead to allowing fixations that were not necessarily located on a specific stimulus. On the other hand, deciding not to use any tolerance might result in misses of fixations because of imprecisions in terms of the eye-tracking procedure. Yet, there is no explicit approach how to find the best trade-off between using a too liberal or too conservative area of interest.

Lastly, there is another challenge when it comes to deciding which eye-tracking variables should be used to uncover underlying mechanisms in emotion perception. As mentioned earlier in this thesis, there is a multitude of variables that can be calculated once the eye-tracker has recorded and saved participants' gaze movement coordinates. The variable "number of fixations", for example, assesses how many stimuli individuals focus on until they reach their decision and thus allows for uncovering the search strategies of the participants. A fixation duration, alternatively, informs about the individuals' inspection time and might serve as an indicator of the speed of information processing. However, there is a multitude of other variables (e.g., hit rate of the first saccade on the target/distractor, saccadic latency, etc.) that deserve consideration when selecting the variables of the eye-tracking analyses.

Although the tracking of gaze movements provides an opportunity to obtain "objective" measures of perception, the interpretation of findings nevertheless remains inconclusive. A higher number of fixations on happy compared to angry expressions might indicate that individuals' preferences guide attention. Alternatively, it is also possible that individuals are more conservative with respect to that specific emotion and need to collect more information until they want to make their decision. With regard to the variable "fixation duration", the reasons for a longer fixation duration can also be manifold: Individuals can fixate stimuli, for example, because they are interested in them, or because they have more difficulty understanding them (Was, Sansosti, & Morris, 2017). Nevertheless, the integration of eye-tracking in response time experiments helps to better localize whether effects occur during the inspection phase or in the evaluation phase. It is possible that individuals' judgements are biased towards one emotion because they preferentially fixate on that emotion. However, it is also possible that individuals inspect the same amount of information from both emotions, but their final decision points towards one specific emotion. Without the assessment of eye-tracking, these differentiations would not be possible to make. An interesting idea for future research would be to use joint modelling of eye-tracking data and other sources – like diffusion model data – in one model (Krajbich, Armel, & Rangel, 2010).

Throughout this thesis, several experiments have been conducted which enabled us to shed more light on the relation of behavioral and eye-tracking data. Considering both measures is crucial to draw conclusions about the underlying cognitive processes that otherwise (only considering a single source of information) stay hidden. For instance, in the first two experiments of Manuscript 1, we consistently found evidence for a higher number of fixations on happy expressions and more accurate judgements in happy crowds. Interestingly, whenever angry crowds were presented, there was a positive association between fixation duration and accuracy rates. However, no such correlation was found for happy crowds. The fact that a link between behavioral data (accuracy of judgments) and eye-tracking (fixation duration) could only be observed in angry crowds helped us gain a better understanding of participants' emotion perception. Concretely, results suggest that in order to correctly evaluate angry crowds, a longer fixation is necessary. Manuscript 3 constitutes another example of the importance of taking both sources of information, namely behavioral and eye-tracking data, into account. Briefly stated, we found evidence that fixation durations as well as diffusion model parameters were affected similarly by individuals' fear of rejection. This indicates that both on the attentional level as well as during information processing and decision-making, individual differences in fear of rejection had an influence.

Whereas the previous two examples were cases in which similar patterns of results between behavioral data and eye-tracking was found, the opposite was true in Manuscript 2. In Manuscript 2, we revealed that older adults fixated on happy and angry expressions to the same degree, but judged the crowd as being angry more frequently. These results suggest a biased processing of information, as older individuals retrieve the same information when inspecting the crowd of faces, but their final decision is nevertheless biased towards the angry response. Therefore, the negative information (angry expressions) seems to influence the final decision more strongly compared to the positive information (happy expressions) in the oldest age group. We found a similar pattern of findings in Manuscript 4 when we revealed that attractive crowds were judged as happy and unattractive crowds as angry more frequently, although this did not translate consistently into the eye-tracking measures. Therefore, we argue that differences in mood judgements in attractive compared to unattractive crowds manifest more strongly in the evaluation phase and are not due to perceptual preferences.

All in all, it has to be emphasized that the additional analyses of gaze movement allow for localizing whether effects occur during the information collection phase, during the decision making phase or both. The interplay of eye-tracking and behavioral measures thus helps gaining a better understanding of the underlying processes in emotion perception.

To conclude, although there are many challenges associated with the use of eye-tracking in experimental psychology, eye movements nevertheless provide insights into many psychological processes – like problem solving, reasoning or visual search. Many different domains in scientific research such as experimental psychology, neuroscience or computer science can profit from the additional integration of gaze analyses (Mele & Federici, 2012). Given the remarkable improvements in eye-tracking technologies and software over the past decades, the reliability and precision of this method allow for gaining insights about underlying cognitive processes in emotion perception. The integration of different sources of data is always beneficial to reach a greater understanding of the findings.

9 Summary and Conclusions

Within this thesis, I was able to test the newly developed mood-of-the-crowd paradigm in terms of the examination of general biases in emotion perception as well as with regard to the investigation of possible moderators at the stimulus and person level. We found evidence for the happiness superiority effect when participants' task was to judge the overall mood of the crowd. Furthermore, we conducted a study to test the new paradigm in an age-stratified sample, revealing evidence for a perceptual bias for happy faces in young adults, but not in older individuals. Furthermore, we were interested in moderators at the person level, investigating the mood-of-the-crowd paradigm in terms of the affiliation motive while additionally integrating diffusion model analyses. We found evidence for an increased drift rate (speed of information uptake) in crowds dominated by angry faces for individuals scoring high on fear of rejection. Additionally, we observed a prior bias towards happy moods for individuals who were less fearful of rejection and who received a negative feedback on their future belonging. Lastly, we investigated a potential influence of stimulus attractiveness on emotion perception. Participants consistently judged crowds of attractive faces more positively compared to unattractive crowds. Moreover, judgments were faster and more accurate when attractive crowds included more happy faces and when unattractive crowds showed more angry expressions.

We were not only able to outline the benefits of this new paradigm (higher ecological validity, disentangling between target and distractor effects, and higher suitability for gaze analyses) but could further test its validity in terms of the investigation of different research areas. Moreover, due to the combination of eye-tracking and behavioral data, we were able to better pinpoint the locus of perceptual biases and highlight the importance of integrating different sources of data. This thesis provided a first step in studying this new paradigm and combining it with eye-tracking analyses. Future research projects are necessary to further improve the ecological validity of the task (integration of a background scene, use of dynamic stimuli, etc.) and to test the stability of the presented findings when applying different stimulus materials, experimental settings or eye-tracking criteria.

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Appendix A1

Manuscript 1: Judging the mood of the crowd: Attention is focused on happy faces.

Bucher, A., & Voss, A. (2018). Judging the mood of the crowd: Attention is focused on happy faces. *Emotion*. https://doi.org/10.1037/emo0000507

Judging the mood of the crowd:
Attention is focused on happy faces

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Abstract

Previous research on valence biases in face perception revealed inconsistent findings either proposing angry or happy faces to be detected more efficiently. We argue that the typical experimental task in this field, the face-in-the-crowd (FiC) paradigm, leads to ambiguous results. In the present paper, we introduce a new task, the mood-of-the-crowd (MoC) paradigm that can complement existing FiC findings. In the new task, participants have to decide which expression is shown by most faces in a crowd. In Experiment 1, photographs were used as stimuli, whereas computer-generated faces were presented in Experiments 2 and 3. While in the Experiments 1 and 2 crowds consisted of faces showing either happy and neutral expressions or angry and neutral expressions, in Experiment 3, crowds were composed of both angry and happy faces. Attentional processes were assessed with gaze recordings. Across the first two experiments, results indicate that happy faces are attended to with higher probability, and that the predominance of happy faces is assessed more accurately compared to the predominance of angry faces. In the last experiment, happy faces were focused on longer compared to angry expressions. Moreover, gender of presented faces was found to be an important moderator: There was a clear bias to classify female crowds as emotional (happy or angry). Additionally, the emotionality of female crowds was assessed more accurately.

Keywords: emotional expressions, visual search, anger superiority, happiness superiority, mood-of-the-crowd effect

Judging the mood of the crowd: Attention is focused on happy faces

The identification of emotional expressions is one of the most prominent mechanisms helping individuals to judge other people's intentions and to predict their behavior (Calvo & Marrero, 2009). During the last decades, many studies have been conducted to shed light on the question, whether angry or happy facial expressions are detected more efficiently. For this purpose, often one emotional expression was presented in a crowd of neutral faces. Hansen and Hansen (1988) introduced the face-in-the-crowd (FiC) paradigm and presented results suggesting an angry-superiority effect (ASE). Accordingly, angry faces were detected faster and more accurately compared to happy expressions. Although some later studies replicated the original findings (Öhman, Lundqvist, & Esteves, 2001; Pinkham, Griffin, Baron, Sasson, & Gur, 2010), there are others indicating an advantage for happy facial expressions, the so called happy-superiority effect (HSE; Becker, Anderson, Mortensen, Neufeld, & Neel, 2011; Savage, Lipp, Craig, Becker, & Horstmann, 2013). Becker et al. (2011) uncovered problems regarding the stimulus material used in previous FiC experiments. The reported ASE seems to be limited to schematic faces that clearly lack ecological validity, while studies using photographic or computer-generated stimuli often found evidence for a more efficient visual search for happy faces (e.g., Becker et al. 2011).

While the FiC paradigm is a very valuable tool for research on automatic attention for emotional faces, and has successfully fostered this line of research for many years, we argue that in the FiC paradigm target effects are confounded with crowd effects and therefore results remain ambiguous: It is not completely clear what a fast identification of – for example – a negative face in a crowd of positive faces means: The standard interpretation is that attention is automatically and quickly directed to a threatening target (or, in a reverser stimulus set, captured longer by threatening distractors), thus indicating a processing advantage for negative information. However, the same pattern of results could be based on a fast evaluation of happy (distractor) faces. Following this explanation, the negative target is found quickly because short fixations on distractors are sufficient to identify their valence. Thus, the second explanation suggests a processing advantage for positive information. The same ambiguity remains of course for studies finding a happy-superiority effect. To put it in a nutshell, it remains unclear whether the detection advantages for specific emotional expressions found in previous studies might be due to a quick and direct focusing of the target or a fast evaluation of the distractors. Furthermore, the search for target emotions in crowds is not the only way in which people engage with crowds of faces. Another line of research addresses the question how people estimate the average mood of a crowd (Haberman & Whitney, 2009; Elias, Dyer, & Sweeny, 2017). In the present paper, we make a link to this kind of research by using more than one emotional target presented in the set of faces. Although the FiC paradigm is an ecologically valid method to research emotional face processing – as the perception of an emotionally divergent face plays an important role in people's lives – it is promising to expand this research to other contexts. Crowds with more target emotions are typical for daily life situations, for example when giving a speech in front of a class.

With the present study we want to add new insights on the perception of emotion by using a similar setup as the FiC paradigm but using another task: In our studies, participants have to evaluate the overall "mood" of a crowd of faces showing different expressions. Despite a lot of studies focusing on the FiC effect, no study has ever raised the question whether there might be an advantage for happy or angry faces when judging more than one emotional face in a crowd of neutral faces. If happy faces are detected more efficiently, the mood of a predominantly happy crowd should be judged more accurately and perhaps also faster. With this new paradigm we avoid possible interactions of target vs. distractor effects (because now all members of the crowd are targets that inform about the correct response) in the investigation of emotional attentional asymmetries.

Our study is the first one to systematically investigate the attentional differences regarding judgements of happy versus angry moods. The next sections of the introduction are organized as follows: First, we will give an overview of the literature investigating advantages for happy and angry single faces in a crowd of neutral ones. Then, we address the questions whether the FiC effect can also be expected when assessing crowds with more than one emotional face, and which emotion should be judged more efficiently. Lastly, to gain insight about the attentional processes, we will take into account eye-tracking data establishing the possibility to figure out why certain emotions have a discrimination advantage.

The Face-in-the-Crowd Effect

When interacting with other human beings, the rapid identification of emotional expressions is essential to decide whether to approach or avoid another person (Juth, Lundqvist, Karlsson, & Öhman, 2005). For example, the perception of anger might be a signal to keep distance from that person in order to prevent being attacked and hurt. It has often been argued that fast and efficient responses to threats bring an evolutionary advantage (e.g., Pratto & John, 1991). However, we argue that the same argument is valid for positive stimuli (i.e. chances to improve the actual situation) as well. From an evolutionary perspective, the fast perception of all action relevant stimuli – whether positive or negative – is equally important (Wentura, Rothermund, & Bak, 2000).

In their seminal study, Hansen and Hansen (1988) asked participants to inspect arrays of faces and to indicate whether or not a target was present that differed in emotionality from the rest of the crowd. There was a clear advantage for detecting angry faces in neutral or happy crowds compared to happy faces surrounded by neutral or angry expressions. Importantly, larger crowds did not substantially impair people's ability to detect angry faces, suggesting a pop-out of the negative emotion. Later, the study by Hansen and Hansen (1988) was criticized for a confound in the stimulus materials (Purcell, Stewart, & Skov, 1996), but results from subsequent studies based on schematic faces were consistent with the ASE (Öhman et al., 2001; Horstmann & Bauland, 2006). A major concern raised by the use of schematic stimuli, however, is a potential lack of external validity. Schematic faces exaggerate the expressed emotions and lead to extremely homogenous crowds, which is untypical for real world crowds (Pinkham et al., 2010). Moreover, it cannot be guaranteed that the more efficient detection of angry faces is based on the emotional expression of the faces. The observed results might also reflect a feature-based effect based – for example – on the exaggerated shape of eye-brows and mouths in schematic faces (Purcell & Stewart, 2010).

Further studies addressed these methodological problems associated with the application of schematic faces. In a very detailed replication of the FiC effect, Becker and colleagues (Becker et al., 2011; Craig, Becker, & Lipp, 2014) found evidence that happy faces, not angry faces, were detected faster and more accurately when using photographic stimuli or realistic computer-generated faces.

Different theoretical accounts can explain a HSE. Becker et al. (2011) take an evolutionary account that focuses rather on the facial expression than on emotion perception: They speculate that in the course of evolution the expression of happiness became more visually discriminable thus making its communicative intent more efficient. Another explanation for the HSE considers the frequency with which we encounter happy and angry faces in real live. The idea here is similar to the word-frequency-effect (Oldfield & Wingfield, 1965): High-frequent words which are used more often in a language can be recognized more efficiently compared to low-frequent words. It is assumed that the accessibility of positive expressions is increased, because we interact more often with friendly and smiling persons, and thus happy faces can be identified faster. Yet another completely different explanation for an HSE is provided by the so-called density hypothesis (Unkelbach, Fiedler, Bayer, Stegmüller, & Danner, 2008): Unkelbach and colleagues assume that positive information is processed faster because it is generally more similar to other positive information, while negative information is thought to be more heterogeneous: Following this line of argumentation, positive emotions are easier to assess because there is less variance in individual positive facial expressions, compared to individual negative expressions. Finally, motivational accounts could explain a bias in emotion perception: When a person hopes to encounter friendly people, a top-down control of attentional processes could trigger the search for smiling faces (cf. Voss, Rothermund, & Brandtstädter, 2008; Voss & Schwieren, 2015).

In the present research we are interested in the interplay of attentional processes and decision making. Thus, we assess the processes leading to a global judgment made across a set of separate stimuli. This process has been investigated before under the label *ensemble coding*. Ensemble coding describes an adaptive mechanism that allows individuals to effectively represent a large amount of information (Chong & Treisman, 2003). It was shown, for example, that observers could precisely estimate the mean size of dots, presented in a cloud of dots with varying sizes, although they did not manage to represent the size of the individual dots (Ariely, 2001). More directly related to our studies, Haberman and Whitney (2009) showed that – although participants could not remember the individual emotional expressions – they were able to represent the average emotion of the displayed expressions. This suggests that individuals consider the “big picture” when judging the mood of a crowd instead of storing single facial expressions. There is also literature on ensemble coding with regard to the evaluation of different emotional expressions. Elias et al. (2017) evaluated differences in sensitivity for judging emotions of crowds with happy, angry and fearful faces when facial expressions changed dynamically within trials. The authors could reveal that the average intensity estimates of happy dynamic faces were more precise compared to the other two emotions. The higher precision of intensity estimates for happy faces was revealed both for individual faces presented alone, as well as for crowds of multiple faces presented simultaneously. Although the results of Elias et al. (2017) were not specific to crowd perception, this study is a good reference point for our research. With our new paradigm, we want to connect to these findings by using static emotional expressions. Furthermore, we are not only interested in the accuracy or precision of the mood judgments but also in the decisional speed and the underlying processes uncovered by the means of eye-tracking analyses.

The Current Study

With the present studies, we aim to test the robustness of the previously reported HSE in another paradigm, and to investigate the relation of attentional processes and decision-making. Specifically, we apply an evaluation task where all presented stimuli are relevant for choosing the correct response, instead of the previously more often used search task. The present task is better suited for gaze analyses because the inspection of the stimulus set is not terminated abruptly as soon as a target is detected. For the new MoC task, several happy or angry faces are shown in a crowd of neutral faces (Exp. 1 and 2), or happy and angry faces are combined within one crowd (Exp. 3). The participants' task is to evaluate the dominating mood of the crowd, that is, to decide whether more faces show an emotional or a neutral expression (Exp. 1 and 2), or whether more happy or more angry faces are present (Exp. 3).

The main objective of the present study is to test whether the previously reported HSE – found in the FiC paradigm – also prevails in the newly developed MoC task. We assume that happy faces attract more attention, and therefore happy faces should have a larger impact on mood judgements compared to angry faces. Hence, we suppose happy moods to be judged more efficiently compared to angry moods. Furthermore, two different kinds of material were used to control for methodological confounds: In Experiment 1, we used realistic photographs that have a higher representativeness. In Studies 2 and 3, computer-generated faces were employed to allow for a better control of the intensity of emotional expressions.

Most important, not only accuracy and response times are analyzed, but also eye tracking data was assessed to get insights in attentional processes underlying the observed responses. We expect a HSE both for attentional processes and for responses. On the attentional level, there should be a preference for fixations on happy faces compared to angry faces. This assumption can be derived from previous findings on search asymmetry favoring happy faces (Becker et al., 2011; Craig, Becker, & Lipp, 2014). Moreover, we expect shorter durations of fixations on happy compared to angry faces, indicating a faster processing of happy expressions (McKelvie, 1995). This idea is supported, for example, by a study of Miyazawa and Iwasaki (2010) who report clear evidence that happy faces capture less attention compared to angry faces, indicated by a smaller attentional blink effect for happy faces. Blanco, Serrano-Pedraza and Vazquez (2017) report evidence that the fixation advantage was larger for happy faces with exposed teeth compared to happy expressions with covered teeth. Participants were faster focusing the happy picture with exposed teeth in comparison to the happy expression with covered teeth. Hence, we predict that shorter fixation duration times for happy faces should be more pronounced when using real photographs instead of the computer-generated material where teeth were not exposed. On the behavioral level, the expected fast and efficient processing of happy faces is expected to improve the classification of happy/neutral crowds compared to the classification of angry/neutral crowds. It remains an open question, whether the expected HSE additionally leads to a general classification bias, that is, the tendency to prefer “happy” or “angry” responses, independent of the current stimuli.

It is also plausible that gender of the presented faces will moderate attentional processes and judgments. Therefore, we present crowds of male and female faces in different trials. There is a large body of research indicating a close connection between femininity and emotionality (Brody & Hall, 1993; LaFrance & Banaji, 1992). Women are perceived to express and experience emotions to a greater degree than men. In addition, previous studies found that happy female faces and angry male faces are detected more efficiently (Becker, Kenrick, Neuberg, Blackwell, & Smith, 2007; Öhman, Juth, & Lundqvist, 2010) due to the stereotype that happiness is more expressed and therefore closer linked to females, whereas anger is perceived to be more tied to males (Plant, Hyde, Keltner, & Devine, 2000). Thus, we expect the HSE to be enlarged for female crowds based on the association between femininity and happiness. This stereotype should lead to an increased discrimination advantage for happy female faces as happy female faces are expected to be more accessible compared to happy male faces. In male crowds, however, we assume that the HSE is – at least partially – counteracted by a threat bias, because the threatening potential might be perceived to be stronger in male crowds.

Experiment 1

The aim of this experiment was to test whether happy or angry moods can be identified more accurately and faster. Additionally, we investigated on which emotional expressions gaze fixations occurred more often and with shorter durations. In this experiment, we used photographs from the Karolinska Directed Emotional Faces (KDEF; Lundqvist, Flykt, & Öhman, 1998) data set as stimuli.

Method

Participants. Thirty-one participants (23 females, $M_{age} = 26.52$, $SD_{age} = 8.16$) who were registered as members of a participant pool at a German university participated in exchange for course credit or financial compensation.[1]

Stimuli and materials. Portrait photos of 35 males and 35 females showing angry, happy and neutral expressions from the KDEF database were used as stimuli. The experiment was run on a Dell laptop computer. Stimulus displays and response time measurement were controlled by a C program using the SDL libraries (www.libsdl.org). Gaze position was

[1] For all three experiments, we determined the required sample size a-priori. The number of analyzed datasets differs slightly from the a-priori planned sample sizes because data from some participants whose performance was at chance had to be removed. To determine the required sample sizes for Experiments 1 and 2, the numbers of participants in different studies investigating the FiC effect (Becker et al., 2011) were used as reference. The reason for this strategy was that power analyses for interactions of repeated-measurement factors are not feasible using G*Power 3. As our main hypotheses require testing the interaction between emotion and valence, we could not use this tool to determine the required sample size. Considering the effects observed by Becker et al. (2011), a sample size of 30 participants is assumed sufficient for reliable tests for attentional differences between angry and happy moods. For Experiment 3, paired t-tests are additionally required. An a-priori power analysis using G*Power 3 revealed a required sample size of 45 participants for a power of 95% assuming a medium effect size and an alpha-value of .05. We assumed a medium effect size, as there are only few experimental designs which are comparable with the MoC task. In Elias et al. (2017), which is most comparable to our method, a medium effect of emotion on sensitivity was revealed ($d = .51$).

recorded using a SMI RED250MOBILE eye-tracker. Participants' eye movements were recorded at a frequency of 250 Hz. Fixations were detected using the SMI Event Detector tool (minimal duration was 80 ms and maximal dispersion was 100 pixel). We analyzed all fixations on the presented faces with a maximum tolerance of 30 pixel (0.5 cm).

In each trial, a crowd consisting of 20 face pictures (each 1.4 cm x 1.9 cm) was shown. Faces were randomly located on the screen (34.5 cm x 19.5 cm) with a light-grey background. A minimum distance between pictures was enforced to avoid overlap (minimum distance was 3.4 cm). We preferred a random allocation of the stimuli because arranging the pictures in specific pattern (e.g., a matrix or a circle) might on the one hand guide the participants' gaze movement (e.g., row-wise or clockwise) and, on the other hand, would undermine a realistic presentation of a crowd. In each crowd, faces from 20 different individuals were randomly chosen from the available 35 female or male pictures.

Design. Each crowd was composed of either only female or only male faces, and always only one emotion (happy or angry) was combined with neutral expressions. The number of emotional faces within the crowds was varied in four steps (7, 9, 11 and 13). Thus the design of Experiment 1 comprised the within-participants factors gender of the crowd (female vs. male), emotion (happy vs. angry), and number of emotional faces.[2]

Procedure. Participants were greeted and seated approximately 60 cm in front of the laptop computer. They were informed about the upcoming task and the possibility to stop the experiment at any time.

The experiment comprised one practice block of 16 trials and 3 experimental blocks of 50 trials each. Trials from practice blocks as well as 2 warm-up trials at the beginning of each experimental block were excluded from the analyses. In the remaining 48 experimental trials of each block, the 16 trial types (gender x emotion x number of emotional pictures) were

[2] In exploratory analyses, we included participants' sex as an additional between-subject factor. However, because participants' sex did not show any effects, we eliminated this factor for the presented analyses. The robustness of this Null-effect is of course disputable, because only 8 men participated.

presented 3 times in random order. Before each trial, participants were informed by a cue whether happy or angry faces were shown in the next crowd. This was done to reduce the probability of confusing neutral and emotional expressions. Then, a fixation cross was presented in the middle of the screen before the crowd was displayed. The crowd remained visible until the participant responded or 10 seconds were exceeded. Participants were instructed to press the S-key when there were more neutral faces in the crowd and the K-key when there were more emotional faces. Participants responded with both hands. There was no counterbalancing of keys for the respective response options.

Results

Separate 2 (target emotion: happy, angry) × 2 (target gender: female, male) × 4 (trial type: 7, 9, 11, 13 emotional faces) repeated measures ANOVAs were conducted to analyze response times and accuracy. For the analyses of the total number of fixations and duration of fixations, the factor valence of the focused picture (emotional vs. neutral) was added.[3] Means and standard deviations of all measures are presented in Table 1[4]. Data from trials with response times faster than 500ms or slower than 10,000ms were excluded from the analyses (0.54% of all trials)[5].

Number of fixations. For each participant, it was computed how many of the presented faces of each type were fixated at least once during a trial. Consistent with our hypotheses, the corresponding analysis revealed significant main effects of valence, $F(1, 30) = 8.29$, $p < .01$, $\eta^2_p = .22$, 95% CI [.04, .40], and emotion, $F(1, 30) = 8.17$, $p < .01$, $\eta^2_p = .21$, 95% CI [.04, .40]. Emotional faces were focused on more often compared to faces with neutral expressions, and, in the happy condition, more faces were fixated in general.

[3] Data from all experiments can be downloaded from https://doi.org/10.11588/data/MES8FE.
[4] In addition to the measures reported here, our analyses originally included also the proportion of fixations (on emotional vs. neutral faces) and proportion of first fixations (on emotional vs. neutral faces). As those variables showed inacceptable low reliability, they were dropped from this paper as advised during the review process. All other recorded measures and all realized manipulations of our studies are exhaustively reported.
[5] We choose these rather liberal criteria to include as many data as possible. Note that the mean response times for the respective trials in this task (with mean response times of about 3.5 seconds) were notably larger than other cognitive paradigms.

Additionally, we conducted separate t-tests to compare which type of faces was fixated more often when comparing the two emotion conditions. Results revealed that happy faces were fixated more frequently compared to angry faces, $t(30) = 3.19$, $p < .05$, $d = .57$, 95% CI [.07, 1.09], whereas there was no significant difference between the amount of fixations on neutral faces when comparing the happy and angry condition, $t(30) = 1.69$, $p = .40$, $d = .31$, 95% CI [-.19, .81].[6] Additionally, there was an effect of trial type, $F(3, 90) = 4.76$, $p < .01$, $\eta^2_p = .14$, 95% CI [.03, .23], with a pronounced quadratic trend, $F(1, 30) = 7.82$, $p < .01$, $\eta^2_p = .21$, 95% CI [.03, .39], that indicated an increased number of fixations in difficult trials, that is, in crowds with similar numbers of emotional and neutral faces. Finally, a trivial interaction effect of trial type and valence emerged, $F(3, 90) = 239.46$, $p < .001$, $\eta^2_p = .89$, 95% CI [.85, .91], based on a higher number of fixations on emotional faces when more emotional faces were presented. No other effects reached significance, all $F < 1.93$, $p > .13$, $\eta^2_p < .06$.

Duration of fixation. Mean durations of gaze position on each fixated face were calculated for each participant and each factorial combination. In case of multiple fixations on (different parts of) the same face, the total duration was entered into the analyses. There were significant main effects of target emotion, $F(1, 30) = 15.68$, $p < .001$, $\eta^2_p = .34$, 95% CI [.12, .51], and valence, $F(1, 30) = 23.35$, $p < .001$, $\eta^2_p = .44$, 95% CI [.20, .59]. Gaze remained longer on emotional faces compared to neutral expressions, and the faces were focused on longer in the angry condition in general. We conducted separate t-tests to reveal which faces were fixated shorter comparing the happy and angry condition. Fixations on happy faces were shorter compared to fixations on angry faces, $t(30) = -3.15$, $p < .05$, $d = .57$, 95% CI [.04, 1.05], and fixations on neutral faces were shorter in the happy compared to the angry condition, $t(30) = -3.57$, $p < .01$, $d = .64$, 95% CI [.13, 1.15], suggesting a

[6] The hypothesized interaction between valence and emotion regarding the number of fixations was significant only in Experiment 2. Thus, we tested whether this interaction differed between the two experiments. When including the factor experiment number (two categories), no significant 3-way-interaction was revealed, $F < 1$, indicating the same tendency of interaction in both experiments.

discrimination advantage in the happy condition. Additionally, gaze remained longer on female faces than on male faces, $F(1, 30) = 11.32$, $p < .01$, $\eta^2_p = .27$, 95% CI [.07, .45]. This main effect was qualified by a valence x gender interaction, $F(1, 30) = 7.44$, $p < .05$, $\eta^2_p = .20$, 95% CI [.03, .38]. Whereas duration of fixations on emotional faces did not vary between male and female targets, neutral female faces were inspected longer compared to neutral male faces (Figure 1a). Finally, there was a significant interaction between target emotion and target gender, $F(1, 30) = 7.65$, $p < .01$, $\eta^2_p = .20$, 95% CI [.03, .39], that was based on increased gaze durations on female faces in angry crowds (Figure 1b). No other effects were significant[7], all $F < 2.56$, $p > .06$, $\eta^2_p < .08$.

Accuracy. Mean accuracies were calculated for each participant and each factorial combination. As expected, a main effect of emotion was found, with happy/neutral crowds being classified more accurately compared to angry/neutral crowds, $F(1, 30) = 15.87$, $p < .001$, $\eta^2_p = .35$, 95% CI [.12, .51]. There was also a trivial main effect of trial type, $F(3, 90) = 19.00$, $p < .001$, $\eta^2_p = .39$, 95% CI [.24, .48], showing a quadratic trend, $F(1, 30) = 151.64$, $p < .001$, $\eta^2_p = .84$, 95% CI [.72, .88]: Mean accuracy was lower when the percentage of emotional faces was closer to 50% (i.e., 9 or 11 out of 20 faces with emotional expressions). These main effects were qualified by a trial type x emotion interaction, $F(3, 90) = 6.20$, $p < .01$, $\eta^2_p = .17$, 95% CI [.05, .27], that is difficult to explain. Contrast analyses indicate different cubic trends of trial type for the happy vs. angry condition, $F(1, 30) = 12.14$, $p < .01$, $\eta^2_p = .29$, 95% CI [.08, .46]. An inspection of Figure 1c suggests that for neutral crowds (i.e., for crowds with less emotional faces) there is a judgmental bias of preferring "non-happy" and "angry" responses. The analyses also revealed a significant interaction of trial

[7] A marginal significant interaction between target emotion and trial type emerged, $F(3, 90) = 2.55$, $p = .06$, $\eta^2_p = .08$, 95% CI [.00, .15], indicating different linear trends of stimulus type for duration of fixation on emotional versus neutral faces, $F(1, 30) = 8.51$, $p < .01$, $\eta^2_p = .22$, 95% CI [.04, .40]. The difference in fixation times was larger between the happy and angry conditions when a smaller number of emotional faces was presented. Furthermore, the interaction between valence and trial type just failed to reach the standard level of significance, $F(3, 90) = 2.41$, $p = .07$, $\eta^2_p = .07$, 95% CI [.00, .15], with a linear trend, $F(1, 30) = 4.88$, $p < .05$, $\eta^2_p = .14$, 95% CI [.01, .30]. The difference in fixation times between emotional and neutral faces was larger when a smaller number of emotional faces was presented in the crowd.

type and target gender, $F(3, 90) = 3.89$, $p < .05$, $\eta^2_p = .12$, 95% CI [.02, .20], again based on a cubic trend of trial type, $F(1, 30) = 6.26$, $p < .05$, $\eta^2_p = .17$, 95% CI [.02, .36]. Female crowds were assessed more accurately when many emotional targets were presented, while male crowds were assessed more accurately when they comprised more neutral faces (Figure 1d). These differences were especially pronounced for trials with nearly the same amount of emotional and neutral trials, but the trend was in the same direction for trials with considerable more neutral or emotional targets. Possibly, floor- or ceiling effects set a limit to the impact of gender in the more easy trials. This pattern suggests a bias for the "emotional" judgments for female crowds and for "neutral" judgments for male crowds. No other effects reached significance, all $F < 1.67$, $p > .21$, $\eta^2_p < .05$.

Response times. Mean correct response times were computed for each participant for each factorial combination. There was a main effect of emotion, indicating a faster response to happy crowds, $F(1, 30) = 4.24$, $p < .05$, $\eta^2_p = .12$, 95% CI [.00, .30]. Furthermore, the effect of trial type reached significance, $F(3, 90) = 4.07$, $p < .01$, $\eta^2_p = .12$, 95% CI [.02, .21], indicating a quadratic trend, $F(1, 30) = 8.23$, $p < .01$, $\eta^2_p = .22$, 95% CI [.04, .40]. As expected, mean response times were longer for difficult trials, that is, for trials with smaller differences between the number of neutral and emotional facial expressions. No other effects were significant[8], all $F < 2.53$, $p > .06$, $\eta^2_p < .08$.

Correlational analyses. Bivariate correlations between accuracy rates and number of fixations as well as fixation durations were analyzed separately for the angry and happy condition (Table 2). In both conditions, a higher number of fixations was associated with more precise mood judgements, $r = .35$, $p = .05$, 95% CI [.00, .63] for the happy condition and $r = .43$, $p < .05$, 95% CI [.09, .68] for the angry condition. When comparing both correlations no significant difference was found, $z(30) < 1$. Furthermore, longer fixation

[8] There was a marginal significant interaction between trial type and emotion, $F(3, 90) = 2.53$, $p = .06$, $\eta^2_p = .08$, 95% CI [.00, .15], with a linear trend, $F(1, 30) = 6.94$, $p < .05$, $\eta^2_p = .19$, 95% CI [.02, .37]. Response times were faster for happy in comparison to angry trials when a small number of emotional faces was displayed.

durations on angry faces were associated with higher accuracy rates for angry moods, $r = .53$, $p < .01$, 95% CI [.19, .73], whereas there was no significant correlation between fixation durations on happy targets and accuracy scores in the happy condition, $r = .06$, $p = .77$, 95% CI [-.30, .41]. The two correlations significantly differed from each-other, $z(30) = 2.02$, $p < .05$.

Discussion

The most important finding of Experiment 1 is the expected HSE that was supported by our data both for attentional processes and for the judgmental outcomes: In the new MoC paradigm, participants made more fixations on happy faces than on angry faces. Fixations on happy faces were also shorter, suggesting a more efficient processing. Moreover, the fixation durations on neutral faces were also shorter in the happy condition, indicating participants' ability to efficiently discriminate neutral from happy faces. Similarly, analyses of responses revealed that participants are faster and more accurate in deciding whether happy faces dominate a crowd, compared to deciding whether angry faces dominate a crowd. Thus, our results go in line with the recent research supporting a HSE using the FiC paradigm with photographic stimuli (e.g., Becker et al. 2011). Interestingly (but not directly related to our hypotheses), the preferred processing of positive information enhances performance in the happy condition, but does not lead to a bias for positive responses. On the contrary, the accuracy analyses suggest that – at least for crowds with only few emotional faces – there might be a negative bias in judgments.

To further explore the associations between attentional processes and judgements, correlations between number of fixations as well as duration of fixations and accuracy of responses were analyzed. Results revealed that the more faces were inspected the higher was the accuracy of responses. More interestingly, longer fixation durations on angry faces resulted in higher accuracy rates for the assessment of angry crowds, whereas this was not the case for happy moods: Here, accuracy of classifications was similar for participants who inspected the happy faces longer or shorter. This implies that long fixations are not necessary for a correct evaluation of happy expressions.

Additionally, we observed interesting interactions with target gender. Accuracy was increased when many emotional targets were present in a female crowd, or when few emotional targets were shown in a male crowd. This suggests that responses were biased by gender stereotypes: Participants expect women to be emotional and men to be neutral and thus classify ambiguous gender-homogeneous crowds accordingly (Brody & Hall, 1993; Fischer & Manstead, 2000; LaFrance & Banaji, 1992). A second, gender related effect was found in gaze analyses: Attention was captured longer on angry female faces compared to happy female and angry male faces. Previous studies propose that happy female faces and angry male faces have a detection advantage (Becker et al., 2007; Öhman et al., 2010) and that happiness is perceived to be more experienced and expressed by females, whereas anger is linked to males (Plant et al., 2000). Thus, we assume that angry female faces are perceived to be unusual and thus capture attention longer, whereas stereotype-conforming happy female faces do not grab attention to the same degree.

Although these results are straightforward, one caveat remains. We do not know whether both happy and angry expressions were perceived with an equal intensity. To control for possible confounds and to test the stability of the present findings, we used standardized computer-generated faces in Experiment 2.

Experiment 2

Using real photos as stimuli trades internal validity for external validity. Several problems of using real photos should be considered: Firstly, although the photos from KDEF are carefully controlled, there might still be some graphical features of the pictures that are confounded with emotionality, and participants might learn to use such features for their responses. Although we consider this to be unlikely, it cannot be guaranteed that the effects found in Experiment 1 are purely based on the expressed emotion. Secondly, and most importantly, the perceived emotionality might differ between happy and angry expressions. To counteract these problems, we used the computer-generated faces from Becker et al. (2011) for Experiment 2.

Method

Participants. Twenty-nine participants (25 females, M_{age} = 23.03, SD_{age} = 4.81) participated in the study in exchange for course credit or financial compensation.

Material. Stimuli comprised 10 male and 10 female computer-generated faces from Becker et al. (2011). Again, for each of the simulated individuals, angry, happy and neutral expressions were used. The emotional faces were generated from faces with a neutral expression and the amount of change that was applied to create the happy or angry one from that neutral expression was identical. The computer-generated faces were rated regarding the intensity of the respective emotions. Angry and happy expressions did not differ significantly in the perceived intensity (Becker et al., 2011). The intensity of lighting and contrast was consistent across each facial expression of the computer-generated material.

Design and procedure. Design and procedure were identical to Experiment 1.

Results

The same set of analyses as in Experiment 1 was conducted. The outlier criteria described above let to an exclusion of 0.43% of all trials. Means and standard deviations of all dependent measures are presented in Table 3.

Number of fixations. There was again a significant main effect of target emotion, $F(1, 28) = 6.64$, $p < .05$, $\eta^2_p = .19$, 95% CI [.02, .38], indicating that overall more faces were fixated in happy trials compared to angry trials. In accordance with our hypotheses, this main effect was qualified by a valence by target emotion interaction, $F(1, 28) = 4.89$, $p < .05$, $\eta^2_p = .15$, 95% CI [.01, .34]: Whereas neutral faces were focused on equally often in happy and angry trials, happy expressions were fixated more frequently than angry expressions (Figure 2a). Trivially, an interaction between trial type and valence, $F(3, 84) = 444.20$, $p < .001$, η^2_p

= .94, 95% CI [.92, .95], with a linear trend, $F(1, 28) = 544.16$, $p < .001$, $\eta^2_p = .95$, 95% CI [.91, .96], indicated that more fixations on emotional targets occurred when more emotional faces were presented and vice versa. Finally, there was a significant interaction of valence and target gender, $F(1, 28) = 10.31$, $p < .01$, $\eta^2_p = .27$, 95% CI [.06, .45], based on the finding that emotional female faces were focused on more often than emotional male faces. On the contrary, more neutral male faces were fixated than neutral female faces (Figure 2b). No other effects reached significance, all $F < 2.11$, $p > .10$, $\eta^2_p < .07$.

Duration of fixation. Mean durations were calculated for each participant and each factorial combination. Like in Experiment 1, there was the main effect of valence, $F(1, 28) = 15.46$, $p < .001$, $\eta^2_p = .36$, 95% CI [.12, .52], indicating that emotional faces were fixated longer than neutral ones. This effect was qualified by the interaction of trial type and valence, $F(3, 84) = 2.96$, $p < .05$, $\eta^2_p = .10$, 95% CI [.00, .18], which was based on different quadratic trends, $F(1, 28) = 5.31$, $p < .05$, $\eta^2_p = .16$, 95% CI [.01, .35]. While for neutral faces the duration of fixation did not depend on the number of presented emotional faces, emotional faces were attended to shorter when there were many emotional faces (Figure 2c). Lastly, there was a significant interaction of trial type with target gender, $F(3, 84) = 2.77$, $p < .05$, $\eta^2_p = .09$, 95% CI [.00, .17], again based on different linear trends of trial type, $F(1, 28) = 8.40$, $p < .01$, $\eta^2_p = .23$, 95% CI [.04, .42]. We investigated the trends separately for female and male targets. For female crowds, there was a significant linear trend of trial type, $F(1, 28) = 15.23$, $p < .01$, $\eta^2_p = .35$, 95% CI [.12, .52], indicating that female faces were fixated longer when the number of presented emotional faces was lower. For male crowds, there was no significant linear trend , $F < 1$ (Figure 2d). No other effects reached significance[9], all $F < 3.88$, $p > .06$, $\eta^2_p < .12$.

[9] A marginal significant effect between valence and target gender emerged, $F(1, 28) = 3.88$, $p = .06$, $\eta^2_p = .12$, 95% CI [.00, .31]. Whereas there was no effect regarding neutral faces, participants fixated female emotional faces essentially longer compared to male emotional expressions.

Accuracy. Mean accuracies were calculated for each participant and each factorial combination. Consistent with our hypotheses and replicating findings from Experiment 1, a main effect of emotion was present, with happiness being evaluated more accurately, $F(1, 28) = 4.39$, $p < .05$, $\eta^2_p = .14$, 95% CI [.00, .32]. The trivial effect of trial type was significant, $F(3, 84) = 35.43$, $p < .001$, $\eta^2_p = .56$, 95% CI [.43, .63], with a quadratic trend, $F(1, 28) = 142.93$, $p < .001$, $\eta^2_p = .84$, 95% CI [.72, .88]. Mean accuracies were lower when the percentage of emotional faces was closer to 50%. As in Experiment 1, analyses revealed a significant interaction of trial type and target gender, $F(3, 84) = 8.32$, $p < .001$, $\eta^2_p = .23$, 95% CI [.09, .33], that was based on gender effects on the linear trend of trial type, $F(1, 28) = 22.37$, $p < .001$, $\eta^2_p = .44$, 95% CI [.20, .59]. When analyzing the effects of trial type separately for female and male crowds, in both conditions a significant quadratic trend of trial type was found, $F(1, 28) = 93.08$, $p < .001$, $\eta^2_p = .77$, 95% CI [.61, .83] for female targets and $F(1, 28) = 59.76$, $p <. 001$, $\eta^2_p = .68$, 95% CI [.49, .77] for male targets. The vertex of the quadratic curve was shifted to the left (more neutral faces) in female crowds and to the right (more emotional faces) for male targets, indicating an increased accuracy for neutral trials in male crowds and for emotional trials in female crowds. This again suggests that responses were guided by gender-stereotypes (Figure 2e). No other effects reached significance, all $F < 1.69$, $p > .21$, $\eta^2_p < .06$.

Response times. Mean correct response times were computed for each participant for each factorial combination. In contrast to Experiment 1, there was no significant effect of emotion, $F(1, 28) = 2.25$, $p = .15$, $\eta^2_p = .07$, 95% CI [.00, .25]. The only significant effect was a three-way interaction between all factors, $F(3, 84) = 4.20$, $p < .01$, $\eta^2_p = .13$, 95% CI [.02, .22], which remains difficult to explain. No other effects reached significance[10], all $F < 2.62$, $p > .06$, $\eta^2_p = .09$.

[10] There was a marginal significant effect of trial type, $F(3, 84) = 2.62$, $p = .06$, $\eta^2_p = .09$, 95% CI [.00, .15], based on a quadratic trend, $F(1,28) = 5.49$, $p < .05$, $\eta^2_p = .16$, 95% CI [.01, .35]. Response times were slower for trials with nearly the same number of emotional and neutral faces.

Correlational analyses. We additionally calculated the correlation between number of fixations and accuracy, separately for happy and angry trials (Table 2). There was a significant correlation for the happy condition, $r = .49$, $p < .01$, 95% CI [.15, .73], indicating higher accuracy rates when more happy faces were inspected. The same pattern emerged for angry trials, $r = .42$, $p < .05$, 95% CI [.06, .68]. Both correlations did not differ significantly from each-other, $z(28) < 1$. Moreover, there was a significant positive correlation between durations of fixations on angry faces and accuracy rates, $r = .38$, $p < .05$, 95% CI [.02, .66], whereas the association of durations of fixations on happy targets and accuracy scores was not statistically significant, $r = -.25$, $p = .19$, 95% CI [-.56, .13]. Like in Experiment 1, there was a significant difference between both correlations, $z(28) = 2.36$, $p < .05$.

Discussion

In Experiment 2, the main findings of Experiment 1 were replicated: Again, happiness was evaluated more accurately than anger, suggesting a general HSE in the perception of and processing of emotions. However, there were also substantial differences in the pattern of results: In Experiment 2, responses and duration of fixations were not faster for happy trials. One possible explanation for the absence of faster reaction times and shorter durations of fixations are the intensity differences between the KDEF pictures and the computer-generated material. We used the intensity ratings reported by Goeleven, Raedt, Leyman and Verschuere (2008) and Becker et al. (2011) and transformed them into the same scale to enable comparability. This reveals that the emotional intensity of the KDEF pictures ($M_{happy} = 6.1$, $M_{angry} = 5.6$) is higher than for the computer-generated faces ($M_{happy} = 4.86$, $M_{angry} = 4.82$). The higher performance regarding the classification of happy moods found in the first experiment might therefore be explained by higher intensity of the presented emotional expression as they might have been easier to assess. It must be noted, however, that although the happy KDEF faces were rated more intensively compared to the angry faces, this difference is not significant (Goeleven et al., 2008).

Another possible explanation is the assumption that the HSE might be partially due to specific feature-based differences between angry and happy emotional expressions. Most likely, the visible teeth of smiling people in the materials of Experiment 1 are such a cue that helps participants to easily and quickly identify happiness. However, the exposed teeth are a low-level feature which became an integral part in the emotional signaling system, and thus should not be regarded as an experimental artefact. Becker and Srinivasan (2014) argue that the exposed teeth in a happy face are designed to be discriminable. The happy face has adopted multiple sign vehicles to retain its affiliative purpose. In close interactions, the upper facial action units might be more influential while especially the exposed teeth become necessary when interacting in a greater distance. Particularly, when confronted with a crowd which is usually located in a more distant level, this feature of the happy facial expression has developed to be both efficiently signaled by the sender and also efficiently processed by the perceiver. We argue that especially in our MoC paradigm, where many small facial expressions (which were perceived as more distant) had to be processed in a rather short amount of time, the exposed teeth might have been essential for a fast processing. Nevertheless, the presence of a robust HSE in accuracy values still indicates that positive information is processed more efficiently, even if no teeth are shown in smiling faces.

Attentional analyses again revealed a preferred attention for happy faces: Happy faces were fixated more often compared to angry faces. These results compliment previous studies revealing a search asymmetry towards happy faces (Becker et al., 2011). We assume that the attentional advantage for happy faces is the basis of the more accurate classification of happy crowds: Because attention is focused on happy faces, participants can quickly estimate the overall number of positive expressions. This assumption is substantiated by a positive association between the accuracy of classifications and number of fixations in the happy condition. Although we did not find faster responses for happy crowds in comparison to angry crowds, participants overall inspect more faces in happy crowds than in angry crowds, resulting in higher accuracy scores for happy crowds. This militates in favor of the hypothesis that happy faces are judged more efficiently and therefore have a discrimination advantage.

Like in Experiment 1, there was a positive association of fixation times on angry faces and the accuracy rates in the angry condition. In contrast, durations of happy fixations were not linked to accuracy of classifications. This suggests that longer fixation durations are necessary for a correct evaluation of angry but not happy emotions.

A third important finding regards gender effects. As in Experiment 1, target gender moderated the effects of emotion. Again, accuracy rates were increased for female faces in crowds with a high amount of emotional expressions and for male faces in crowds with only few emotional faces, suggesting that gender-stereotypes biased responses. This pattern of results might be expected, because women are perceived to be more emotional and to express emotions to a greater extent than men (Brody & Hall, 1993). Again, a basis of this effect was revealed in the gaze analyses: Emotional female faces were focused on more frequently compared to emotional male faces, and fixations on neutral male faces were more frequent than fixations on neutral female faces.

Experiment 3

In the previous experiments, only one type of emotional expression (happy or angry) was presented in each crowd. This had the advantage that effects of happy and angry expressions could be separated. However, a more stringent test of the HSE is accomplished when happy and angry faces compete for attention. Thus, in Experiment 3, we investigated whether the advantage for happy faces holds when they are presented simultaneously with angry faces.

Method

Participants. Fourty-four participants took part in the study in exchange for course credit or financial compensation. Three participants had to be excluded from the analyses because their accuracy rates did not significantly differ from chance, resulting in a final sample of 41 participants (30 female, M_{age} = 22.22, SD_{age} = 3.05).

Material. Again, the 10 male and 10 female computer-generated faces from Becker et al. (2011) were used. Neutral faces were not included in the study.

Design and procedure. Except from reducing the number of conditions (emotion was not manipulated anymore as both emotions were presented together), the experimental design and procedure were largely identical to the previous studies. Now, the number of happy faces among angry faces was varied (7, 9, 11, or 13 out of 20 faces with happy expressions). In this experiment, the keys for the response option were counterbalanced to avoid possible influences of handedness on the effects.

Results

The same outlier criteria used in the previous experiments resulted in the exclusion of 0.88% of all data. Separate 2 (target gender: female, male) × 4 (trial type: 7, 9, 11, 13 happy faces) repeated measures ANOVAs were conducted to analyze response times and accuracy rates. For the analyses of the number of fixations and duration of fixations the emotion of the focused picture was added as a third factor. Paired t-tests were applied to compare mean response times and mean accuracy rates for trials with more happy vs. more angry faces. Means and standard deviations of all measures are presented in Table 4.

Number of fixations. The analysis of the number of fixations revealed a main effect of trial type, $F(3, 120) = 10.76, p < .001, \eta^2_p = .21$, 95% CI [.10, .30], based on a quadratic trend, $F(1, 40) = 28.35, p < .001, \eta^2_p = .42$, 95% CI [.21, .55], that indicates an increased number of fixations for more difficult trials with similar numbers of happy and angry expressions. This main effect was qualified by a trivial interaction of trial type and target emotion, $F(3, 120) = 468.67, p < .001, \eta^2_p = .92$, 95% CI [.90, .93], indicating that more fixations on happy faces were recorded when more happy faces were presented. Lastly, there was an interaction of trial type x target gender, $F(3, 120) = 3.26, p < .05, \eta^2_p = .08$, 95% CI

[.01, .14], based on gender effects on the cubic trend of trial type, $F(1, 40) = 4.25$, $p < .05$, $\eta^2_p = .10$, 95% CI [.00, .25]: Figure 3 suggests that in female crowds, there was a higher number of fixations when more happy faces were presented compared to male crowds. The opposite pattern was observed for male crowds where more fixations occurred in trials with less happy faces compared to female crowds. No other effects reached significance, all $F < 1.07$, $p > .36$, $\eta^2_p < .03$.

Duration of fixations. Mean durations of fixations on each focused face were calculated for each participant and each factorial combination. There was a significant main effect of emotion, $F(1, 40) = 11.97$, $p < .001$, $\eta^2_p = .23$, 95% CI [.06, .39], indicating longer durations of fixations on happy faces. Furthermore there was a significant effect of trial type, $F(3, 120) = 3.54$, $p < .05$, $\eta^2_p = .08$, 95% CI [.01, .15], with a quadratic trend, $F(1, 40) = 5.35$, $p < .05$, $\eta^2_p = .12$, 95% CI [.01, .28]. In trials with nearly the same amount of happy and angry expressions the fixation times were longer. There were no other significant findings, all $F < 2.92$, $p > .10$, $\eta^2_p < .07$.

Accuracy. Mean accuracies were calculated for each participant and each factorial combination. Only the main effect of trial type reached significance, $F(3, 120) = 55.31$, $p < .001$, $\eta^2_p = .58$, 95% CI [.48, .64], indicating a quadratic trend, $F(1, 40) = 227.55$, $p < .001$, $\eta^2_p = .85$, 95% CI [.77, .89]. Accuracy rates were lower for trials with similar number of angry and happy faces. No other effects were significant, all $F < 1.02$, $p > .32$, $\eta^2_p < .03$. The paired t-test revealed no difference between the mean accuracy of trials with more happy or angry targets, $t < 1$.

Response times. Mean correct response times were computed for each participant for each factorial combination. The main effect of trial type was significant, $F(3, 120) = 7.08$, $p < .001$, $\eta^2_p = .15$, 95% CI [.05, .23], with a quadratic trend, $F(1, 40) = 17.73$, $p < .001$, $\eta^2_p = .31$, 95% CI [.12, .46], indicating slower responses for trials with more similar numbers of happy and angry expressions. No other effects were significant, all $F < 1$. A paired t-test showed no difference between the mean correct response times of trials with more happy or angry targets, $t < 1$.

Correlational analyses. The number of happy and angry fixations as well as fixation durations on happy and angry targets were correlated with the accuracy rates of the participants (Table 2). Results show that higher numbers of fixations on both emotions were associated with higher accuracy rates, $r = .64$, $p < .01$, 95% CI [.41, .79] for fixations on happy targets and $r = .62$, $p < .01$, 95% CI [.39, .78] for fixations on angry expressions. The correlations did not significantly differ from each-other, $z(40) < 1$. The same pattern could be revealed for duration of fixations, $r = .42$, $p < .01$, 95% CI [.13, .64] for fixation durations on happy faces and $r = .41$, $p < .01$, 95% CI [.12, .64] for fixation durations on angry targets. There was no significant difference between both correlations, $z(40) < 1$.

Discussion

In the direct comparison of the attention grabbing power of happy vs. angry faces, responses were not biased by emotions: Crowds dominated by happy or by angry faces were classified with the same accuracy and the same speed. This can be expected, because any regarded face has the same information value in this paradigm: No matter whether you inspect a happy or an angry face, you get the same amount of information for the classification.

In contrast to the results of the previous experiments, attention was captured longer by happy faces compared to angry faces. When targets of both emotions were presented together, happy expressions seem no longer to be processed faster than angry emotions. A possible explanation could be a tendency to avoid focusing on negative information. Because individuals show an approach tendency in response to happy faces and an avoidance tendency towards angry faces (Roelofs et al., 2010), it is possible that participants take longer to find a new target position for the next saccade, when threatening stimuli (angry faces) are present in the stimulus display. Again, target gender moderated the gaze behavior: In female crowds more happy faces were fixated while for male crowds this pattern reversed. The correlation coefficients indicate a positive association between both number of fixations and duration times on happy and angry faces and accuracy rates.

General Discussion

The current research was designed to expand findings from previous studies investigating attentional biases for happy or angry faces using the FiC paradigm. A new task was developed in which crowds of faces were presented that differed in emotional expressions. Participants had to evaluate the prevailing emotion, that is, the emotion shown by the majority of the faces. This task differs in two important ways from the more common FiC paradigm: Firstly, instead of presenting only one target face in a field of similar distractors, we show several faces of each of two emotion categories (happy, angry, or neutral). Secondly, the search task (i.e., "find a divergent face in the crowd") was changed to a judgement task ("assess the overall mood of the crowd"). Gaze movements were assessed to get information on attentional processes. Consequently, we can analyze biases in decision-making and in more basal attentional processes. Following recommendations from Becker et al. (2011), we used heterogeneous crowds in which all presented pictures within one crowd showed different individuals, or different computer-generated faces that differed in head shape, eye-color, and other facial characteristics. Although using realistic photographs increases the representativeness of the study, it remains unclear whether both emotions (happy vs. angry) were perceived as representing the same level of emotionality. Therefore, we employed the better controlled computer-generated pictures from Becker et al. (2011) in Experiments 2 and 3. Furthermore, we arranged the pictures randomly to create a realistic presentation of a crowd.

Evidence for a Happy-Superiority-Effect (HSE)

Results from previous studies investigating attention for happy and angry faces are rather mixed: Although there are many studies claiming an ASE (e.g., Frischen, Eastwood, & Smilek, 2008; Horstmann, 2009), many of the more recent studies report a HSE (e.g., Becker et al., 2011; Savage et al., 2013). Our results mainly support the latter account: We found evidence for a faster (Exp. 1) and more accurate (Exp. 1 and 2) evaluation of happy expressions compared to angry expressions. Furthermore, happy faces were focused on more frequently (Exp. 1 and 2) and with a shorter duration (Exp. 1). These findings are in accordance with other studies revealing a faster processing of happy expressions (Craig et al., 2014; Leppänen, Tenhunen, & Hietanen, 2003). The fact that differences in response times and fixation durations were only observed in Experiment 1 suggests that happiness in real faces might be judged even faster than in the computer-generated faces, possibly, because the white teeth of the smiling people facilitate the detection of happiness. Furthermore, as the intensity of the presented emotions of the KDEF pictured was higher – especially for happy expressions – compared to the computer-generated material, the classification might have been more difficult in Experiment 2.

Across experiments, the number of fixations was positively associated with accuracy. The more information participants gathered the better they could decide which expressions dominated the crowd. More interestingly, whereas longer durations of fixations on angry faces were linked to higher accuracy in the angry condition, there was no such correlation for happy faces in Experiments 1 and 2. This suggests that happiness is immediately perceived, and no long fixations are needed for accurate classifications.

In Experiment 3, we found – unexpectedly, and in contrast to results from Study 1 – longer durations for fixation on happy faces compared to fixations on angry faces. When presenting both emotions together, different mechanisms seem to guide attention. Roelofs et al. (2010) found evidence that individuals show an approach tendency in response to happy faces and an avoidance tendency towards angry faces. The longer fixations on happy faces in our study could thus suggest an attentional shift towards the preferred positive emotion. Leyman, De Readt, Vaeyens and Philippaerts (2011) also compared fixation duration times between happy, angry, sad and neutral facial expressions. In their study, faces showing the four different emotions were presented simultaneously. Participants could freely allocate their attention towards the pictures for a certain amount of time. Although not completely comparable to our experiment – in which participants had to classify the overall mood of the crowd as fast as possible – the authors also found evidence for longer fixation durations on happy faces. This positivity bias can be explained by an emotion regulation strategy that protects participants against negative thoughts and feelings (Matthews & Antes, 1992). When both happy and angry emotions are presented together, this mechanism might come into account as participants tend to avoid negative information to retain well-being. Sanchez and Vazquez (2014) found preferential focusing of happy faces to be associated with higher levels of well-being.

In Experiments 1 and 2, however, the task was to discriminate happy or angry targets from neutral ones. Faster fixation durations in the happy condition in Experiment 1 might therefore reflect happy faces to be discriminated more easily and efficiently from neutral facial expressions. On the other side, angry expressions might be more difficult to differentiate from neutral expressions. This line of reasoning is supported by the correlational analyses, which revealed a positive association of fixation durations and accuracy for negative crowds, whereas this relation was not present for happy expressions. This pattern of findings suggests that happy expressions are easier recognized and that consequently a short inspection is sufficient to uncover the emotional value of these faces. It has been argued that during human evolution happy expressions have adopted specific features to ensure a fast and correct processing by the perceiver (Becker & Srinivasan, 2014).

Generally, our results in large parts compliment previous studies revealing an attentional advantage for happy faces (Becker et al., 2011, Craig et al. 2014). One possible explanation for a HSE is the assumption that positive interactions occur more frequently in people's lives as they prefer being around people they like to increase their well-being, and people thus observe more often smiling faces (Nesse & Ellsworth, 2009). Thus, the accessibility of happy faces is increased which translates into faster classification as well as higher accuracy rates. Moreover, we could replicate the existing literature of ensemble coding by showing that happy moods are judged more precisely (with a higher accuracy) compared to angry moods (Elias et al., 2017). We furthermore expanded the existing research on ensemble coding by showing that happy faces are fixated more frequently compared to angry faces in the first two experiments and that happy moods are judged faster at least in the first experiment.

At this point it must be stated that although our results predominantly support the HSE, findings across experiments are not perfectly consistent. Even though there are plausible explanations for inconsistencies, this underlines the necessity to further explore inter-individual differences. In a meta-analysis by Armstrong and Olatunji (2012), there was clear support for a more sustained attention processing of negative facial expressions being related to affective disturbance. As we did not assess any clinical measures, we cannot be certain whether the samples entirely consisted of healthy individuals. Furthermore, also affective states, like mood, are promising control variables, as they might influence the processing of emotional expressions. More research is necessary to target these issues in future applications of the MoC paradigm.

Gender and Emotion

In addition to the findings discussed above, our results also revealed moderation effects of target gender on both attentional processes and on decision making: In Experiments 1 and 2, participants tended to classify female crowds as emotional (i.e., as happy or angry, respectively) and male crowds as neutral (evident from the gender by trial-type interactions on accuracy). This gender-bias in emotional classifications is in line with the belief that females experience emotions to a greater extent compared to males, which is one of the most consistent findings in gender stereotype research (Fabes & Martin, 1991).

Furthermore, we found that happy female faces were evaluated faster compared to angry female expressions. Again, this effect reflects gender stereotypes: Generally, a connection between particular types of emotions and gender is assumed. For example, Öhman et al. (2010) found a faster detection for female happy targets than female angry targets. Similar findings are reported by Becker et al. (2007): In their study, participants were faster and more accurate at detecting happy expressions from female faces and angry expressions from male faces. Research on nonverbal behavior found evidence that women not only are better decoders but also better encoders of emotion (Hall, Carter, & Horgan, 2000). In particular, women are perceived to smile more often compared to men (Hall, 1990). This was partly replicated by our findings showing happy female faces to be fixated shorter compared to angry female targets, indicating a faster processing of happiness in female expressions.

In Experiment 2, we found additional evidence for the link between gender and emotionality. Results revealed significantly higher accuracy rates, an increased number of fixations and shorter fixations for female crowds with a high amount of emotional expressions. Again, these findings go in line with the previous mentioned stereotypes of gender and emotionality. Women are perceived to express emotions to a greater extent than men (Brody & Hall, 1993).

In Experiment 3, again, fixations occurred more often on happy female faces compared to angry female faces, whereas more angry male faces were focused on than happy male faces. A plausible explanation is the stereotypical associations of happiness and femininity and of anger and masculinity. Happiness is perceived to be more typical and expressed by females, whereas anger is more likely for males (Plant et al., 2000).

Methodological Considerations and Future Research

The present study introduced the MoC paradigm as a tool to assess attentional processes in an emotion classification task. By using two different kinds of material (i.e., real and computer-generated faces) we provided first evidence for the stability of the present findings. Realistic photographs were presented to ensure a high ecological validity. The computer-generated material was even better controlled for possible differences regarding the intensity of the displayed emotions and other graphical confounds. Further variations are clearly necessary to test the generalizability of the observed HSE: For example, classifications and gaze behavior should be assessed using other types of pictures, different set-sizes, and gender-mixed crowds. Although Craig et al. (2014) found evidence for a robust HSE while varying the size of the presented crowd, it is not clear whether the advantage for happy moods remains the same when different crowd sizes are presented. As could be seen in our studies, the selection of materials plays an important role in the allocation of attention. For example, the NimStim set of facial expressions (Tottenham et al., 2009) could be applied in future investigations. In this set, faces with closed-mouth expressions are used which are matched in terms of perceived intensity based on norming experiments. By using this material, equal intensities of the displayed emotions and representativeness of the pictures can be ensured.

Another detail needs some attention: In Experiments 1 and 2, a cue informed participants which emotions had to be classified in the next crowd (happy vs. angry). This was done to prevent confusion about the mapping of response keys (the same key was used for the positive and negative responses). In addition, not informing the participants about the emotion in each trial could have possibly led to confusion of neutral and angry faces. Although we believe this to be necessary for the present investigations, the presented emotion cue limits the applicability of the MoC paradigm to address additional questions. The use of smaller set sizes might reduce the need of pre-informing the participants to reduce complexity.

Even more fruitful than the search for general attentional biases (as in the focus of the present work) might be the identification of important moderators, for which traits and states should be considered. For example, we expect (socially) anxious persons to focus more angry faces and to classify crowds more often as being angry (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007). Furthermore, the HSE could be especially pronounced for participants of higher age. Mather and Carstensen (2003) reported that older participants responded faster to the dot in a dot probe task when it was presented on the same side as a neutral face compared to a negative face. The authors demonstrated also that age had an effect on the ability to recognize the presented faces. Older participants could remember positive facial expressions better compared to negative emotions. These findings reveal that age has an essential impact, as adults of higher age seem to avoid negative information more strongly than younger people which might explain the finding that older adults report a higher emotional well-being. In a similar vein, Johnson and Whiting (2003) found that older participants showed a positive response bias in emotional perception clearly favoring happy expressions over neutral and angry ones. Thus, we expect this positivity bias to translate into a potentiated HSE for older adults in our MoC paradigm.

In the domain of state moderators we consider the current motivational and affective state of the participants to be most important. For example, Rothermund and colleagues (e.g., Rothermund, Voss, & Wentura, 2008; Wentura, Voss, & Rothermund, 2009; Wentura, Müller, Rothermund & Voss, 2018) found strong and consistent evidence for an affective counter-regulation mechanism. Following this account, we expect an increase of the HSE, when people are in negative emotional or motivational states, and an ASE, when in positive states. However, there is also evidence that not only a negative mood induction leads to a higher attention towards happy faces as also positive mood induction maintained in a preferred focusing of happy moods (Sanchez, Vazquez, Gomez, & Joormann, 2014). The HSE we found in our MoC paradigm could therefore be more pronounced when both a positive and negative mood induction preceded the attention task.

Conclusion

In Experiment 1, we found evidence for happy moods being evaluated faster and more accurately, indicating a HSE. Furthermore, happy faces were fixated more frequently compared to angry faces. When using the computer-generated material in Experiment 2, we again found a more accurate processing of happy moods in comparison to angry moods and a higher fixation rate of happy compared to angry faces. Participants fixated more happy faces than angry faces in the same amount of time, which translated into an increased accuracy for the happy trials. This argues in favor for the HSE, suggesting a faster processing of happy compared to angry pictures. In our last experiment, however, happy faces were fixated with a longer duration compared to angry expressions when both emotions were presented together. Overall, results are in line with a large body of previous empirical findings and mainly support the assumption of a fast and more efficient evaluation of happiness. The happy face has adopted multiple sign features to secure its affiliative purpose, emphasizing the more positive and prosocial side of human nature.

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Table 1

Means and standard deviations of all measures from Experiment 1 as a function of target gender, trial type and target emotion

	Female targets				Male targets			
Variable	7	9	11	13	7	9	11	13
Response times								
Happy	3522 (1335)	3765 (1407)	3681 (1518)	3560 (1514)	3535 (1314)	3662 (1387)	3717 (1392)	3645 (1580)
Angry	3854 (1556)	3898 (1802)	3831 (1611)	3597 (1477)	3645 (1436)	4137 (1918)	3638 (1705)	3507 (1457)
Accuracy								
Happy	.76 (.15)	.62 (.16)	.62 (.16)	.74 (.16)	.81 (.17)	.72 (.19)	.51 (.22)	.77 (.19)
Angry	.69 (.20)	.53 (.22)	.64 (.18)	.78 (.18)	.72 (.16)	.53 (.22)	.59 (.18)	.73 (.16)
Number of fixations								
Happy								
Neutral	6.91 (2.30)	5.96 (2.30)	4.72 (1.80)	3.53 (1.22)	6.81 (2.46)	5.96 (2.08)	4.96 (1.62)	3.60 (1.53)
Emotional	3.82 (1.24)	4.90 (1.62)	6.01 (2.20)	7.06 (2.41)	3.80 (1.23)	4.94 (1.71)	6.08 (21.91)	6.98 (2.53)
Angry								
Neutral	6.89 (2.46)	5.82 (2.14)	4.73 (1.79)	3.45 (1.30)	6.79 (2.40)	5.80 (2.15)	4.67 (1.82)	3.57 (1.39)
Emotional	3.84 (1.35)	4.73 (1.77)	5.82 (2.01)	6.63 (2.25)	3.75 (1.45)	4.86 (1.74)	5.98 (2.19)	6.61 (2.58)
Duration of fixation								
Happy								
Neutral	258 (44)	270 (52)	260 (51)	262 (57)	255 (43)	252 (45)	260 (49)	266 (59)
Emotional	261 (47)	276 (58)	270 (49)	265 (38)	272 (59)	263 (47)	279 (47)	276 (49)
Angry								
Neutral	276 (47)	285 (54)	287 (45)	284 (58)	272 (47)	267 (47)	265 (49)	266 (59)
Emotional	300 (62)	286 (60)	289 (48)	284 (47)	293 (51)	284 (62)	280 (58)	273 (44)

Table 2

Correlations of accuracy rates with the number of fixations and the duration of fixations

		Experiment 1		Experiment 2		Experiment 3
		Happy	Angry	Happy	Angry	
Variable	Emotion	Accuracy	Accuracy	Accuracy	Accuracy	Accuracy
Number of Fixations	Happy Faces	**.35**	.41*	**.49****	.38*	**.64****
	Angry Faces	.38*	**.43***	.50**	**.42***	**.62****
Duration of Fixation	Happy Faces	**.06**	.36*	**-.25**	.23	**.41****
	Angry Faces	.38*	**.53****	-.16	**.38***	**.42****

Note. *p < .05. **p < .01.

Table 3

Means and standard deviations of all measures from Experiment 2 as a function of target gender, trial type and target emotion

	Female targets				Male targets			
Variable	7	9	11	13	7	9	11	13
Response times								
Happy	3315 (944)	3548 (1121)	3597 (1472)	3168 (996)	3253 (947)	3312 (940)	3154 (913)	3345 (1111)
Angry	3272 (950)	3431 (1029)	3045 (869)	3138 (1107)	3309 (1034)	3311 (1109)	3355 (1139)	3128 (1049)
Accuracy								
Happy	.69 (.16)	.53 (.20)	.63 (.16)	.80 (.16)	.80 (.15)	.64 (.19)	.57 (.12)	.76 (.16)
Angry	.70 (.15)	.50 (.20)	.60 (.17)	.79 (.15)	.74 (.20)	.59 (.24)	.54 (.18)	.69 (.21)
Number of fixations								
Happy								
Neutral	6.37 (1.27)	5.43 (1.44)	4.50 (1.17)	3.19 (.89)	6.44 (1.62)	5.57 (1.31)	4.26 (1.10)	3.33 (1.06)
Emotional	3.51 (.87)	4.60 (1.12)	5.62 (1.41)	6.38 (1.69)	3.25 (.77)	4.32 (1.22)	5.27 (1.36)	6.15 (1.69)
Angry								
Neutral	6.26 (1.50)	5.15 (1.38)	4.21 (1.16)	3.27 (.93)	6.46 (1.55)	5.40 (1.42)	4.35 (1.19)	3.38 (.92)
Emotional	3.30 (1.06)	4.32 (1.22)	5.27 (1.36)	6.15 (1.69)	3.37 (.95)	4.29 (.96)	5.12 (1.32)	5.99 (1.61)
Duration of fixation								
Happy								
Neutral	253 (46)	266 (55)	268 (52)	258 (62)	258 (46)	254 (43)	264 (53)	257 (53)
Emotional	278 (64)	274 (53)	272 (64)	264 (41)	270 (53)	268 (59)	266 (52)	274 (55)
Angry								
Neutral	269 (47)	261 (46)	250 (47)	247 (54)	256 (54)	260 (50)	266 (47)	267 (47)
Emotional	291 (66)	267 (61)	267 (45)	263 (49)	269 (66)	263 (59)	259 (47)	267 (55)

Table 4

Means and standard deviations of all measures from Experiment 3 as a function of target gender and trial type

	Female targets				Male targets			
Variable	7	9	11	13	7	9	11	13
Response times	3961 (1304)	4205 (1425)	4189 (1451)	4029 (1319)	3917 (1322)	4252 (1457)	4125 (1377)	3980 (1304)
Accuracy	.82 (.12)	.64 (.13)	.61 (.14)	.82 (.12)	.82 (.12)	.66 (.11)	.62 (.17)	.82 (.14)
Number of fixations								
Happy	3.78 (1.13)	5.02 (1.55)	6.25 (1.90)	7.31 (2.15)	3.80 (1.08)	5.16 (1.57)	6.28 (1.83)	7.18 (2.14)
Angry	7.17 (2.04)	6.25 (1.74)	5.11 (1.42)	3.75 (1.21)	7.23 (2.04)	6.50 (1.83)	5.01 (1.49)	3.69 (1.20)
Duration of fixation								
Happy	296 (54)	294 (48)	295 (48)	298 (50)	290 (54)	306 (50)	303 (57)	297 (45)
Angry	283 (54)	296 (57)	290 (51)	298 (50)	287 (55)	294 (54)	294 (56)	289 (51)

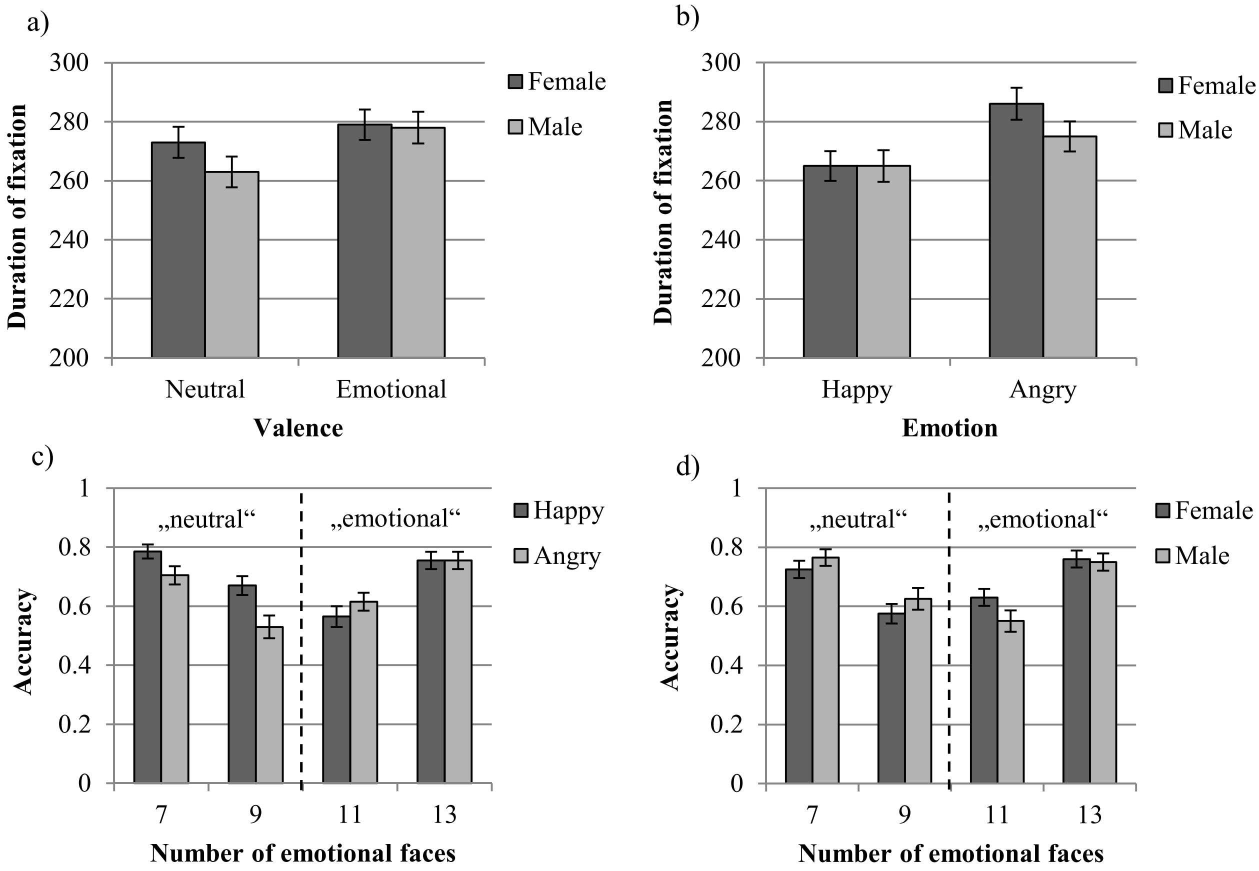

Figure 1. Visualization of the search results from Experiment 1. The significant interaction of valence and target gender as well as the emotion x target gender interaction on duration of fixation (in ms) can be seen in Figure 1a and 1b. Figure 1c and 1d display the significant interaction effect of trial type and emotion as well as the interaction between trial type and target gender on the accuracy rates. For the accuracy rates, the respective correct response is displayed above the corresponding bars. Vertical bars indicate SE. We corrected the SE computationally eliminating the between-subject variation using the method suggested in Franz and Loftus (2012).

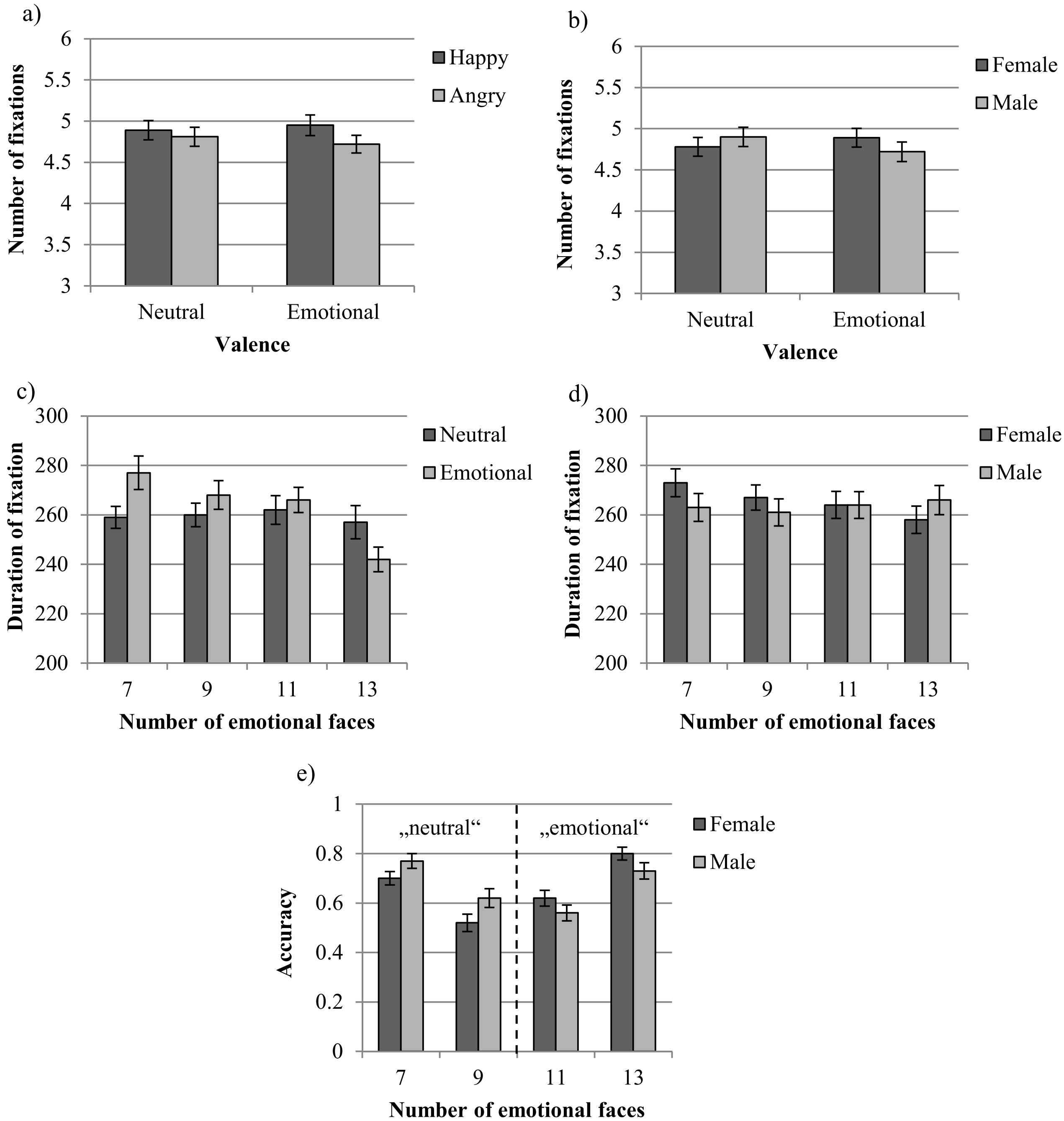

Figure 2. Visualization of the search results from Experiment 2. Figure 2a and 2b capture the valence x emotion interaction and the valence x target gender interaction on number of fixations. The significant interaction of trial type and valence as well as the interaction of trial type x target gender on duration of fixation (in ms) can be seen in Figure 2c and 2d. Figure 2e displays the significant interaction effect of trial type and target gender on the accuracy rates. For the accuracy rates, the respective correct response is displayed above the corresponding bars. Vertical bars indicate SE.

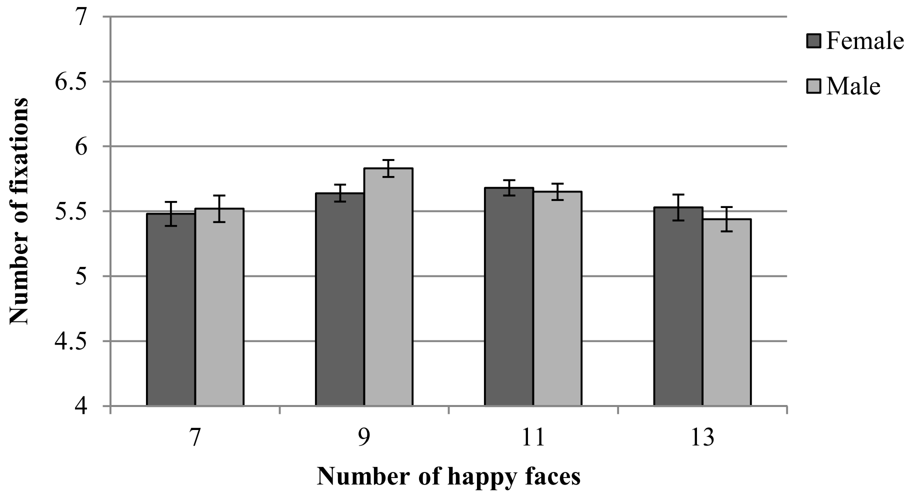

Figure 3. Visualization of the the significant interaction effect of trial type and target gender on the number of fixations in Experiment 3. Vertical bars indicate SE.

Appendix A2

Manuscript 2: Age differences in emotion perception in a multiple target setting: An eye-tracking study.

Age differences in emotion perception in a multiple target setting: An eye-tracking study

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Abstract

Research focusing on the association between age and emotion perception has revealed inconsistent findings, with some support for an age-related positivity effect, as predicted by socioemotional selectivity theory. We used the mood-of-the-crowd (MoC) task to investigate whether older adults judge a crowd consisting of happy and angry expressions to be dominated by happy faces more frequently. The task was to decide whether an array of faces included more angry or more happy faces. Accuracy, reaction times, and gaze movements were analyzed to test the hypothesis, derived from socioemotional selectivity theory, that age would be associated with a bias toward judging crowds as happy, and with longer and more numerous fixations on happy expressions. Seventy-six participants took part in the study representing three different age groups (young, middle-aged, old). Contrary to the hypothesis, older participants more often judged the emotional crowd to be angry compared to younger participants. Furthermore, whereas fixations were longer for happy faces than for angry faces in younger adults, this difference was not present in older adults. Overall, the present findings are inconsistent with an age-related positivity effect in emotion perception.

Keywords: emotion perception, aging, visual search, positivity effect, gaze movement

Age differences in emotion perception in a multiple target setting: An eye-tracking study

The ability to select information from a complex environment is essential for human functioning and psychological well-being (Kastner & Ungerleider, 2001; Miller & Cohen, 2001). As it is impossible to process all available information simultaneously, the focus on specific elements as well as the inhibition of irrelevant content is necessary for adaptive behavior (Ebner & Johnson, 2010). With regard to emotion perception, many studies have been conducted to investigate whether there is a perception advantage for certain emotions (Becker, Anderson, Mortensen, Neufeld, & Neel, 2011; Hansen & Hansen, 1988; Öhman, Lundqvist, & Esteves, 2001; Savage, Lipp, Craig, Becker, & Horstmann, 2013). However, studies using the face-in-the-crowd (FiC) paradigm have revealed inconsistent findings, with some reporting a perception advantage for angry faces, and others reporting an advantage for happy faces. In addition to the inconsistency of results, it remains unclear from these investigations whether the reported angry superiority effects and happy superiority effects reflect efficient perception of the target emotion, or whether they reflect efficient processing of the distractors surrounding the emotional expression. To address this limitation, Bucher and Voss (2018) introduced the mood-of-the-crowd (MoC) paradigm, which was inspired by studies on ensemble coding (Haberman & Whitney, 2009; Elias, Dyer, & Sweeny, 2017). In the MoC paradigm, multiple emotional targets are presented in a crowd of neutral or other emotional distractors. The participant's task is to judge whether the crowd contains more neutral or more emotional faces, or whether it contains more happy or more angry faces. In this task, distractor effects are eliminated because all members of the crowd are targets that jointly inform the correct response. The MoC paradigm may also offer greater ecological validity than the FiC paradigm, as crowds with multiple target emotions are highly prevalent in daily life (e.g., at a political demonstration, a sporting event, etc.). Using the MoC task, Bucher and Voss (2018) found support for the happiness superiority effect, as happy crowds were evaluated with a higher accuracy than angry crowds, and happy faces received more frequent fixations than angry faces.

It is currently unknown whether this happiness superiority effect is preserved throughout the lifespan. Research on emotion perception in younger and older adults has yielded inconsistent results. Whereas some studies report an anger superiority effect for older adults (Hahn, Carlson, Singer, & Gronlund, 2006; Mather & Knight, 2006), others have favored a happiness superiority effect in older adults, in line with the predictions of socioemotional selectivity theory (Carstensen & Mikels, 2005; Mather & Carstensen, 2003). This theory proposes that a diminishing time horizon leads older adults to prioritize emotion-focused goals over knowledge-focused goals (Carstensen, Isaacowitz, & Charles, 1999). Consistent with this assumption, there is rich evidence for an age-related “positivity effect”, such that older adults show a relative preference for positive over negative stimuli (Reed, Chan, & Mikels, 2014). The current study aimed to make a novel contribution to this literature by comparing performance in the MoC paradigm, which represents a multiple target setting, across younger, middle-aged, and older participants. In addition to capturing behavioral responses, we analyzed visual search processes using eye tracking. If aging is associated with a positivity effect in visual search, one would expect more fixations, and longer fixation durations, for happy faces in older participants, compared with other age groups. This eye-movement pattern should then result in an age-related shift toward “happy” responses in the MoC task.

The current study is the first application of the MoC paradigm to examine emotion perception across the adult lifespan. The next sections will review relevant prior literature on emotion perception, eye movements, and visual search in younger and older adults.

Selective Perception of Emotional Faces

In social interactions, efficient perception of emotional expressions is essential to decide quickly whether to approach or avoid another person or group of people (Juth, Lundqvist, Karlsson, & Öhman, 2005). The correct identification of emotional expressions is of high importance because positive and negative expressions signal positive outcomes such as safety, food, or community, or negative outcomes such as aggression and injury, respectively (Ebner & Johnson, 2010). Thus, it is not surprising that many studies have used facial expressions to investigate perception advantages of specific emotional faces. Hansen and Hansen (1988) introduced the FiC paradigm in which participants were asked to indicate whether a face of discrepant emotionality was presented in an array of facial expressions, and found an anger superiority effect (see also Horstmann & Bauland, 2006; Öhman et al., 2001). This threat advantage was explained by the fact that efficient perception of angry faces confers an evolutionary advantage (Pratto & John, 1991). However, the use of schematic faces in this literature limits the ecological validity of its findings (Becker et al., 2011). Schematic faces produce crowds that are far more homogenous than natural crowds composed of diverse individual faces.

In a detailed replication of the FiC effect, Becker et al. (2011) found that happy faces were detected more efficiently than angry faces, contradicting the previously found anger superiority effect. This study included computer-generated faces, in addition to naturalistic face stimuli. Although less ecologically valid, computer-generated faces allow for precise control of emotional intensity and other potential confounds. Becker et al. (2011) provide several explanations for the happiness superiority effect. As positive interactions are likely to occur more frequently in people's everyday life than negative interactions – because individuals prefer interacting with friendly and smiling people – happy faces may be more accessible than angry faces. This phenomenon can be compared to the word frequency effect (Oldfield & Wingfield, 1965). Words that are used more often in language are recognized more easily and with higher accuracy. Another possible explanation involves the perceptual characteristics of happy faces (e.g., exposed teeth), which may render them particularly accessible (Becker & Srinivasan, 2014). Lastly, the happiness superiority effect could reflect differences in the variability of positive and negative facial expressions. Specifically, positive expressions such as happiness may be more homogenous than negative expressions, which may cover a broader range of specific emotions (Unkelbach, Fiedler, Bayer, Stegmüller, & Danner, 2008).

In a novel modification of the FiC paradigm, Bucher and Voss (2018) presented participants with more than one emotional face in a crowd of neutral or other emotional faces. This “mood-of-the-crowd” (MoC) task has several advantages when compared to the FiC paradigm. In the FiC paradigm target effects are confounded with distractor effects, such that efficient identification of the target may reflect a perception advantage of the target emotion, the distractor emotion, or both. The MoC paradigm overcomes this limitation by presenting more than one emotional face in the crowd, and by requiring a majority-emotion judgment. This makes every face a target face, and thus eliminates target-distractor confounds. Using the MoC paradigm, Bucher and Voss (2018) found evidence for faster and more accurate processing of happy moods as well as more fixations on happy faces indicating a perception advantage for happy faces. This pattern was first found for naturalistic face stimuli representing combinations of emotional (happy or angry) and neutral expressions. In a replication with computer-generated faces, happy moods were evaluated with a higher accuracy and happy faces were fixated more often. Combining behavioral and eye-tracking analyses and therefore investigating emotion processing and emotion perception allows for investigating the interplay of these components and helps to better understand participant’s response behavior in the task.

The findings of Bucher and Voss (2018) were in line with a study by Elias et al. (2017), who found that emotionality of happy crowds was judged with higher precision, compared to angry and fearful crowds. In their study, participants were confronted with dynamically changing facial expressions of one emotion and had to indicate the average mood of the presented crowd afterwards. This suggests that the happiness superiority effect also holds when participants' task is to evaluate the overall mood of a crowd instead of judging the presence or absence of a single emotional target. When presenting happy and angry faces together, Bucher and Voss (2018) found longer fixation durations on happy compared to angry expressions. Roelofs, Putman, Schouten, Lange, Volman and Rinck (2010) proposed that happy faces elicit approach tendencies, whereas angry faces elicit avoidance tendencies. Therefore, it is possible that participants take longer to find a new target position for the next saccade when threatening stimuli (angry faces) are present in the stimulus set. The longer fixations on happy faces could indicate a perceptual shift towards the preferred positive emotion.

Age Differences in Emotion Perception

From the overview of previous experiments, it remains an open question whether the more efficient perception of certain emotions is constant over the lifespan or changes during aging. According to the socioemotional selectivity theory (Carstensen, 1992; Carstensen et al., 1999), the perception of a diminishing time horizon during aging increases the relative salience of emotion-focused over knowledge-focused goals (Hahn et al., 2006). For example, older people tend to spend more time with emotionally meaningful partners whereas young individuals engage in making new contacts (Fredrickson & Carstensen, 1990; Fung, Carstensen, & Lutz, 1999). Furthermore, Carstensen and colleagues have found age related decreases in the frequency and duration of negative emotions (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000). Generally, socioemotional selectivity theory thus predicts a "positivity effect" (Mather & Carstensen, 2005), whereby aging is associated with an increasing bias on positive over negative information. It should be noted, however, that older adults also pursue knowledge-related goals if the task requires them to do so (e.g., Löckenhoff & Carstensen, 2007), and that the positivity effect is reduced when older adults' cognitive resources are constrained (Reed et al., 2014).

Results from studies examining age differences in perception of positive and negative stimuli are rather mixed. Mather and Carstensen (2003) employed a dot-probe task, in which an emotional face (happy, angry, or sad) was presented next to a neutral face prior to probe onset. Older adults, but not younger adults, showed valence effects on response times to the probe. Probes appearing in the location of happy faces elicited faster responses than probes in the location of neutral faces. Likewise, probes appearing in the location of neutral faces elicited faster responses than probes in the location of sad faces. These findings are consistent with an age-related positivity effect in visual attention. In a study using a face-in-the-crowd paradigm (Hahn et al., 2006), the participants' task was to detect an emotionally divergent face in a crowd of homogenous distractors. Older participants were faster to detect non-angry targets in angry crowds compared to non-happy targets in happy crowds. Younger adults did not show this pattern. This led to the conclusion that older participants were more efficient at disengaging from negative compared to positive stimuli.

To shed further light on these findings, Isaacowitz, Wadlinger, Goren and Wilson (2006) analyzed the search processes of younger and older adults using eye-tracking methods in a dot-probe task. The gaze-movement data strongly suggested an age-related increase in attention to happy faces and away from sad ones specifically for older adults. Applying a dual-task paradigm, Allard and Isaacowitz (2008) found that older adults showed a preference for positive and neutral compared to negative images. This again indicates that older adults preferentially attend to positive information and are more efficient at disengaging from negative stimuli compared with younger adults.

Cross-sectional studies of age differences in emotion-cognition interactions typically involve extreme-group comparisons (i.e., younger vs. older adults). The lack of data on middle-aged adults means that it is unknown whether changes in emotional processing biases occur gradually or abruptly. Socioemotional selectivity theory assumes that the relative priority of different types of goals changes as a function of future time perspective (i.e., perceived time left in life; Löckenhoff & Carstensen, 2007), and that there is a gradual shift in processing strategies over the adult lifespan (e.g., Carstensen & Turk Charles, 1994; Mather & Carstensen, 2005). Accordingly, one would expect differences to emerge during midlife, rather than suddenly in old age, but this has not been tested empirically. Moreover, the studies reviewed above used single target paradigms. Indeed, the use of single target emotions in experimental tasks investigating age differences in emotion perception was recently criticized in the literature (Isaacowitz, Livingstone, & Castro, 2017). Thus, the aim of the current study was to transfer the previous findings to a multiple target setting.

The Current Study

The current study used the MoC paradigm to investigate age differences in perceptual processes. For this task, participants have to judge the mood of the crowd by scanning an array that contains multiple happy and angry faces. The combination of behavioral and eye-tracking data is particularly powerful in this context, as it helps to pinpoint the locus of potential age-related biases in emotion perception: If age differences in the MoC task are observed in eye movements (e.g., an increased probability of fixations on positive emotional expressions), this would indicate that biased perceptual preferences guide decision making. As argued by Roelofs et al. (2010), a preferential focus on positive stimuli could result from an approach tendency towards positive information, or from an avoidance tendency towards negative information. In either case, the perceptual preference may serve the individual's emotion-regulation goals. An alternate possibility is that age differences occur during the evaluation phase (e.g., a positive reappraisal of ambiguous crowds of faces). Kellough and Knight (2012) observed that older participants perceive more positive emotion in ambiguous expressions compared to young individuals. Although we do not present ambiguous faces in the MoC paradigm, judging the mood of a crowd of faces (containing of happy and angry faces) is of high ambiguity (especially in trials with nearly the same amount of happy and angry faces presented). There are also other findings demonstrating more efficient perception and recall of, positive relative to negative information in older adults (Allard & Isaacowitz, 2008; Charles, Mather, & Carstensen, 2003, Löckenhoff & Carstensen, 2007). Therefore, it is possible that although older individuals retrieve the same information when inspecting the crowd of faces, their final decision may nevertheless be biased.

The MoC paradigm was already applied to a younger age cohort (Bucher & Voss, 2018). Young participants preferentially focused on positive stimuli when the crowd consisted of both angry and happy faces. In line with the predictions of socioemotional selectivity theory, we expected that a positivity effect in responding and the preferential focusing of happy faces would occur more often in older participants. If older participants preferentially focus on positive stimuli, fixations on happy faces will be more frequent and long-lasting. We expected that such a positivity effect in emotion perception would also be associated with a higher proportion of positive (or non-negative) classifications when judging the mood of the crowds. As elaborated above, it is also plausible that a positive bias in classifications is present without any bias regarding the gaze movements. Therefore, the additional consideration of eye-tracking data is an important and novel feature of the current study. Finally, in contrast to most other studies examining the effects of age on emotion perception, the current study includes not only younger and older participants, but also middle-aged individuals, thus shedding light on the emergence of emotional perception and processing differences across the adult lifespan.

Method

Participants

Prior to recruiting the participants, we conducted a power analysis using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) to determine the required sample size. The required sample size to detect a large effect[1] with a power of .90 and an alpha-error of .05 in an

[1] When estimating the effect size, we oriented towards the effects found in Hahn et al. (2006) who applied the face-in-the-crowd-paradigm in their studies.

ANCOVA setting with two covariates was *N* = 83. Seventy-nine adults participated in the study. Three participants from the oldest age cohort had to be excluded due to accuracy rates smaller or equal to chance level in the MoC task. The final sample consisted of 76 adults (M_{age} = 45.95 years, *SD* = 21.02, range = 18-87; 66% female), with roughly equal representation of younger, middle-aged, and older age groups (Table 1). Participants were recruited from a large participant pool that includes students from various disciplines, as well as through advertisements posted around the Heidelberg University campus and in area senior centers, and through newspaper advertisements. Prior to the study, all participants were screened on the phone, and only those reporting normal vision and hearing as well as no psychological, neurological or medical problems were invited to participate. We used the Mini Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975) to screen for dementia-related impairments. A range of demographic, cognitive and affective measures was assessed to characterize the sample. These variables showed typical age-related differences in affective and cognitive dimensions (see Table 1). Before participating in our study, all participants were informed about the study details and gave their informed consent. They participated in exchange for course credit or financial compensation (10€). All procedures used in the study were approved by an Ethics Board of Heidelberg University.

Material and Design

Mood-of-the-Crowd Paradigm. Ten male and 10 female computer-generated faces from Becker et al. (2011) were used as stimuli. For each of the simulated individuals, angry and happy facial expressions were created from the neutral-expression prototypes. To ensure equivalent intensity of angry and happy expressions, Becker et al. (2011) applied identical amounts of warping to the prototypes, and validated the results with intensity ratings. There was no significant difference in rated intensity of angry and happy expressions (Becker et al., 2011). Lighting and visual contrast were consistent across all faces in the set.

The experiment was run on a Dell laptop computer. Stimulus displays and response time measurement were controlled by a C program using the SDL libraries (www.libsdl.org). To record gaze movement, a SMI RED250MOBILE eye-tracker was used. The eye movement of the participants was recorded at a frequency of 250 Hz. Fixations were detected using the SMI Event Detector tool (minimal duration was 80 ms and maximal dispersion was 100 pixel)[2]. For the registration of fixations on the faces, a tolerance of 30 pixels around each stimulus (0.5 cm) was allowed[3].

For the eye-movement recording, the camera software was calibrated using a 9-point calibration routine prior to each block of the experiment (practice block and experimental blocks). Each calibration was followed by a 4-point validation. Only if the validation was successful (participants' gaze was within 1° visual angle of the presented points), the participants started with the experimental trials. If the validation was not successful, a new calibration and validation round started. In each trial, a crowd consisting of 20 face pictures (each 1.4 cm x 1.9 cm) was shown. The faces were located randomly on the screen (34.5 cm x 19.5 cm) with a light-grey background. To avoid overlap between the pictures, we ensured a minimum distance between the edges of the pictures (minimum distance was 3.4 cm). A random arrangement was used to encourage naturalistic eye movements, rather than systematic scanning of rows and columns. Each crowd was composed of either only female or only male faces and both emotions were presented together. The number of angry faces which were presented in the crowd was varied in four steps (7, 9, 11 and 13 angry faces).

Procedure

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[2] As the criterion of 80 ms as minimal fixation duration reflects a rather liberal one, we inspected the fixation times again. The shortest fixation time was about 125 ms meeting the criterion recommended in Manor & Gordon (2003), where a temporal threshold of 100 ms was found to discriminate fixations from other oculomotor activity effectively.

[3] We used this tolerance to correct for possible measurement errors in gaze recording. We also reanalyzed data setting the tolerance to zero, and the results did not change essentially.

After providing informed consent, participants completed the MMSE. Afterwards, they were seated approximately 60 cm in front of the laptop computer. They were informed about the MoC task and the possibility to stop the experiment at any time. Before starting with the experiment, participants were instructed to judge the dominant mood of the crowd, namely to decide whether more happy or angry faces are presented in the crowds. Furthermore, they were advised to make their decision as fast and accurate as possible to prevent them from simply counting the respective faces.[4]

The experiment included one practice block of 16 trials and two experimental blocks of 50 trials each. Trials from the practice block were excluded from the analyses. Each block started with two warm-up trials. In the 48 experimental trials of each block, the 8 trial types (gender of presented faces x number of angry pictures) were presented 6 times in random order. Each trial started with the presentation of a fixation cross in the center of the screen before the crowd was presented. The crowd remained visible until the participants gave their response. If participants responded with a delay of more than 10 seconds, a warning message ("please try to respond more quickly") was shown. Participants had to indicate whether happy or angry faces dominated the crowd by pressing the S-key and the K-key. The assignment of the emotions to the keys was balanced across participants. At the bottom of the screen, the words "happy" and "angry" appeared on the appropriate sides to remind participants of the response assignment.

Subsequent to the eye-tracking experiment, participants completed cognitive and affective measures. Lastly, crystallized intelligence and fluid intelligence were measured using the vocabulary test and the Digit Symbol Substitution Task, respectively. After completing all questionnaires and tests, participants were debriefed and compensated.

Results

[4] Mean response time across participants was approximately 5 seconds and only 12 faces (of 20 faces) per trial were fixated on average. Therefore, our instructions ensured that participants did not simply count all of the presented faces and worked in a mode where there was enough room for motives to bias performance.

To analyze the behavioral data (response proportions, accuracy, and response times), a series of 3 (age groups: young, middle-aged, old) x 2 (target gender: female, male)[5] x 4 (trial type: 7, 9, 11 and 13 angry facial expressions) mixed ANCOVAs was conducted. For the analyses of the eye-tracking data (number of fixations and duration of fixation) the emotion of the focused picture (happy vs. angry) served as an additional within-subjects factor. Additionally, participants' gender (female vs. male) and education were included as covariates in each model. The inclusion of these covariates was motivated by a recent meta-analysis that identified them as moderators of age effects in emotion perception (Gonçalves, Fernandes, Pasion, Ferreira-Santos, Barbosa, & Marques-Teixeira, 2018). There is indication of an advanced processing of emotional faces in female participants (Hall & Matsumoto, 2004; Williams et al., 2009), and of a more efficient perception of anger and sadness among less-educated participants (Trauffer, Widen, & Russell, 2013).

Behavioral Results

Response proportions. The proportion of "happy" responses was calculated for each participant and each experimental condition. The age group effect was significant, $F(2, 71) = 4.29$, $p = .017$, $\eta^2_p = .11$, 95% CI [.01, .23]. The polynomial contrast analysis indicated a linear effect of age on mood judgements ($c_{linear} = -.049$, $p = .006$; $c_{quadratic} = .011$, $p = .518$). Contrary to our hypothesis, the probability of positive classifications decreased with age (Figure 1). The youngest age cohort differed significantly from the oldest group, $t(50) = 2.80$, $p = .006$, $d = .78$, but not from the middle-aged group, $t(50) = .92$, $p = .372$, $d = .25$. The oldest group also differed significantly from the middle-aged cohort, $t(46) = 2.09$, $p = .041$, $d = .60$. Trivially, the main effect of trial type was also significant, with a lower probability of "happy" judgments when more angry faces were present in a crowd, $F(3, 213) = 32.94$, $p <$

[5] Target gender was added as additional within-subject factor to the analysis as we wanted to use the exact same experimental design reported in the last study of Bucher and Voss (2018). In their studies, the authors consistently found influences of target gender on emotion perception. However, the influence of gender of the presented faces is not of main interest in the current study but the same procedure was implemented to allow comparability.

.001, η^2_p = .32, 95% CI [.23, .39], indicating a linear trend, $F(1, 71) = 72.37$, $p < .001$, η^2_p = .51, 95% CI [.36, .60]. Lastly, there was a significant main effect of target gender, with a higher proportion of "happy" judgments in female crowds compared with male crowds, $F(1, 71) = 8.17$, $p = .006$, η^2_p = .10, 95% CI [.02, .22]. No other effects reached significance, all $F < 3.47$, $p > .07$, $\eta^2_p < .05$.

Accuracy. Mean accuracy was calculated for each participant and each experimental condition. The three age groups differed significantly, with the oldest age cohort achieving the lowest accuracy, $F(2, 71) = 3.23$, $p = .045$, η^2_p = .08, 95% CI [.00, .20] (Figure 2). The polynomial contrast analysis indicated a linear effect of age group on accuracy ($c_{\text{linear}} = -.034$, $p = .013$; $c_{\text{quadratic}} = .002$, $p = .884$). The oldest age group significantly differed from the youngest age cohort, $t(50) = 2.53$, $p = .013$, $d = .70$, but not from the middle-aged participants, $t(46) = 1.29$, $p = .218$, $d = .37$. The youngest age group also did not differ from the middle-aged cohort, $t(50) = 1.44$, $p = .159$, $d = .40$. Moreover, the main effect of trial type was significant, with lower accuracy on difficult trials (9 and 11 angry faces in the crowds), $F(3, 213) = 5.12$, $p = .002$, η^2_p = .07, 95% CI [.02, .12], indicating a quadratic trend, $F(1, 71) = 23.32$, $p < .001$, η^2_p = .25, 95% CI [.11, .37]. Furthermore, there was a significant interaction of age group and trial type, $F(6, 213) = 2.57$, $p = .020$, η^2_p = .07, 95% CI [.01, .10], with a linear trend, $F(2, 71) = 4.70$, $p = .012$, η^2_p = .11, 95% CI [.02, .22] (Figure 3). For mostly-angry crowds (11 or 13 angry faces out of 20 faces), the age groups did not differ on accuracy, $t < .90$, $p > .362$, $d < .26$. For mostly-happy crowds (7 and 9 angry out of 20 faces), accuracy was lower for the oldest age group in comparison to the middle-aged cohort, $t(46) = 2.41$, $p = .019$, $d = .70$, and the youngest group, $t(50) = 3.81$, $p < .001$, $d = 1.06$. Young and middle-aged participants did not differ on accuracy, $t(50) = 1.55$, $p = .122$, $d = .43$. Lastly, there was a significant interaction of trial type and target gender, $F(3, 213) = 5.67$, $p = .001$, η^2_p = .07, 95% CI [.02, .13], with a linear trend, $F(1, 71) = 8.27$, $p = .005$, η^2_p = .10, 95% CI

[.02, .22]. Participants were more accurate when judging female faces in crowds with more happy and male faces in crowds with more angry faces (Figure 4).

Response time. Mean correct response times were computed for each participant for each experimental condition. The ANCOVA yielded no significant effects, all $F < 2.26$, $p > .09$, $\eta^2_p < .09$.

Eye-Tracking Results

Fixation duration. Mean durations of gaze position on each fixated face were calculated for each participant and each experimental condition. In cases of multiple fixations on (different parts of) the same face, the total duration was entered into the analysis. We calculated difference scores between fixation durations on happy faces and fixation durations on angry faces[6].

Analyses revealed that there was a marginal significant main effect of age group, $F(2, 71) = 2.74$, $p = .071$, $\eta^2_p = .07$, 95% CI [.00, .19]. The polynomial contrast analysis indicated a significant linear effect of age group on the difference score between happy and angry fixations ($c_{\text{linear}} = -10.46$, $p = .029$; $c_{\text{quadratic}} = -2.65$, $p = .549$). Younger participants fixated significantly longer on happy faces than on angry faces compared to the oldest age group, $t(50) = 2.22$, $p = .029$, $d = .62$. There was no significant difference between the young and middle-aged group, $t(50) = .64$, $p = .526$, $d = .18$, and no significant difference between the middle-aged and old cohort, $t(46) = 1.73$, $p = .089$, $d = .50$ (Figure 5). No other effects reached significance, all $F < 2.93$, $p > .06$, $\eta^2_p < .08$.

Number of fixations. This measure assesses how many faces of each type received at least one fixation during a trial (thus, the maximum possible number is 13 fixations of one emotional expression in one trial).[7] For the following analyses, difference scores between

[6] Difference scores for fixation durations as well as number of fixations on happy versus angry faces were calculated to analyze trend effects (linear versus quadratic) for the three age groups and to ease interpretation of the results. Analyzing trend effects is not possible in case of interaction effects between age group and emotion.
[7] With the variable number of fixations, it was assessed how many faces of each type were fixated in each trial. This variable is important because it maps the information sampling strategies in two ways: Firstly, when

fixations on happy and angry faces were computed for each participant and each factorial combination. No significant main effect of age group on the number of fixations emerged, $F < 1$. The trivial effect of trial type reached significance, $F(3, 213) = 85.44$, $p < .001$, $\eta^2_p = .55$, 95% CI [.47, .60], indicating more fixations on angry faces when more angry faces were presented in the crowd. Lastly, a significant but difficult to interpret three-way interaction of target gender, trial type and years of education was revealed, $F(3, 213) = 3.73$, $p = .012$, $\eta^2_p = .05$, 95% CI [.01, .09], indicating a linear trend, $F(1, 71) = 9.66$, $p = .003$, $\eta^2_p = .12$, 95% CI [.03, .24]. No other effects were significant, all $F < 2.83$, $p > .09$, $\eta^2_p < .04$.

Discussion

The aim of this study was to expand previous findings on emotion perception from face perception paradigms. The present experiment goes beyond previous studies in several regards: Firstly, we investigated three different age groups, which allows us to examine cross-sectional age differences. Secondly, we combined the measurement of emotion-classifications and response times with the recording of eye-tracking data to assess both judgment biases and perceptual biases. Finally, in a departure from most other studies examining the association of age and emotion perception, we used the newly introduced MoC paradigm (Bucher & Voss, 2018), which represents a multiple target setting. To our knowledge, this is the first study examining age effects in emotion perception applying a multiple target paradigm. Specifically, the MoC task maps more closely onto everyday situations, and effects of target valence are not confounded with effects of distractor valence because all faces are targets.

We expected an age-related positivity effect, resulting in a higher number of happy judgments for emotionally heterogeneous crowds. Furthermore, we predicted that older adults would show more and longer fixations on happy faces, compared to the younger and middle-

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examined in the context of a participant's response time, the total number of faces receiving a fixation provides information about the participant's speed-accuracy tradeoff settings. Secondly, and more importantly, we obtain a measure of biased information sampling, which is essential to the analysis of age differences in emotion perception and processing.

aged adults. Contrary to these hypotheses, the data offered no evidence for a “happy” bias for older participants. Instead, when judging the mood of the crowd, older adults responded “angry” more often than the younger adults. A linear trend indicated that the response bias continuously changes over the lifespan from positive to negative. Thus, our results are in conflict with predictions from socioemotional selectivity theory, according to which older adults regulate their emotions by approaching positive and avoiding negative information (Allard & Isaacowitz, 2008; Carstensen et al., 2000).

With respect to duration of fixations, younger and middle-aged participants spent more time fixating happy faces in comparison to angry expressions than older adults. This is in line with the findings by Bucher and Voss (2018) who also revealed longer fixation durations on happy faces in a young sample. Critically however, this “happiness superiority effect” was not found for the oldest age group, contrary to the prediction by socioemotional selectivity theory. Again, these findings contradict the assumption that older individuals inhibit negative and approach positive information (Carstensen, 1992). For both the response tendency as well as duration of fixations we revealed a linear trend between the three age groups, suggesting that changes in emotion perception occur gradually instead of abruptly in high age. Although not consistent with the predictions of the socioemotional selectivity theory (Carstensen, 1992), which assumes a positivity effect with increasing age, we found support for a linear change with aging implicating a gradual shift in processing strategies over the adult lifespan (e.g., Carstensen & Turk Charles, 1994; Mather & Carstensen, 2005).

The negativity effect in response tendency and the absent positivity effect in fixation durations found for older participants may be related to an age-related decline of inhibitory processing that leads to a decreased ability to ignore negative information in the context of a demanding task. Note that younger and middle-aged individuals focused longer on positive compared to negative faces whereas this difference was absent for the oldest age cohort. There are several empirical findings suggesting a decline of inhibitory functions with increasing age (Hasher & Zacks, 1988; Kane, Hasher, Stoltzfus, & Zacks, 1994). According to the meta-analysis of Reed et al. (2014), it is assumed that the positivity effect is more likely to occur in low-demand tasks. It is plausible that because of the increased difficulty of the MoC task in comparison to other tasks – like the FiC paradigm – more cognitive control is needed which might impair a spontaneous emotion regulation in older adults. This might serve as a possible explanation for the absent positivity effect in older adults when performing the MoC task. Another possibility is that negative facial expressions are more difficult to recognize for older adults compared to positive faces. For example, Sullivan and Ruffman (2004) report that older adults had problems detecting sadness, anger and fear from photographs, whereas there was no deficit with respect to the perception of other emotions (cf. also McDowell, Harrison and Demaree, 1994). Furthermore, in a meta-analysis by Ruffman, Henry, Livingstone and Phillips (2008), it was found that older participants were less effective at identifying most of the basic emotional expressions (anger, sadness, fear, happiness and surprise) compared to younger participants. The differences between older and younger participants with regard to the perception of angry, sad and fearful faces were notably larger compared to the perception of happiness and surprise. Similar findings emerged in a more recent meta-analysis on the effects of age on emotion identification (Gonçalves et al., 2018). We speculate that increased difficulties especially in the perception of angry expressions might be an explanation for the disappearance of longer fixation durations on happy compared to angry expressions between young and old individuals.

Moreover, as older participants fixated angry and happy faces to the same degree and fixation durations on angry faces were only slightly increased compared to fixations on happy faces, perceptual processes were not biased. However, with regard to the final judgement, the crowds were generally rated as being angry more often, implicating a judgmental bias. These results rather suggest a biased processing of information, as older individuals retrieve the same information when inspecting the crowd of faces, but their final decision is nevertheless biased towards the angry response. Therefore, the negative information (angry expressions) seems to influence the final decision to a stronger degree compared to the positive information (happy expressions) in the oldest age group.

An additional finding which was not part of our a priori hypotheses but which replicates the findings of Bucher and Voss (2018) was the fact that the gender of the presented targets influenced the mood judgments. Female crowds were more often judged as being happy, whereas male crowds were more often judged as being angry. Furthermore, accuracy was higher in female crowds with more happy faces and in male crowds with more angry expressions. A possible explanation might be the close association between happiness and femininity and anger and masculinity. Happiness is perceived to be more typical and expressed by females, whereas anger is more likely for males (Plant, Hyde, Keltner, & Devine, 2000). In a similar vein, Becker, Kenrick, Neuberg, Blackwell and Smith (2007) found that participants were also more accurate at perceiving happy expressions from female faces and angry expressions from male faces. Thus, mood judgements were again influenced by gender stereotypes.

Limitations and Future Directions

We used the MoC paradigm that is based on a free inspection of a crowd without a search instruction and the computer-generated material of Becker et al. (2011) to ensure that angry and happy faces are of comparable emotional intensity and to prevent low-level perceptual confounds. It would be desirable, in future work, to replicate the present findings with real human faces to test the robustness of the current findings, especially with respect to the negativity effect in older adults. To further increase the ecological validity of the task, one may also consider embedding faces into a physical context (e.g, the background scene; Noh & Isaacowitz, 2013), or using dynamic rather than static facial expressions (Isaacowitz & Stanley, 2011). In addition to increasing the ecological validity of the MoC task, it would be important to collect longitudinal data to learn more about developmental change in emotion perception and processing. The current study was cross-sectional, making it impossible to separate age and cohort effects.

Furthermore, it should be tested whether the bias towards negative emotions remains the same when different crowd sizes are presented. Moreover, a more gender-balanced sample would allow for a more comprehensive investigation of interactions of participants' gender and the gender of the presented stimuli. Lastly, it would be interesting to use ambiguous trials with the same number of happy and angry faces, as the judgment bias we found in our study may be even more pronounced when positive and negative information is balanced.

Another important modification of the present MoC task would be the use of young and old emotional target faces. In a study by Ebner, He and Johnson (2011) it was found that younger and older participants fixated longer on own-age faces which predicted a better emotion identification for pictures of the same age. Not only the emotion of the face itself but also the age of the presented target affects how participants of different age perceive the respective emotion. This own-age effect in visual perception – reflecting a higher social relevance of own-age individuals – might also play a role when investigating the MoC paradigm. It could be the case that the often-reported positivity effect would be found when using targets of higher age as emotional expressions of older adults might be of higher interest and importance for older participants.

Another interesting future avenue is to connect the findings from the MoC paradigm with behavior, attitudes, or health related variables. For example, Slessor, Miles, Bull and Phillips (2010) found evidence that older participants who showed a positive response bias also indicated an increased probability to approach someone to ask a favor. Moreover, it is plausible that there is a link between personality factors and response biases in emotion perception paradigms. A positivity effect might be associated with higher extraversion and a negativity bias with increased neuroticism.[8] It is also plausible that personality factors act as moderators regarding the link between age and emotion perception. Future research is necessary to uncover possible influential factors that can account for the inconsistent results revealing a happiness superiority effect or anger superiority effect for older adults. Lastly, affective and cognitive measures (negative and positive affect, measures of inhibition processes or memory) should be taken into account to point towards mechanisms underlying the found negativity bias in older participants. Larger samples are needed to allow for controlling these measures in future research.

Conclusion

In our experiment, we found no evidence for a positivity effect in aging. Older participants judged the crowd more negatively and fixated angry pictures slightly longer compared to middle-aged and young participants who fixated longer on happy expressions. According to the socioemotional selectivity theory, older participants are expected to approach positive information and avoid negative stimuli to regulate age-related losses and impairments. These assumptions could not be confirmed in our study. We assume that age-related impairments of inhibitory processing in general as well as characteristics of the MoC task (higher cognitive demands) might be an explanation for the absent positivity effect in older adults. A closer look with regard to inter-individual differences is necessary to uncover possible moderators that can account for inconsistent findings with respect to the association of age and emotion perception.

[8] A first hint regarding the connection between personality factors and response bias tendencies provides a correlation between the BIS/BAS measures and the response variable. For the drive variable, there was a positive association with response (0 = angry, 1 = happy), $r = .26$, $p = .02$, indicating a positivity effect to go along with higher drive values.

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Table 1

Group characteristics

	Young Adults		Middle-aged Adults		Older Adults				
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	η^2
N	28	–	24	–	24	–	–	–	–
N (Female)	20	–	15	–	15	–	–	–	–
Age, years	21.39	2.35	50.08	3.92	70.46	6.38	**804.65**	**< .001**	**.96**
Age range, years	18-29	–	43-55	–	60-87	–	–	–	–
Education, years	13.71	1.98	16.88	3.19	17.29	3.63	**11.51**	**< .001**	**.24**
MWT-B	29.61	2.49	32.54	2.28	33.71	2.22	**21.48**	**< .001**	**.37**
DSST	85.39	8.69	75.29	12.54	59.25	13.73	**32.51**	**< .001**	**.47**
MMSE	29.57	.57	28.71	.99	28.63	1.14	**8.65**	**< .001**	**.19**
FTP	5.18	1.02	4.38	.85	3.55	1.17	**16.50**	**< .001**	**.31**
BIS/BAS									
Inhibition	1.87	.39	1.78	.31	1.72	.46	1.01	.368	.03
Drive	1.88	.56	1.98	.49	1.71	.58	1.51	.229	.04
Fun Seeking	1.77	.45	1.85	.54	1.90	.61	.39	.676	.01
Reward Responsitivity	2.25	.44	2.37	.39	2.28	.42	.57	.581	.02
PANAS									
Positive Affect	2.93	.64	3.23	.61	3.34	.72	2.73	.072	.07
Negative Affect	1.35	.44	1.10	.13	1.12	.24	**5.37**	**.007**	**.13**
DASS-21									
Depression	.75	.80	.45	.59	.43	.41	2.14	.125	.06
Anxiety	.51	.47	.31	.35	.32	.38	1.94	.152	.05
Stress	.88	.59	.85	.74	.73	.65	.37	.695	.01

Note: MWT-B = Mehrfachwahl-Wortschatz-Test (Lehrl, 2005); DSST = Digit Symbol Substitution Task (Wechsler, 1955); MMSE = Mini Mental State Exam (Folstein et al., 1975); FTP = Future Time Perspective (Lang & Carstensen, 2002); BIS/BAS = Behavioural Inhibition System and Behavioural Activation Scales (Carver & White, 1994); PANAS = Positive and Negative Affect Schedule (Watson et al., 1988); DASS-21 = Depression Anxiety Stress Scales (Lovibond & Lovibond, 1995).

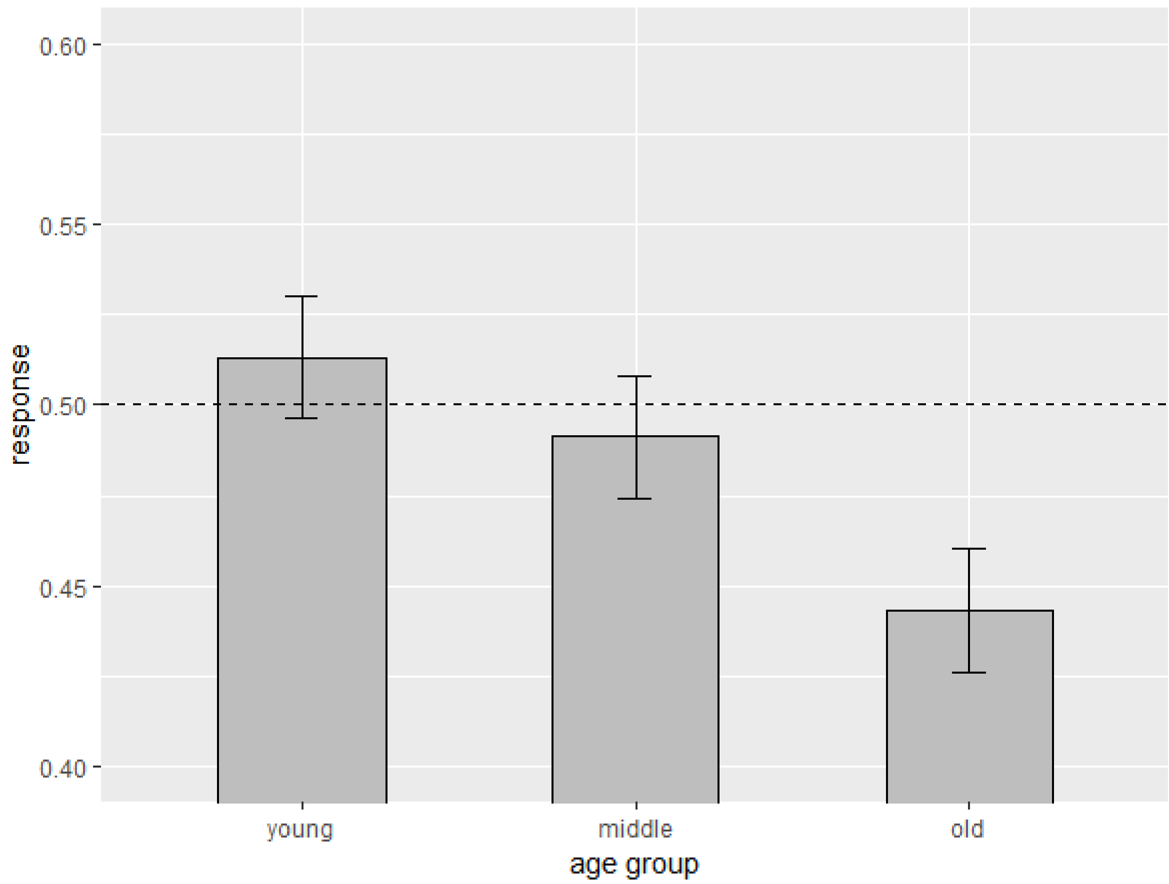

Figure 1. Main effect of age on response tendency (0 = angry, 1 = happy). Error bars indicate standard errors.

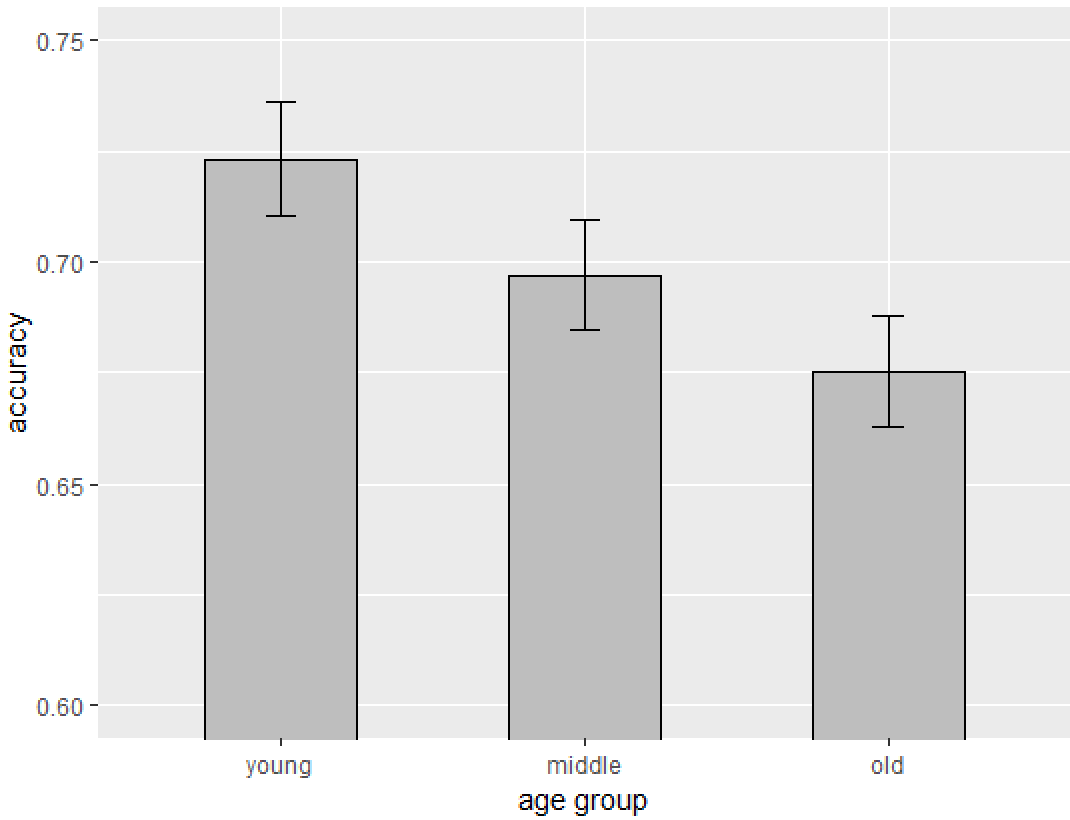

Figure 2. Main effect of age on accuracy (0 = false, 1 = correct). Error bars indicate standard errors.

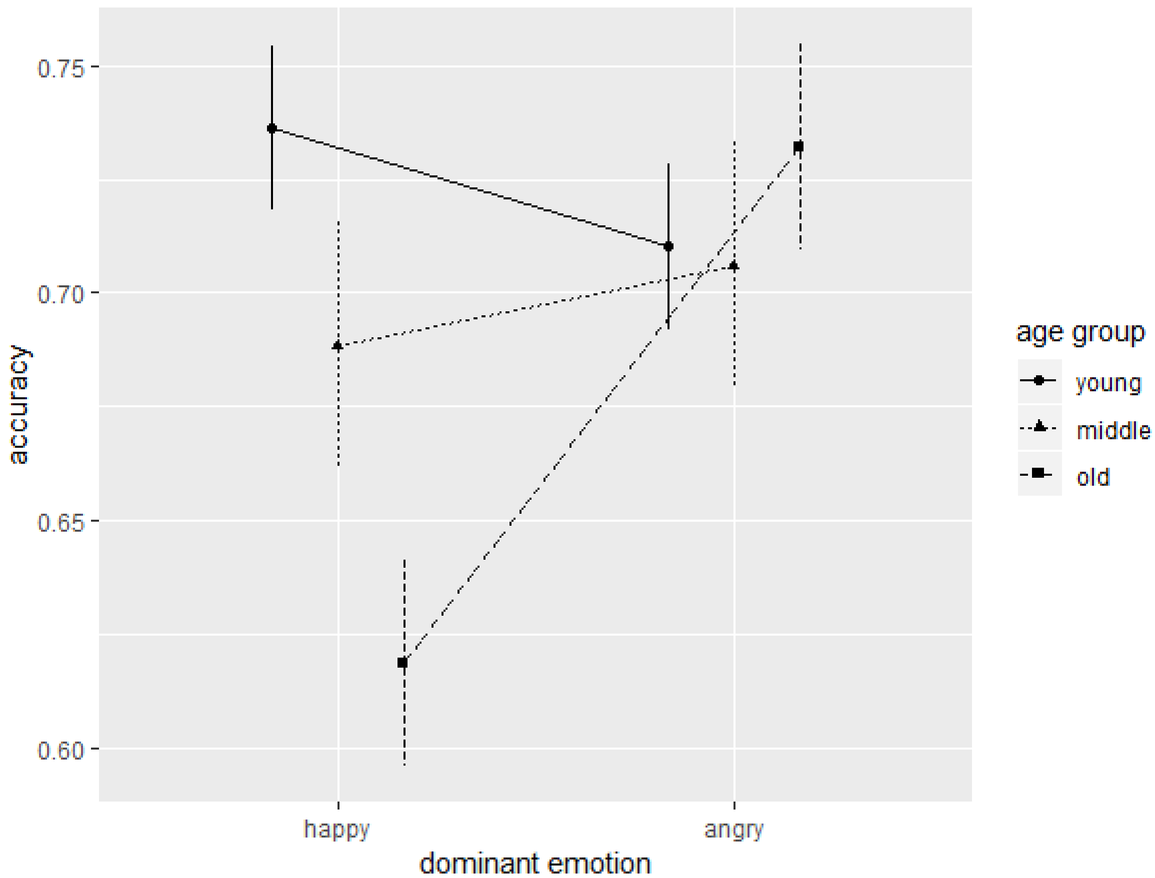

Figure 3. Interaction effect of dominant emotion and age group on accuracy (0 = false, 1 = correct). Trials with 11 and 13 happy expressions were combined, as were trials with 11 and 13 angry expressions. Error bars indicate standard errors.

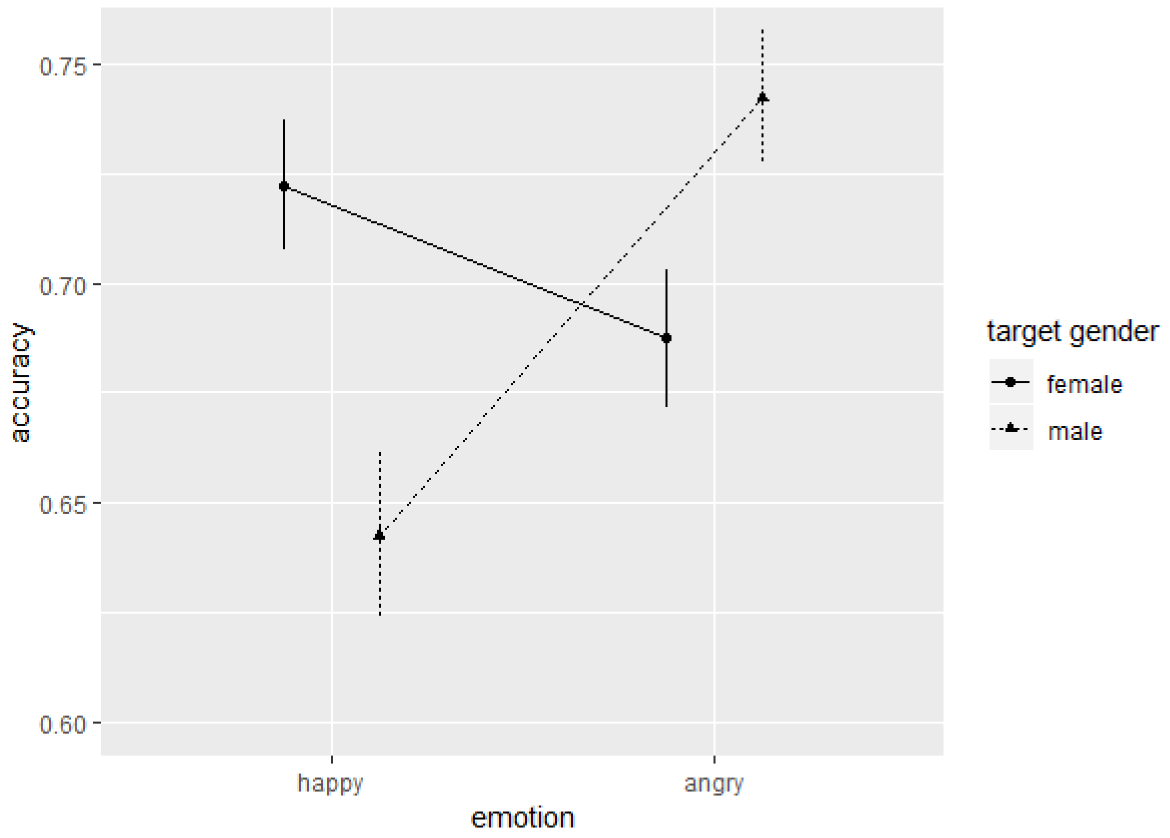

Figure 4. Interaction effect of dominant emotion and target gender on accuracy (0 = false, 1 = correct). Trials with 11 and 13 happy expressions were combined, as were trials with 11 and 13 angry expressions. Error bars indicate standard errors.

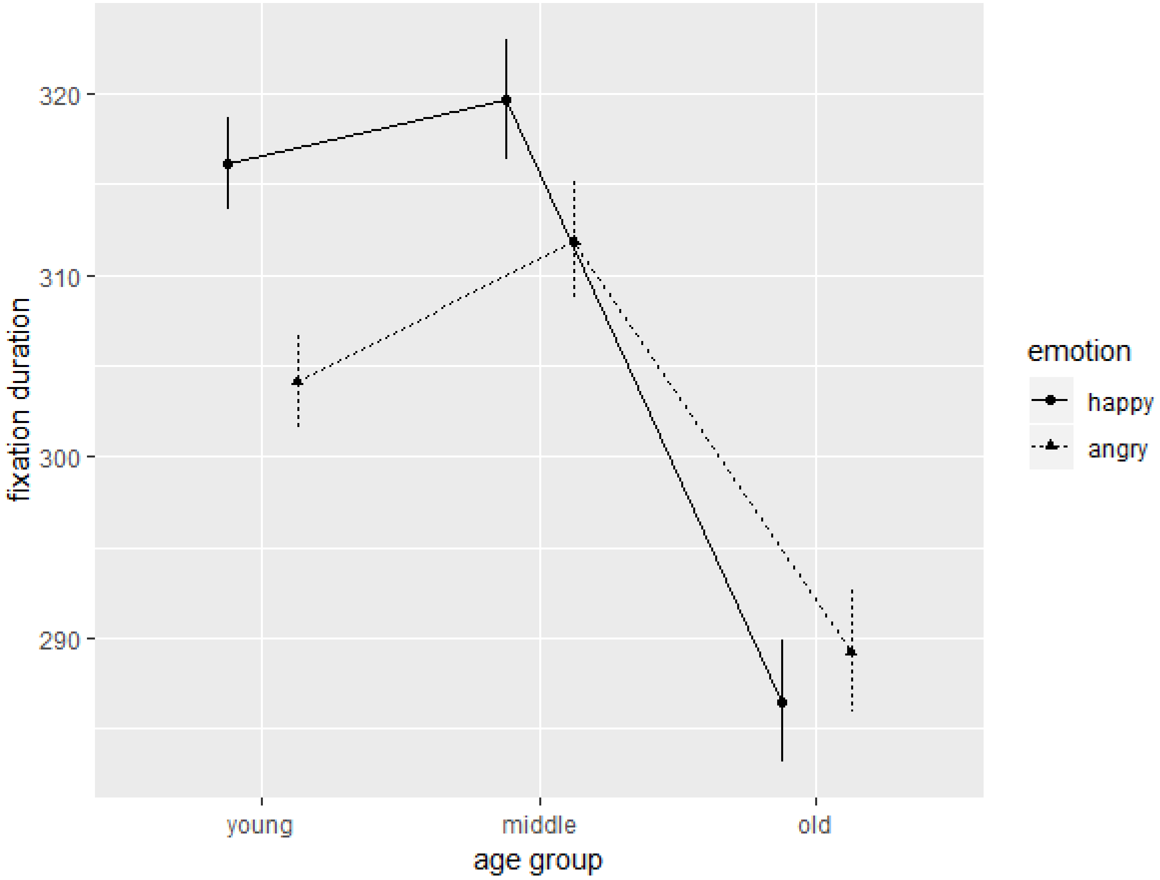

Figure 5. Visualization of means and standard errors of fixations durations on happy and angry faces for the three age groups.

Appendix A3

Manuscript 3: Processing emotional expressions under fear of rejection: Findings from diffusion model and eye-tracking analyses.

Running head: FEAR OF REJECTION: DIFFUSION MODELING AND EYETRACKING

Processing Emotional Expressions under Fear of Rejection: Findings from Diffusion Model and Eye-Tracking Analyses

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Abstract

By means of a diffusion model analysis (Ratcliff, 1978) we examined the cognitive processes in an emotion classification task following the arousal of fear of rejection. Participants (N = 84) received either negative (frustration group) or positive feedback on their future social relationships (control group). Then, they attended to the mood-of-the-crowd task, in which they had to classify crowds of emotional faces according to the predominant emotions. Individuals with a lower implicit (but not explicit) fear of rejection who were frustrated showed a prior bias (i.e., shifted starting point of the diffusion model) for positive rather than negative faces in contrast to the more fearful individuals. At the same time, in the frustration group, the less fearful individuals were faster in accumulating negative information (dynamic bias) than their more fearful counterparts. Thus, our findings suggest that the less fearful individuals restore a thwarted motive by shifting a criterion, so that ambiguous situations are perceived to be positive. However, at the same time, they tend to accumulate rejection-related (i.e., negative) information faster than positive information after motive frustration. The present study demonstrates that diffusion modeling supplies important information about underlying cognitive processes in the domain of the affiliation motive. Furthermore, results from additional eye-tracking analyses are in line with previous findings of a positivity bias, which was moderated by the group and fear of rejection: The positivity bias was weaker in the frustration group and for more fearful individuals.

Keywords: diffusion model, affiliation motive, eye-tracking, future-alone manipulation

Processing Emotional Expressions under Fear of Rejection: Findings from Diffusion Model and Eye-Tracking Analyses

According to motive disposition theory (MDT; e.g., McClelland, 1985) the affiliation motive is a fundamental psychological motive that energizes and drives behavior. Several studies examined the effects of this motive on cognitive processes. For example, Schultheiss and Hale (2007) report that individuals high in the implicit affiliation motive pay more attention to joyful faces than less affiliation-motivated individuals. Similarly, individuals high in implicit fear of rejection (FR) more often interpret poorly visible facial expressions as negative in comparison to individuals with a lower motive score (Nikitin & Freund, 2015).

Common to these and other studies in the field of motive research is that they examine behavioral variables such as error rates or mean RTs. However, these variables do not allow definite conclusions about the underlying cognitive processes (Voss, Rothermund, & Brandtstädter, 2008). For example, the finding that individuals with high FR interpret facial expressions more negatively than their less-fearful counterparts might have different reasons. The fearful individuals could adopt a *prior bias* for negative facial expressions. In this case, already before a stimulus is shown, they would be inclined to respond “negative”. An alternate explanation of a bias is based on the processing of the presented stimulus (*dynamic bias*): In the case of a negative dynamic bias, negative information is accumulated faster than positive information. By means of an analysis of error rates or mean RTs alone it is not possible to disentangle these two effects because both types of biases go along with a reduction in error rates and mean RTs for one class of stimuli (here, the negative facial expressions). In the present study, we employ the diffusion model (Ratcliff, 1978) to get independent measures for both the prior and the dynamic biases in the perception of emotional expressions.

These biases are investigated as a function of both the fear component of the affiliation motive and the contextual arousal of fear of rejection. In the arousal condition (in the following, also termed *frustration condition*), participants received negative feedback regarding their future social relationships. In the *control condition*, however, individuals got positive feedback. This so-termed *future-alone-manipulation* has already been employed in several studies (e.g., Baumeister, DeWall, Ciarocco, & Twenge, 2005; Twenge, Baumeister, DeWall, Ciarocco, & Bartels, 2007; Twenge, Baumeister, Tice, & Stucke, 2001).

We were interested in the interaction of FR and motive frustration on cognitive processing. We hypothesized that individuals low in FR are more likely to counteract the negative future feedback than their more fearful counterparts. We examined the interaction of FR and motive frustration on prior and dynamic biases in a task that is based on the classification of the prevalent mood of a crowd of facial expressions (Bucher & Voss, in press). Additionally, the diffusion model analyses are backed up with eye-tracking data.

In the following chapters, we first give a brief introduction to the diffusion model. Then, we derive the research questions, followed by the presentation of design and results of our study.

Introduction to Diffusion Modeling

In this section, we give a short introduction to diffusion modeling. Readers with interest in further details are referred to Wagenmakers (2009) and Voss, Nagler, and Lerche (2013, see also Ratcliff, Smith, Brown, & McKoon, 2016).

The diffusion model (Ratcliff, 1978) is a stochastic model that disentangles processes involved in the execution of binary choices. The model relies on the assumption that relevant information is collected continuously (e.g., orange vs. blue pixels in a color discrimination task; Voss, Rothermund, & Voss, 2004). The process of information accumulation runs until an upper or lower threshold is reached. Then, the corresponding response is initiated (Figure

1). In the present application, the upper and lower thresholds are associated with the emotions "angry" vs. "happy", which are also the response alternatives in the binary classification task of our study.

Several parameters influence the responses time distributions predicted by the model. First, the distance between the thresholds (*a*) is a measure for the adopted speed-accuracy settings. The larger the threshold separation, the longer it takes on average for the accumulation process to reach a threshold. As more information is considered, it becomes at the same time less likely that processes mistakenly end at the wrong threshold.

The second parameter, the drift rate (*v*), measures the average speed of information accumulation. The higher the drift rate, the faster information are collected, resulting in a higher percentage of correct responses and shorter RTs. In addition to the systematic influence of the drift, the diffusion process is also affected by random Gaussian noise. Therefore, processes can differ in duration and outcome, even if the same information is presented.

A third diffusion model parameter is the starting point (*z*, or the relative starting point $z_r = z/a$). An unbiased decision maker will locate the starting point centered between thresholds ($z_r = .5$). If, however, the starting point is closer to one of the two thresholds, fewer information is required to reach this threshold and the corresponding decision will be reached more often and with shorter decision times. For example, if the starting point is positioned closer to the "negative" threshold, "negative" responses will occur more often and mean RTs will be reduced for this response.

The fourth diffusion model parameter is the non-decision time (t_0). This parameter only influences the response time but not accuracy. It subsumes the time required for all processes that take place in addition to the decision process (e.g., encoding of information and motoric response).

The reliability (Lerche & Voss, 2017b; Yap, Balota, Sibley, & Ratcliff, 2012) and validity of the four main diffusion model parameters (e.g., Arnold, Bröder, & Bayen, 2015; Lerche & Voss, 2017a; Voss et al., 2004) have been secured in several studies. In addition to the four main diffusion model parameters, there are intertrial variabilities of drift rate (s_v), starting point (s_{zr}), and non-decision time (s_{t0}). Both s_v and s_{zr}, however, cannot really be estimated reliably and fixing these parameters to zero can lead to improved estimation of the main diffusion model parameters (Lerche & Voss, 2016; see also van Ravenzwaaij, Donkin, & Vandekerckhove, 2017).

Importantly, in the diffusion model framework, biases in favor of one response can manifest in two different ways. On the one hand, a bias can arise from a shift of starting point as explained above. This bias is similar to a response bias in the sense of signal detection theory (e.g., Macmillan, Kaplan, & Creelman, 1977). However, we will use the term *prior bias* in this manuscript because one of the two response options has an advantage independent of the presented information. On the other hand, a bias in information accumulation (i.e., drift rates) is possible: In this case, information supporting one response alternative is collected faster than information supporting the alternative decision. We call this a *dynamic bias*, because it operates during information accumulation. Several studies focus on the disentangling of these two types of biases (e.g., Leite & Ratcliff, 2011; Lerche, Christmann, & Voss, in press; Voss et al., 2008).

The Present Study

In the present study, we examine the effect of the arousal of FR on cognitive processes (prior bias, dynamic bias) in dependency of stable inter-individual differences in motive strength. For the manipulation of the arousal of FR we employ the so-called future-alone manipulation. This manipulation has been introduced by Twenge et al. (2001) and has also been used in many subsequent studies to frustrate the need for relatedness (e.g., Baumeister et al., 2005; DeWall, Maner, & Rouby, 2009; Hames et al., 2018; Twenge et al., 2007).

In recent years, it has been repeatedly argued that the affiliation motive of the MDT is an analogue to the need for relatedness from needs theories (e.g., Schüler, Sheldon, & Fröhlich, 2010). Accordingly, for the arousal of the affiliation motive we employed a manipulation from the need for relatedness research.

In the future-alone manipulation, participants first have to fill in a personality questionnaire. Then, they get accurate feedback on their extraversion score and false feedback about the implications of this score regarding their future belongingness with significant other persons. Previous research based on this manipulation has revealed, for example, that social exclusion makes individuals more aggressive (Twenge et al., 2001) and reduces prosocial behavior (Twenge et al., 2007). Whereas most studies focused on behavioral effects, the study by DeWall et al. (2009) examined cognitive processes. In their experiments, the authors examined the influence of relatedness need frustration on selective attention to emotional expressions. Individuals who experienced threat of exclusion were faster at identifying happy faces in a crowd of distractor faces. Moreover, they showed higher fixation rates on happy faces and were slower at disengaging from happy faces compared to participants who did not experience social exclusion.

DeWall et al. (2009) concluded that threatening the need for relatedness fosters a motivation to restore this need. Also in line with this interpretation is a study by Maner, DeWall, Baumeister, and Schaller (2007) who found that following social exclusion individuals had a preference for working on a task together with others rather than solving the task by themselves. However, the underlying mechanisms of these restoration processes remain unclear. Do frustrated individuals shift their response criterion (prior bias) or do they accumulate positive facial information faster (dynamic bias)? And how do individuals with high FR react to such a frustration? DeWall et al. (2009) did not measure the affiliation motive or any other potential moderator variables. We assume that individuals with high FR might be less competent to restore their frustrated motive. This assumption is supported by findings of Nikitin and Freund (2015), who report that individuals with high implicit FR more often misclassify happy facial expressions as negative and less often misclassify angry facial expressions as positive. Thus, individuals with high FR seem to have a bias for angry faces (whether it is a prior or dynamic bias has not yet been examined). Accordingly, we hypothesized that these fearful individuals show a reduced restoration process following motive frustration.

Previous studies have shown that implicit motives are predictive of spontaneous behavior, whereas explicit motives are predictive of deliberate choices (e.g., Brunstein & Hoyer, 2002; Brunstein & Maier, 2005; see also McClelland, Koestner, & Weinberger, 1989). For example, Wegner, Bohnacker, Mempel, Teubel, and Schüler (2014) report correlations between the strength of the implicit affiliation motive and the extent of pleasant, non-verbal communication with opponents during sport activities, whereas the explicit motive correlated with the extent of verbal communication with team-mates (see also Hagemeyer, Dufner, & Denissen, 2016). As we did not measure deliberate choices but task processing, we expected effects for the implicit affiliation motive. However—in contrast to many previous studies—we assessed both the implicit and explicit motive in order to test whether any effects are specific to the implicit motive.

To assess potential biases in emotion perception, we employed the mood-of-the-crowd paradigm (MoC; Bucher & Voss, in press), which is an adapted version of the face-in-the-crowd paradigm (FiC; Hansen & Hansen, 1988). Whereas in the face-in-the-crowd paradigm one emotional face has to be detected among a number of neutral distractor faces, in the MoC paradigm the overall mood of the crowd of faces has to be assessed. The task is more complex, requiring the processing of several stimuli and has a higher ecological validity as in every-day situations typically crowds with more than one target are prevalent. Previous analyses of eye-tracking data of the MoC task revealed that participants fixated more positive than negative expressions and are more accurate in evaluating crowds with happy and neutral compared to angry and neutral faces (Bucher & Voss, in press). The authors did not examine any possible moderators of this positivity bias. For example, it is questionable whether this general positivity bias is also present for individuals high in FR. Nikitin and Freund (2015) in line with Bucher and Voss (in press) also found a general positivity effect. This effect was, however, reduced for individuals higher in FR. We thus expected the positivity bias to be smaller (or even absent) for individuals with high FR in the frustration condition.

To sum up, this study addresses three main research questions: First, using diffusion modeling we examine whether the advantage for positive stimuli in the frustration condition reported by DeWall et al. (2009) is based on a prior bias or on a dynamic bias. Second, we test whether this bias is moderated by FR, with the hypothesis that only low-fear individuals show a positivity bias after motive frustration. Third, we additionally examine gaze movements and investigate whether a positivity bias in gaze fixations (as observed by Bucher & Voss, in press) depends on motive frustration, FR, or an interaction of both.

Method

Participants

Sample size was based on a power analysis with GPower 3.1.9.2 (Faul, Erdfelder, Lang, & Buchner, 2007), which resulted in a required sample size of 77 for the detection of a medium-sized effect (f^2 = .15, linear multiple regression with three predictors, power = .80, α = .05). Based on the software hroot (Bock, Baetge, & Nicklisch, 2014), we recruited a total of 90 participants from the participants' pool of the Psychological Institute of Heidelberg University. Six participants did not complete the study because the eye-tracker could not assess their gaze position reliably. Thus, our sample consisted of 84 participants. All participants signed an informed consent prior to the beginning of the study and declared at the end of the study that their data could be used for analyses. Participants received either course credit or 5 € (approx. 6 US $). Most of the participants were students (93%); amongst them, 38% studied psychology. Seventy-five percent of the participants were females. On average, participants were 23.0 years old (range: 18 to 43, *SD* = 4.2).

Future-Alone Manipulation

To enhance the credibility of the manipulation, we adapted the original procedure in a few aspects. First, participants completed a short version of the Big Five Inventory (BFI-K; Rammstedt & John, 2005) and received accurate feedback on all five personality dimensions, thus not only on the extraversion dimension. We expect that the false feedback regarding future social interactions is more trustworthy, when ostensibly computed from a combination of these different dimensions. Specifically, participants got the following instruction (translated from German): "Now you will work on a short personality questionnaire. In a longtime study by Brody et al. (2011) it was examined which components of personality have the greatest influence on well-being. From these personality components personality profiles can be derived. These also allow predictions about the further development of the person. In our investigation, we want to validate the applied questionnaires on a German sample. In the following, we ask you to answer to some questions on your personality. Please try to respond as spontaneously as possible to the statements. If you are not sure, please choose the value that matches best with how you see yourself. At the end of the personality test you will receive an individual feedback about your personality profile."

After the participants had filled in the questionnaire items, a loading bar appeared (for a duration of 8 seconds) accompanied by the following text: "Please wait a moment until the evaluation of your personality profile has been completed." Then, the participants received scores on the five personality dimensions. Next, they saw the manipulated feedback. In our translation of the original texts by Twenge et al. (2001) from English to German, we modified several passages, attenuating them to increase the credibility. In the *frustration condition* (future-alone condition), the following statement was presented: “The data that you entered in the preceding questionnaires indicate that you probably belong to people who will be lonely later in life. You may have friends and relationships now, but already in the next years most of them might dissolve. It is very probable that during your live you will become more and more lonely.” In the *satisfaction condition* (future belonging condition), on the other hand, participants were told: “The data that you entered in the preceding questionnaires indicate that you probably belong to people who have good relationships throughout their lives. You are likely to have a long and stable partnership and friendships that will last well into old age. It is very probable that you will always have friends and other people you are important to.”

The adapted manipulation was tested in an online pilot study. Thirty-nine participants took part in this study. They were randomly assigned to one of the two conditions. After participants received the feedback about their personality profile, they had to fill in the Positive and Negative Affect Schedule (PANAS; Krohne, Egloff, Kohlmann, & Tausch, 1996; Watson, Clark, & Tellegen, 1988). They were instructed to rate their feelings with respect to the present moment. Furthermore, participants answered to the need-threat items by Schoel, Eck, and Greifeneder (2014) referring to the moment when they read the feedback regarding their personality profile. These items are informative about participants’ need of belonging, self-esteem, meaningful existence and control.

Results of the pilot study indicate that individuals in the frustration condition experience higher levels of negative affect (M = 2.11, SD = 0.75) than individuals in the satisfaction condition (M = 1.51, SD = 0.82), $t(37) = 2.41$, $p = .021$, $d = 0.78$. In addition, there was a tendency for lower positive affect in the frustration (*M* = 2.92, *SD* = 0.83) compared to the satisfaction condition (*M* = 3.15, *SD* = 0.63), *t*(37) = -0.97, *p* = .338, *d* = -0.31. Participants from the two groups also differed in the perceived fulfillment of the need for belonging, with lower assessments of belonging in the frustration (*M* = 3.82, *SD* = 1.55) than in the satisfaction condition (*M* = 6.00, *SD* = 0.69), *t*(37) = -5.39, *p* < .001, *d* = 1.74. Participants in the frustration condition further reported lower levels of satisfaction of the need for self-esteem (*M* = 3.45, *SD* = 1.54) than in the satisfaction condition (*M* = 5.24, *SD* = 1.23), *t*(37) = -3.89, *p* < .001, *d* = -1.25. They also indicated lower values with regard to the need for a meaningful life (*M* = 4.42, *SD* = 1.35) compared to the satisfaction condition (*M* = 5.86, *SD* = 0.65), *t*(37) = -4.04, *p* < .001, *d* = -1.30, but did not report significantly lower feelings of control (*M* = 2.22, *SD* = 1.54) compared to participants in the satisfaction condition (*M* = 2.92, *SD* = 1.19), *t*(37) = -1.53, *p* = .133, *d* = -0.50.

Design, Material and Procedure

The experiment was run in a windowless laboratory to ensure constant lighting conditions. All participants were assessed in individual sessions. Participants were seated in front of a laptop with a screen resolution of 1920 × 1080 pixels. An iView RED250 mobile eye-tracker (SensoMotoric Instruments; temporal resolution: 250 Hz) was mounted below the monitor.

Instructions, questionnaires and the MoC task were all computerized. First, participants worked on 16 practice trials of the MoC task. Then, demographic data were collected. Next, the implicit and explicit affiliation motive were assessed. This was followed by the future-alone manipulation. Participants were assigned to either the frustration or control condition. After the false feedback, they worked on the test trials of the MoC task. Following the binary task, participants had to answer to a number of open-framed questions (“What do you think that this study is about?”; “How might the feedback about your personality profile be related to the other questions?”). Furthermore, on a five-point Likert scale, they had to indicate whether they had any doubts during the study. If they answered with at least 2, they were further asked why and when they had these doubts. Finally, participants were debriefed about all aspects of the study.

Motive Measures

For the assessment of the implicit affiliation motive, we used a short version of the Multi-Motive Grid (MMG; Schmalt, Sokolowski, & Langens, 2010; Sokolowski, Schmalt, Langens, & Puca, 2000). The MMG is a semi-projective measure that has been frequently applied for the assessment of implicit motives (e.g., Gable, 2006; Langens & Schmalt, 2002; Müller & Rothermund, 2017; Nikitin & Freund, 2015; Puca & Schmalt, 1999). Note that there is some debate on the question of whether the MMG is an implicit (e.g., Langens & Schmalt, 2008, see also Baumann, Kazén, & Kuhl, 2010) or rather a “semi-implicit” motive measure (Schüler, Brandstätter, Wegner, & Baumann, 2015, p. 852). In the MMG, each motive component is assessed by means of 12 statements (binary items measuring the agreement/disagreement). Accordingly, a maximum sum score of 12 can be reached. The MMG measures both hope and fear components of the affiliation, achievement and power motive. Our central interest was in the FR component of the affiliation motive, but we also conducted additional analyses with the hope component. In the MMG, FR is measured with the items “Being afraid of being rejected by others” and “Being afraid of being boring to others”, hope of affiliation (HA) with the items “Feeling good about meeting other people” and “Hoping to get in touch with other people”; The fear values of our sample ranged from 1 to 11 ($M = 6.33$, $SD = 2.36$), the hope values from 2 to 10 ($M = 5.82$, $SD = 1.98$) and the internal consistency of Cronbach’s α was .60 and .52 for the fear and hope components, respectively. Note that the internal consistency of FR (the motive variable which is in the center of our analyses) despite being rather low is still comparable to values observed in other MMG studies (e.g., α = .63 in the study by Nikitin & Freund, 2015).

The explicit affiliation motive in its hope and fear components was assessed by means of the Mehrabian Affiliative Tendency Questionnaire (MAFF) and the Mehrabian Sensitivity to Rejection Scale (MSR) (Mehrabian, 1970; German items as in Engeser & Langens, 2010). Each scale consists of 25 items. The participants rated their agreement to the items on a five-point Likert scale. We computed the mean MAFF score (in the following, explicit HA) and the mean MSR score (explicit FR). The hope values of our sample ranged from 1.48 to 4.44 ($M = 3.42$, $SD = 0.49$) and the fear values from 2.08 to 4.40 ($M = 3.23$, $SD = 0.52$) and the internal consistency of Cronbach's α was .81 and .83 for the hope and fear components, respectively.

Mood-of-the-Crowd Task (MoC)

In each trial of the MoC task (Bucher & Voss, in press), 20 computer-generated faces (adopted from Becker, Anderson, Mortensen, Neufeld, & Neel, 2011) were presented randomly distributed across the screen. Each face showed a happy or an angry expression. Participants had to indicate the overall mood of the faces. If the majority of the faces was happy (angry), they had to press the key associated with the response happy (angry). The assignment of the responses to the keys ("A" and "L") to emotions was counterbalanced across participants. We varied the dominant mood (happy vs. angry) and the difficulty of the task, showing 7, 9, 11, or 13 happy faces. Furthermore, in half of the trials only female faces were presented and in the other half only male faces. Thus, we used a 2 (dominant mood) × 2 (difficulty) × 2 (gender of presented faces) within-subject design. Each combination of factors was repeated 12 times, resulting in a total number of 96 test trials. In the 16 practice trials, each combination of factors appeared twice.

Both the practice and test block were preceded by a 9-point calibration of the eye tracker, followed by a 4-point validation. Each trial started with the presentation of a fixation cross which remained on the screen until the participant's gaze position was on the cross for at least 500 ms. In cases in which the recorded gaze position deviated from the fixation cross for more than 5 seconds, a recalibration was performed. After the fixation cross, the facial stimuli were presented and remained on the screen until the participant responded. If the response of the participants exceeded 10 seconds, a warning message ("please respond faster") was shown. The words "happy" and "angry" appeared on the appropriate sides at the bottom of the screen to remind participants of the response assignment. Following an inter-trial interval of 500 ms, the next trial started.

Estimation of Diffusion Model Parameters

For parameter estimation, we used the program *fast-dm-30* (Voss & Voss, 2007, 2008; Voss, Voss, & Lerche, 2015)[1], using maximum likelihood as optimization criterion. Parameters were estimated independently for each participant. The thresholds of the model were associated with the responses "angry" (upper threshold) and "happy" (lower threshold). We fixed the intertrial variabilities of starting point and drift rate to zero because these parameters cannot be estimated reliably and fixation of these parameters can lead to improved estimates of the other, more meaningful parameters (Lerche & Voss, 2016; see also van Ravenzwaaij, Donkin, & Vandekerckhove, 2016). Separate drift rates were estimated for the easy vs. difficulty task. Thus, in total, our model comprised the following parameters: threshold separation (a), starting point (z_r), non-decision time (t_0), drift rates for happy ($v_{happy,}$

[1] The program can be freely downloaded from https://www.psychologie.uni-heidelberg.de/ae/meth/fast-dm/index-en.html. A command line version and, additionally, since recently a graphical user interface, developed by Stefan Radev, are available.

$_{easy}$ and $v_{happy, difficult}$) and for angry stimuli ($v_{angry, easy}$ and $v_{angry, difficult}$) and intertrial variability of non-decision time (s_{t0}).[2]

Results

Responses with logarithmized latencies being more than three interquartile ranges above the third quartile or more than three interquartile ranges below the first quartile of the individual logarithmized RT distributions were removed from all analyses (Tukey, 1977). This resulted in an exclusion of 0.34% of data. One participant with more than 20% of fast outliers was excluded from the further analyses (including the participant did not alter the pattern of results). The diffusion model fit the data reasonably well (Figure 2). In this scatter plot, observed (x-axis) and predicted statistics (y-axis) are juxtaposed. Each participant is illustrated by one symbol and perfect model fit is given if observed and predicted statistics are identical (i.e., the points lie exactly on the diagonal).

For each dependent variable, we conducted hierarchical regression analyses (Table 1): In a first regression analysis, the criterion was regressed on group (1 = frustration, 0 = control) and implicit FR (centered on the sample mean). Then, in a second step, we included the group × FR interaction term.

We first examined mean RT of correct responses and accuracy (separately for positive and negative facial stimuli). In these analyses of behavioral data, there were no significant main effects or interactions (all *p*s ≥ .123). Next, we analyzed the *diffusion model parameters*. No significant main or interaction effects were found for threshold separation (all *p*s ≥ .273), non-decision time (all *p*s ≥ .198) and intertrial variability of non-decision time (all *p*s ≥ .275). For starting point, a significant group × FR interaction effect emerged, b = 0.02, 95% CI [0.00, 0.04], ß = .38, p = .018. This effect is visualized in Figure 3 (upper

[2] We did not include the gender of the faces as further factor because we did not have any expectations about an influence of this factor. Furthermore, given that the trial number of our task was only moderate, the estimation procedure would become unstable with the inclusion of a further factor.

panel). As can be seen in the figure, in the control group, individuals with low FR (*M* – 1 *SD*) had a starting point closer so the angry threshold (z_r = .52) and individuals with high FR (*M* + 1 *SD*) a starting point that is closer to the happy threshold (z_r = .46). In the frustration group, on the other hand, the opposite pattern emerged: For individuals with low FR starting point was shifted toward the happy threshold (z_r = .47), whereas the starting point of individuals with high FR was closer to the angry threshold (z_r = .51). These results indicate that individuals with low but not high FR counter-regulated a threat of the affiliation motive by shifting starting point toward the happy threshold.

For drift rates, we computed the mean of the drift rates across easy and difficult trials to facilitate interpretations. Furthermore, we recoded drift rates directed to the lower (i.e., happy) threshold, multiplying them by -1. Accordingly, higher drift rates always imply higher speed of information accumulation for the dominant stimulus (i.e., v_{angry} and v_{happy} describe the speed of information accumulation for angry- vs. happy-dominated crowds, respectively). Finally, a bias was computed as the difference in drift rates between angry and happy trials ($v_{angry-happy}$).

Interestingly, there was a significant group × FR interaction effect for $v_{angry-happy}$, b = -0.10, 95% CI [-0.19, -0.01], ß = -.34, p = .033. Results indicate that the interaction is mainly driven by the speed of accumulation of negative information. In the control group, individuals with low FR accumulated negative information more slowly (ν = 0.39) than their fearful counterparts (ν = 0.59). In the frustration group, on the other hand, the fearless individuals accumulated the negative information faster (ν = 0.62) than the fearful individuals (ν = 0.47; see also Figure 3, bottom row). Additionally, there was a significant main effect of FR on v_{angry}, b = 0.04, 95% CI [0.00, 0.09], ß = .32, p = .047. Generally, higher FR is related to faster accumulation of negative information. Additionally, we computed all analyses for drift rates separately for easy vs. difficult trials. In these analyses, the same pattern of results emerged for both the drift rates for easy and difficult stimuli.

From the eye-tracking data, the proportion of fixations on angry facial stimuli compared to the total number of fixations on facial stimuli (% number of angry fixations in Table 1) and the mean duration of fixations on angry facial stimuli compared to the mean duration on all faces (% duration of angry fixations in Table 1) were computed. For fixations on presented faces a tolerance of 30 pixel (0.5 cm) was allowed. In case of multiple fixations on the same face, only one fixation was counted (thus, the maximum possible number of fixations on angry expressions is 13 fixations in one trial).

For the proportion of fixations, there was a significant main effect of condition: Individuals in the frustration condition showed a higher proportion of fixations on angry faces (49.81%) than individuals in the control condition (49.01%), $b = 0.80$, 95% CI [0.06, 1.54], ß = .23, $p = .035$. Furthermore, there was a significant main effect of FR, $b = 0.18$, 95% CI [0.02, 0.34], ß = .24, $p = .025$. In the control condition, individuals with high FR showed a higher proportion of fixations on angry faces (49.44%) than individuals low in FR (48.59%). There was no significant group × FR interaction effect ($b = 0.02$, 95% CI [-0.30, 0.34], ß = .02, $p = .917$). Regarding the duration of fixations on angry faces, no significant effects emerged (all ps ≥ .114).

Additionally, we conducted all analyses with explicit instead of implicit FR. No significant group × FR interaction effects emerged (all ps ≥ .241). Furthermore, all analyses were executed with the hope instead of the fear component of the affiliation motive. Again, no significant interaction effects were found (all ps ≥ .086). Finally, in a further set of analyses, we excluded all participants ($N = 21$) that expressed serious doubts about the correctness of the future belongingness feedback (4 or 5 on the Likert scale ranging from 0 to 5). An exclusion of these participants did not change the pattern of results.

Discussion

In the present study, we aroused fear of rejection using the future-alone manipulation (Twenge et al., 2001): Two groups received fictitious negative feedback (frustration group), or positive feedback (control group) about their future social relationships. As expected, the diffusion model analyses revealed that individuals from the frustration group who scored low on implicit fear of rejection (FR) shifted the starting point toward the positive threshold. The starting point of the more fearful individuals, on the other hand, was closer to the negative threshold. In addition and unexpectedly, the fearless individuals in the frustration group accumulated negative information faster than individuals high in FR. Thus, for low-fear-participants, the manipulation simultaneously provoked an incongruent effect in starting point (prior bias), and a congruent effect in drift rate (dynamic bias).

Top-Down and Bottom-Up

DeWall et al. (2009), who also used the future-alone manipulation, found that individuals in the future-alone condition oriented their attention more toward positive stimuli than individuals in the future-belonging condition. They explained their findings in terms of a "desire for compensatory social acceptance" (p. 738). We also find such a desire for restoration of the frustrated motive, thus a prior bias for positive stimuli. Interestingly, this bias is only present for individuals with low FR. Only the fearless individuals shifted the starting point toward the positive threshold after motive frustration, whereas the starting point of the fearful individuals was closer to the negative threshold after motive frustration.

Whereas individuals counter-regulated in terms of the starting point, we found a mood-consistent effect in the drift rate. In the frustration group, the fearless participants accumulated negative information faster and in the control group positive information was collected more quickly. We did not have any prior hypotheses about differences in speed of information accumulation. However, taken together, our findings suggest that even if individuals tried to counteract their current motivational state (“top-down”), this state still (“bottom-up”) influenced how they processed information.

Counter-Regulation Theory

One further finding from our study might seem astonishing at first glance: In the control group, the fearless individuals had a prior bias for negative facial expressions. This was not predictable on the mere basis of needs theories, which only assume that individuals will try to restore a thwarted need. However, our result is in line with the counter-regulation theory by Rothermund, Voss, and Wentura (2008, see also Rothermund, 2011; Wentura, Müller, Rothermund, & Voss, 2018; Wentura, Voss, & Rothermund, 2009). This theory assumes that automatic attentional processes operate to counteract momentary motivational states. This incongruence effect is expected for both positive and negative states. Thus, individuals with a negative outcome focus, direct their attention to positive information, whereas the opposite is true for individuals in a positive outcome focus. Importantly, the exact processes underlying this counter-regulation have not yet been fully understood (but see Voss & Schwieren, 2015, for an example of a diffusion model analysis on the counter-regulation effect). Our results suggest that counter-regulation manifests in the prior setting of the starting point rather than in differences in speed of information accumulation. Furthermore, whereas the previous studies typically observed counter-regulatory processes in the context of anticipated financial outcomes, our study further expands the scope of this approach to the realm of motive frustration (see Koranyi & Rothermund, 2012, for an example of the application of counter-regulation in social relationships).

Diffusion Modeling in Motive Research

Interestingly, we did not find significant group by FR interaction effects for the behavioral variables (mean RT and accuracy). This finding is in line with the results from other diffusion model studies that report effects on model parameters but not on behavioral data (e.g., Lerche et al., in press; Lerche, Neubauer, & Voss, 2018). There are different explanations why effects on model parameters can be more robust than effects on behavioral data: Firstly, it is possible that experimental effects spread over error rates and RT means, and only the combination of both sources allows pinpointing an effect. Secondly, diffusion model parameters are purer measures for single processes, thus possibly reducing measurement errors. Thirdly, as is the case in the present analyses, two different cognitive mechanisms might be triggered that cancel out each other's effects to a certain degree. Thus, one great advantage of diffusion modeling is the ability of disentangling different, otherwise confounded, processes.

As far as we know, up to date only one other study has applied the diffusion model to analyze effects of a threatened motive (Lerche et al., 2018). The authors investigated effects of the frustration of the achievement motive. They found that individuals with higher implicit Fear of Failure accumulated information more slowly (drift rate) when they received negative performance feedback. However, individuals with high Fear of Failure did not differ from their less fearful counterparts in terms of how carefully they executed the task (threshold separation). The authors assumed that due to ruminatory processes activated by the negative feedback the fearful individuals were distracted from the actual task. The present study that was based on the affiliation motive further demonstrates that mathematical models such as the diffusion model can help to gain new insights in the field of motive research.

Eye-Tracking: Positivity Bias

As mood classification task we used the mood-of-the-crowd task by Bucher and Voss (in press) who found a positivity bias applying eye-tracking technology. In the present study, we replicated this bias regarding the proportion of fixations: Fixations occurred generally more often on happy faces than on angry faces. Interestingly, this bias was reduced in the frustration group. In addition, the bias was also affected by inter-individual differences in FR:

The higher FR, the smaller was the positivity bias. Thus, our study adds to the current literature in that we could identify two moderating variables of the positivity bias.

One problem of eye-tracking is that a higher percentage of fixations does not give clear indications about the exact underlying processes. The reasons for a fixation can be manifold: Individuals can fixate stimuli, for example, because they are interested in them, or because they have more difficulty to understand them (e.g., Was, Sansosti, & Morris, 2017, p. 156). In our study, we observed the same effect of FR for drift rate and the proportion of fixations: Individuals with higher FR accumulated negative information faster and had a higher proportion of fixations on negative information. This might be seen as an indication that the proportion of fixations in the MoC task rather measures the efficiency of information processing than problems of identifying the presented emotions or enhanced pleasure in looking at certain stimuli. Thus, our study exemplarily shows that an integration of diffusion modeling and eye-tracking can be fruitful because a better understanding of the task-underlying processes can be gained.

Integration of Motive Disposition Theory and Needs Theories

In different research traditions, different concepts have been investigated that focus on satisfying relationships with other individuals. Schüler and Brandstätter (2013, see also Schüler et al., 2010) regard the *affiliation motive* of the motive disposition theory (e.g., McClelland, 1985) to be analogue to the *need for relatedness* of needs theories (e.g., Baumeister & Leary, 1995; Deci & Ryan, 2000, 2002) such as the self-determination theory. They argue that the incentives of the affiliation motive are “phenomenologically closely related” to characteristics of the environment that are supposed to fulfill the social relatedness need (p. 689). One major difference between motive disposition theory and self-determination theory is the significance of inter-individual differences. Whereas supporters of self-determination theory usually declare no particular interest in such differences ("we believe that these innate differences are not the most fruitful place to focus attention", Deci & Ryan, 2000, p. 232), inter-individual differences are in the focus of motive disposition theory. For example, Schüler and Brandstätter (2013) examined the moderating role of the implicit affiliation motive in regard to affective reactions to satisfaction of the need for relatedness (see also Hofer & Busch, 2011; Schüler, Wegner, & Knechtle, 2014). They found that individuals with a high implicit affiliation motive profit more from environments that fulfill their need for relatedness than less affiliation-motivated individuals. The need frustration × motive interaction effects observed in our study further support the idea of an integration of MDT and need theories such as SDT.

Limitations and Future Directions

One limitation of our study is that we had only two groups, a frustration and a control group. In future studies, it would be important to include a further control group with no affiliation-relevant feedback (but, for example, competence-relevant feedback), a medium-intensity feedback (in between our frustration and control group), or no feedback at all. The reason for our choice of two rather than three conditions was of economical nature. As we conducted an eye-tracking study, we could administer only one participant per session so that the assessment of more than 80 participants was already effortful and expensive.

As noted above, our results regarding a prior bias are in line with predictions of the counter-regulation theory by Rothermund et al. (2008), whereas the drift related finding points in the opposite direction. Future studies need to test the stability and generalizability of these biases across different manipulations and different tasks. For example, one might replace the future-alone manipulation by a manipulation of the immediate satisfaction of the affiliation motive. However, as previous studies did not find differences between anticipated and immediate threats (DeWall et al., 2009; Maner et al., 2007; Twenge et al., 2001), we do not expect to find diverging results either.

Some researchers argue that the MMG does not measure implicit, but rather “semi-implicit” motives (e.g., Schüler et al., 2015, but see e.g., Langens & Schmalt, 2008). Notably, we only found effects for the implicit, but not for the explicit motive. We also computed correlations between the implicit and explicit fear and hope components of the affiliation motive and found only small relationships (fear: $r = .20$; hope: $r = .14$). Accordingly, our results support the view that the MMG measures something different from explicit motive measures. However, it would still be interesting to test whether our findings can be replicated with a motive measure that uncontroversially measures implicit motives. Thus, in a future study, a Picture Story Exercise (e.g., McClelland et al., 1989; Schultheiss & Pang, 2007) might be used rather than—or in addition to—the administration of the MMG.

Conclusions

Our study demonstrates that diffusion modeling can supply interesting insights into motivational processes. Individuals with lower implicit fear of rejection who got negative feedback on their future relationships accumulated negative facial expressions faster, but showed a decision bias for positive facial expressions. The diffusion model allowed the separation of these mood-congruent processes (drift rate) from counter-regulatory processes (starting point). In future studies, the diffusion model could also be applied to other research topics from the field of motive research (e.g., power motive).

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Table 1

Hierarchical regression of the diffusion model parameters and eye-tracking variables on group, implicit fear of rejection (FR) and the interaction thereof

Step	Variable	a	z_r	$v_{angry\text{-}happy}$	v_{angry}	v_{happy}	t_0	s_{t0}	% number of angry fixations	% duration of angry fixations
1	Intercept	2.46*** (0.08)	.49*** (.01)	-0.10 (0.08)	0.43*** (0.05)	0.52*** (0.05)	2.91*** (0.24)	2.49*** (0.22)	49.01*** (0.26)	49.07*** (0.24)
	Group[a]	0.12 (0.11)	.00 (.02)	0.15 (0.11)	0.06 (0.07)	-0.1 (0.07)	-0.26 (0.34)	-0.35 (0.32)	0.80* (0.37)	0.56 (0.35)
	FR	0.01 (0.02)	.00 (.00)	0.01 (0.02)	0.00 (0.02)	-0.01 (0.01)	-0.02 (0.07)	0.01 (0.07)	0.18* (0.08)	0.11 (0.08)
	R^2 (adjusted)	-.01	-.02	.01	-.02	.01	-.01	-.01	.11	.04
2	Intercept	2.46*** (0.08)	.49*** (.01)	-0.07 (0.07)	0.45*** (0.05)	0.52*** (0.05)	2.95*** (0.24)	2.52*** (0.22)	49.01*** (0.26)	49.06*** (0.25)
	Group[a]	0.12 (0.11)	.00 (.02)	0.15 (0.11)	0.06 (0.07)	-0.1 (0.07)	-0.26 (0.34)	-0.35 (0.32)	0.80* (0.37)	0.56 (0.35)
	FR	0.02 (0.03)	-.01 (.01)	0.06 (0.03)	0.04* (0.02)	-0.02 (0.02)	0.07 (0.10)	0.08 (0.10)	0.17 (0.12)	0.10 (0.11)
	Group × FR	-0.02 (0.05)	.02* (.01)	-0.1* (0.05)	-0.08* (0.03)	0.02 (0.03)	-0.19 (0.14)	-0.14 (0.14)	0.02 (0.16)	0.01 (0.15)
	R^2 (adjusted)	-.02	.03	.05	.05	.00	-.01	-.01	.10	.03

Note. The table contains unstandardized regression coefficients with standard errors in parentheses. FR was centered on the sample mean prior to the analyses

*p < .05; **p < .01; *** p < .001.

[a] 1 = frustration; 0 = control.

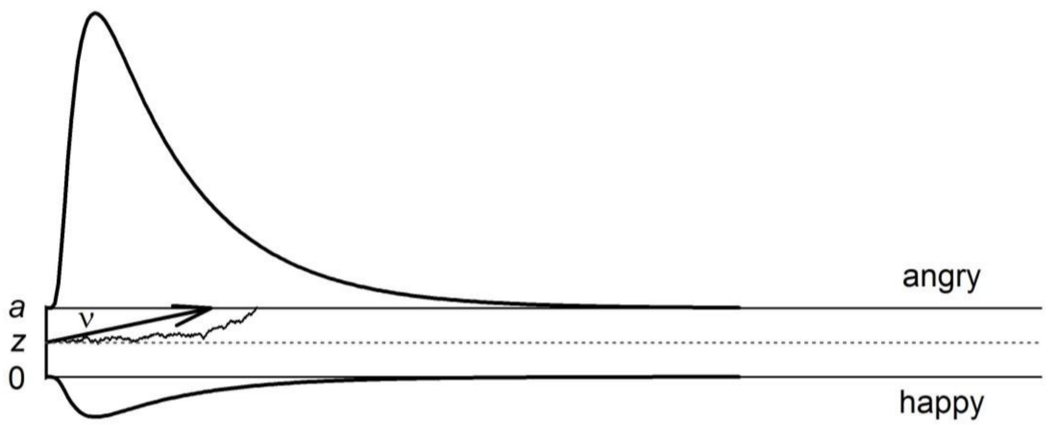

Figure 1. Illustration of the decision process of the diffusion model for a task with the response options angry and happy. Angry is associated with the upper threshold and happy with the lower threshold. The information accumulation initiates at starting point *z* and moves in the corridor delimited by the two thresholds, the so-termed threshold separation *a*. Information are accumulated with drift rate *v* until one of the two thresholds has been reached. Subsequently, the corresponding response (e.g., a key press) will be executed (not depicted in the figure; neither depicted is the encoding of information preceding the decision process).

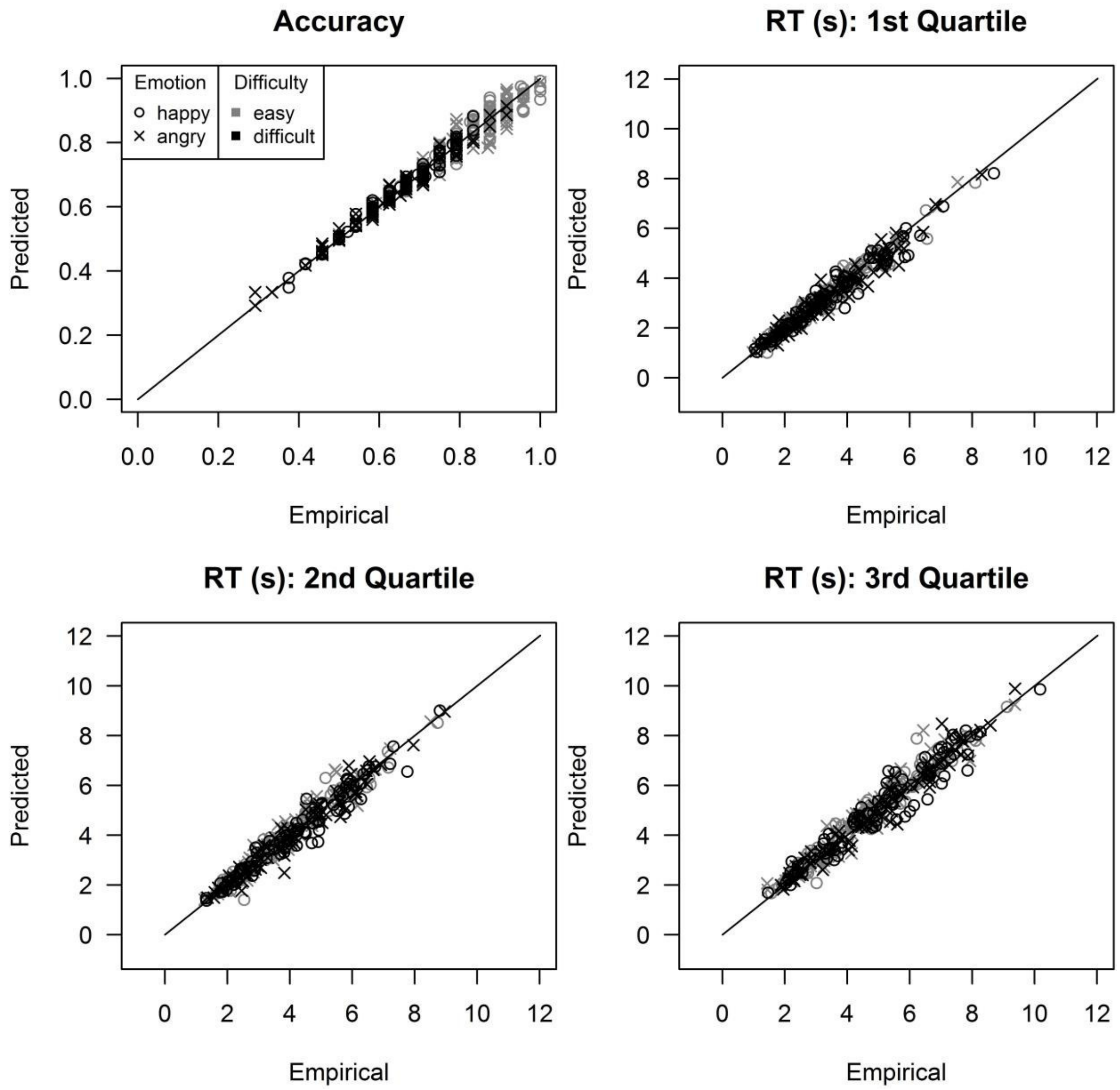

Figure 2. Graphical examination of model fit.

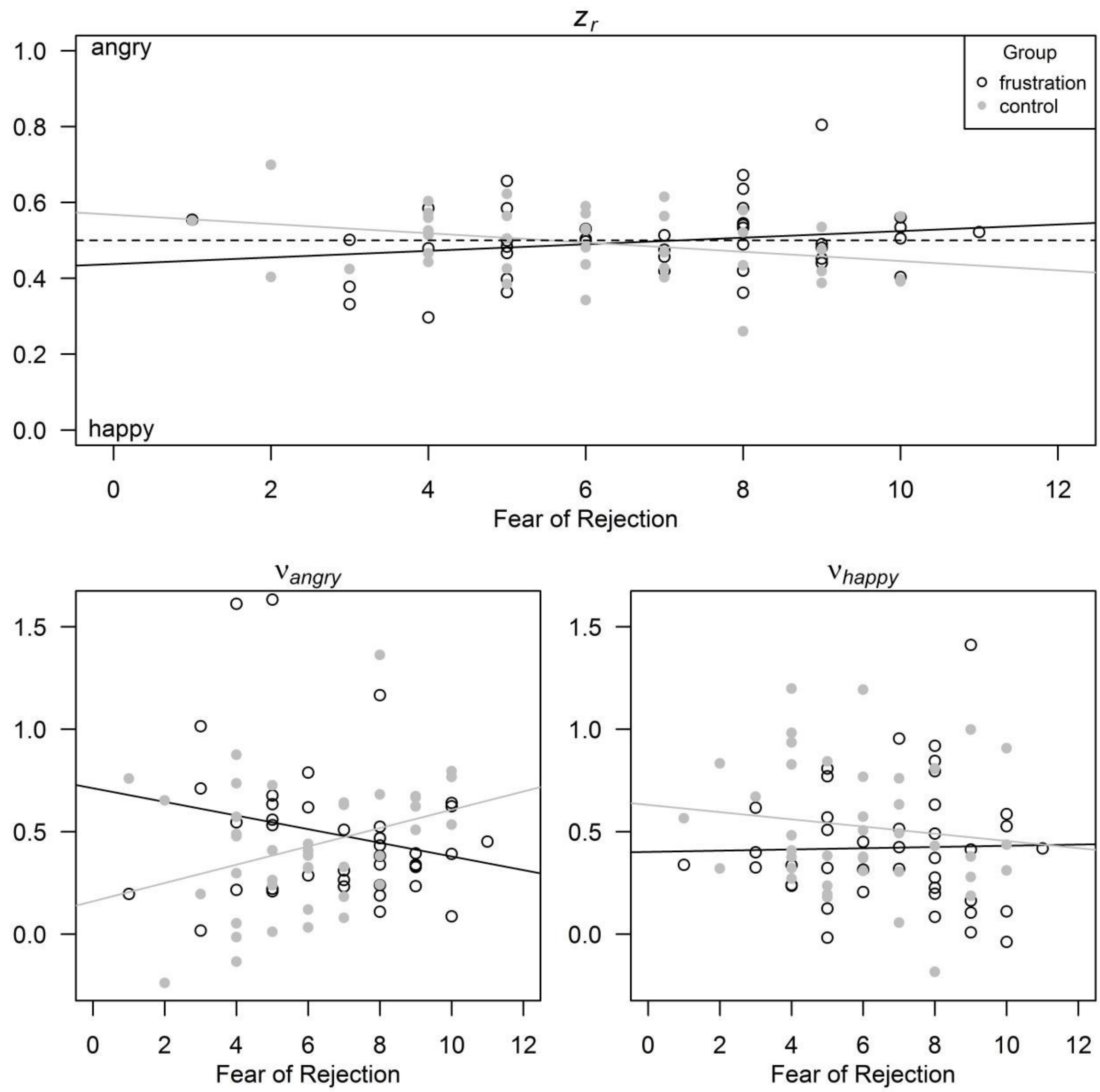

Figure 3. Group × implicit FR interaction effect on starting point and drift rates.

Appendix A4

Manuscript 4: Happy crowds are pretty crowds: The influence of attractiveness on mood perception.

Happy crowds are pretty crowds –

The influence of attractiveness on mood perception

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Abstract

Empirical findings predominantly support a happiness superiority effect in visual search paradigms and reveal that social cues, like sex and race, moderate this advantage. A more recent study showed that the facial attribute attractiveness also influences the accuracy and speed of emotion perception. In the current study, we investigated whether the influence of attractiveness on emotion perception translates into a more general evaluation of moods when more than one emotional target is presented. In two experiments, we used the Mood-of-the-Crowd (MoC) task to investigate whether attractive crowds are perceived more positively compared to less attractive ones. The task was to decide whether an array of faces included more angry or more happy faces. Furthermore, we recorded gaze movements to test the assumption that fixations on happy expressions occur more often when attractive crowds are shown. Thirty-four participants took part in Experiment 1 as well as in Experiment 2. In both experiments, crowds presenting attractive faces were judged as being happy more frequently whereas the reverse pattern was found for unattractive crowds of faces. Moreover, participants were faster and more accurate when evaluating attractive crowds containing more happy faces as well as when judging unattractive crowds composed of more angry expressions. Additionally, in Experiment 1, there were more fixations on happy faces compared to angry expressions in attractive crowds. Overall, the present findings support the assumption that attractiveness moderates emotion perception.

Keywords: emotion perception, attractiveness, visual search, evaluative congruence account, gaze movement

Happy crowds are pretty crowds – The influence of attractiveness on mood perception

The fast and correct identification of emotional expressions in human faces is essential for social interactions, because facial expressions signal a person's potential intentions and behavior (Savage, Lipp, Craig, Becker, & Horstmann, 2013). While a smiling face signals affiliation and approachability, an angry face signals a lack of approachability or even threat of aggression (Scherer & Wallbott, 1994). Due to the centrality of facial emotion perception for adaptive social interaction, many theorists have argued that humans can automatically detect signs of affiliation or threats of aggression in faces (Öhman & Mineka, 2001). Building on this assumption, some have postulated that specific emotional expressions have a perception advantage over others. Initially, a perception advantage was postulated for angry faces (Hansen & Hansen, 1988; Öhman, Lundqvist, & Esteves, 2001; Pinkham, Griffin, Baron, Sasson, & Gur, 2010), but recent studies have found compelling evidence for an advantage for happy faces, termed 'happiness superiority effect' (Becker, Anderson, Mortensen, Neufeld, & Neel, 2011; Savage et al., 2013). These studies used a visual search paradigm (the 'Face-in-the-Crowd paradigm', FitC), in which participants have to decide as quickly and accurately as possible whether an array of faces (all displaying the same expression, e.g. all neutral/happy/angry) contains a deviating face. In this paradigm, the happiness superiority effect manifested itself in faster reaction times and lower error rates for happy expressions compared to angry but also other negative expressions (Becker et al., 2011; Leppänen & Hietanen, 2004; Leppänen, Tenhunen, & Hietanen, 2003, Nummenmaa & Calvo, 2015).

In an extension of the classic FitC paradigm, a very recent study has used a paradigm in which participants had to judge the *overall* mood of the crowd ('Mood-of-the-Crowd paradigm', MoC). The study was able to replicate the happiness superiority effect in this setting: happy crowds were identified faster and more accurately than angry crowds (Bucher & Voss, 2018). The MoC paradigm has a number of advantages over the FitC paradigm. First, judging the mood of a crowd represents a more ecologically valid task than detecting a single face in a crowd, because crowds with multiple target emotions are highly prevalent in daily life (e.g., in class, at a sporting event, etc.). Moreover, the presentation of more than one emotional target prevents confusion about whether any observed effects result from a target or a crowd effect (see Bucher & Voss, 2018). Furthermore, in contrast to the FitC paradigm, the MoC task can be well combined with process tracing methods such as eye-tracking. Eye-tracking is less applicable to the FitC paradigm, because the search process ends abruptly as soon as the participant detects the target, which makes it difficult to identify underlying search patterns. In the present study, we thus applied the MoC paradigm in combination with eye-tracking to further investigate the happiness superiority effect. Specifically, we aimed to assess whether facial features beyond the displayed emotion affect the happiness superiority effect.

Previous empirical studies suggest that there are several facial features that can influence the size of the happiness superiority effect, including sex and race (Bruce & Young, 1986; Haxby, Hoffman, & Gobbini, 2000). Specifically, the happiness superiority effect was larger for female targets (Becker, Kenrick, Neuberg, Blackwell, & Smith, 2007; Bucher & Voss, 2018; Craig & Lipp, 2017; Hugenberg & Sczesny, 2006) and for male own-race targets compared to male other-race targets (Bijlstra, Holland, & Wigboldus, 2010; Craig, Mallan, & Lipp, 2012). In addition to this research on features signaling race and gender, a recent study also found that facial attractiveness affects emotion perception (Lindeberg, Craig, & Lipp, 2018). The authors found evidence for a faster and more accurate identification of happiness (versus anger) in attractive female and male faces compared to unattractive faces when presenting one face in each trial. The authors link these findings to the *evaluative congruence account* (Hugenberg, 2005; Hugenberg & Sczesny, 2006) which assumes a faster perception of an emotion (e.g. happy) when it matches the evaluation of the respective social cue (e.g. attractive). In other words, happiness and attractiveness are both positive features of a face and should therefore be processed faster than if the pairing of affect and a social cue were incongruent (e.g. angry + attractive).

Extending the work by Lindeberg and colleagues (2018), the current study aimed to test the evaluative congruence account by assessing whether facial attractiveness moderates the happiness superiority effect. To do this, we employed the MoC paradigm in combination with eye-tracking. The implementation of eye-tracking analysis makes it possible to pinpoint the locus of the effect of attractiveness on emotion perception. If an attractiveness effect was apparent in eye movements (e.g., an increased probability and longer duration of fixations on happy-attractive / angry-unattractive faces), this would indicate biased perceptional preferences for congruent stimuli. In contrast, if participants showed no differences in their fixation patterns between congruent (happy-attractive/ angry-unattractive) and incongruent (happy-unattractive/ angry-attractive) stimuli, but did show differences at the choice level, this would suggest effects in the evaluation phase (e.g., a biased response towards happiness for attractive crowds). In the following, we summarize literature investigating the happiness superiority effect and the influence of attractiveness on emotion perception and derive our hypotheses from these.

The Happiness Superiority Effect

As outlined above, early studies using visual search paradigms initially supported a perception advantage for angry faces (Hansen & Hansen, 1988; Öhman et al., 2001), whereas recent studies generally found happy faces to be detected faster and with higher accuracy (Becker et al., 2011; Juth et al., 2005). Studies found this happiness superiority effect with both photographs of actual faces and with computer-generated material (Becker et al., 2011, Bucher & Voss, 2018), including dynamic stimuli (Becker et al., 2012), and when using single emotional targets (Leppänen & Hietanen, 2004; Leppänen et al., 2003) as well as multiple emotional faces (Bucher & Voss, 2018; Elias, Dyer, & Sweeny, 2017). A faster and more accurate perception of happy versus angry faces has thus been shown in multiple empirical studies, using different material and diverse experimental settings.

Explanations accounting for the happiness superiority effect are manifold. One explanation is that in human evolution the happy face became visually more discriminable so that perceivers can efficiently process and senders can efficiently signal happiness (Becker & Srinivasan, 2014). A second explanation is that individuals frequently encounter positive social interactions in everyday life, which increases the accessibility of happy expressions. This phenomenon is comparable to the word-frequency-effect, which assumes that words are processed more easily the more they are used in a language (Oldfield & Wingfield, 1965). A further explanation for the happiness superiority effect posits that there is less variance in happy expressions compared to angry expressions, which makes happy faces easier to detect compared to angry faces (Unkelbach, Fiedler, Bayer, Stegmüller, & Danner, 2008).

While multiple studies have empirically demonstrated the happiness superiority effect, there are many conceivable factors that could have an influence on emotion perception and thus on the size of the happiness superiority effect. As previously outlined, the most thoroughly investigated factors are the stimulus gender and race. Specifically, studies showed that the happiness superiority effect is larger for female than for male faces (Becker et al., 2007; Bucher & Voss, 2018; Craig & Lipp, 2017; Hugenberg & Sczesny, 2006; Lipp, Craig, & Dat, 2015), and for own-race compared to other-race faces (Bijlstra et al., 2010; Craig et al., 2012). However, it remains somewhat unclear whether these effects are the result of evaluative congruence or of stereotype processes. Hugenberg (2005) and Hugenberg and Sczesny (2006) compared both accounts and found support for the evaluative congruence account, which posits that emotion perception is facilitated when the evaluation of the social cue matches the respective presented emotion. In their experiments, participants had to detect happy versus angry and happy versus sad expressions, and the authors manipulated the gender and race of the presented targets. Based on previous results showing that female (vs. male) and own-race (vs. other-race) targets are evaluated more positively (Degner & Wentura, 2010; Eagly, Mladinic, & Otto, 1991), the evaluative congruence account would predict that happy-female and happy-own-race targets should be categorized the fastest. In contrast, stereotype accounts would predict that sadness is more strongly associated with women (Plant, Kling, & Smith, 2004) and anger with men or other-race men (Devine, 1989). If the stereotype account explained the results, perception should be fastest for sad-female and angry-male or angry-other-race targets. Results supported the evaluative congruence account, showing the fastest perception for happy-female and happy-own-race targets. Therefore, with regard to other social cues – like attractiveness – the evaluative congruence account would assume a faster perception of happy attractive and angry unattractive faces because attractiveness and happiness are evaluated positively whereas unattractiveness and anger are evaluated more negatively.

Attractiveness and Emotion Perception

Consensus about what is attractive and what is not is high both across and within different cultures (Langlois et al., 2000) and facial attractiveness plays an important role in many different social interactions. For example, attractiveness increases the likelihood of getting a job interview (Watkins & Johnston, 2000), entails higher ratings on favorable personality traits such as Agreeableness (Borkenau & Liebler, 1992; Borkenau & Liebler, 1995; Smits & Cherhoniak, 1976) and higher intelligence ratings (Jackson, Hunter, & Hodge, 1995). Moreover, participants generally tend to attribute positive qualities to attractive and negative attributes to unattractive persons (Dion, Berscheid, & Walster, 1972). Beyond this, participants give more honest self-reports when confronted with attractive in comparison to unattractive face pictures (Wang et al., 2017).

With regard to the association between attractiveness and emotion perception, there is evidence that participants evaluate happy faces as more attractive than faces displaying negative emotions (Mueser, Grau, Sussman, & Rosen, 1984). A recent study demonstrated that the reverse relationship might also hold, such that happiness in attractive faces is perceived more efficiently. Specifically, Lindeberg et al. (2018) assessed the influence of attractiveness on emotion perception in four different studies. The authors found that – for both male and female targets – the happiness superiority effect was larger or even only present for attractive faces compared to unattractive ones. Moreover, Golle, Mast and Lobmaier (2014) showed that judgment of relatively happier compared to neutral faces was facilitated when those faces were attractive. Thus, there is some evidence for attractiveness influencing emotion perception.

These findings can be interpreted in light of the evaluative congruence account (Hugenberg, 2005; Hugenberg & Sczesny, 2006). The evaluative congruence account would predict that positively evaluated social cues – like attractiveness and happiness – as well as negatively evaluated social cues – like unattractiveness and anger – should become more salient when combined together and therefore facilitate emotion perception. Therefore, a combination of attractiveness and happiness may explain the findings by Lindeberg and collagues (2018) as well as Golle et al. (2014). However, these studies did not find a perception advantage for unattractive faces paired with angry expressions, even though the evaluative congruence account would predict this. It might be the case that the experimental tasks in these studies were too easy, incurring very low error rates, which might impede the detection of response biases. The MoC paradigm, characterized by higher cognitive demands and lower accuracy rates, might leave more space for motives to bias emotion perception and therefore to test the evaluative congruence account for both attractive and unattractive crowds of faces.

The Current Study

The aim of the current study was to conceptually replicate the findings from Lindeberg et al. (2018) and to test the evaluative congruence account when using the MoC paradigm. In this paradigm, participant's task is to decide as fast and accurately as possible, whether more angry or more happy faces are presented in a crowd of faces. There are several merits with regard to this task. First, evaluating the mood of a crowd provides ecological validity as crowds with multiple target emotions are common in everyday life (e.g., in class, at a sporting event, when giving a speech, etc.). Additionally, it disentangles crowd and target effects as all presented faces are targets and need to be inspected to find the correct response. Moreover, the use of this paradigm allows for analyzing eye-tracking data in addition to response times and accuracy rates. The combination of behavioral and eye-tracking data is particularly powerful in this context, as it helps to better understand the processes with regard to the evaluative congruence account. If biases occur on the attentional level due to an increased fixation rate on happy attractive and angry unattractive faces, this would indicate that perceptional preferences guide the evaluation of the crowd. If attractiveness only influences the speed and accuracy of the judgements itself, while there is no attractiveness effect in gaze movement, a biased evaluation of the face pictures is most likely.

Based on the evaluative congruence account (Hugenberg, 2005; Hugenber & Sczesny, 2006) and empirical findings by Lindeberg et al. (2018), we hypothesized that participants would identify attractive crowds more often as happy than unattractive crowds. Reversely, we also expected that participants would identify unattractive crowds more often as angry than attractive crowds. Moreover, we hypothesized that attractive crowds containing a higher number of happy faces, and unattractive crowds containing a higher number of angry expressions should entail faster and more accurate responses. Lastly, we expected higher fixation rates on happy-attractive and angry unattractive faces than on happy-unattractive or angry-attractive faces, due to evaluative congruence.

Experiment 1

Method

Participants. Prior to recruiting participants, we conducted a power analysis using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) to determine the required sample size.

The required sample size to detect an effect of medium size with a power of .80 and an alpha-error of .05 in a repeated measures ANOVA setting was 34. Thirty-four adults participated in the study (M_{age} = 23.06 years, *SD* = 5.22, range = 19-47; 50% female). We recruited participants from a large participant pool at Heidelberg University, in which students of diverse subjects are registered. Before participants took part in the study, they received information about the study details and provided written, informed consent. As compensation for the study, participants could choose between course credit or a financial compensation of five Euros.

Stimulus material. Following Lindeberg et al. (2018), we chose the stimulus material for the first experiment by selecting the most and least attractive faces from a pool of faces. We selected the stimulus faces from the Chicago Face Database (Ma, Correll, & Wittenbrink, 2015), restricting the stimulus material to faces of Caucasian individuals that provided both angry and happy (closed mouth) expressions. We used the attractiveness ratings of the remaining 37 female and 36 male faces provided by the norming data of the Chicago Face Database and selected 9 faces that were rated the most attractive and 9 faces that achieved the lowest attractiveness ratings for female and male faces, respectively. This procedure resulted in 18 female (9 attractive and 9 unattractive) and 18 male (9 attractive and 9 unattractive) individuals with happy and angry expressions available. The attractiveness ratings of the 'attractive' female models (*M* = 4.60, *SD* = 0.32; Models 3, 11, 12, 15, 22, 24, 25, 27 and 29) differed from those of the 'unattractive' female models (*M* = 2.32, *SD* = 0.45; Models 2, 8, 10, 23, 26, 28, 30, 34 and 37). Likewise, the attractiveness of the 'attractive' male models (*M* = 3.89, *SD* = 0.46; Models 3, 4, 6, 9, 14, 15, 24, 29 and 33) differed from that of the 'unattractive' male models (*M* = 2.36*, SD* = 0.16; Models 2, 10, 17, 19, 35, 37, 38, 39, 41). Lighting and visual contrast were similar across all faces in the set.

Procedure. The experiment was run on a Dell laptop computer. Stimulus displays and response time measurement were controlled by a C program using SDL libraries (www.libsdl.org). We used a SMI RED250MOBILE eye-tracker to record gaze movements at a frequency of 250 Hz. We defined fixations using the criteria of a minimal duration of 100 ms and maximal dispersion of 100 pixels.

After providing written, informed consent, participants were seated approximately 60 cm in front of the laptop computer. First, participants provided demographic information and then received information that the upcoming task was to judge whether the crowd contained more happy or angry faces. We specifically instructed participants to make their decisions as fast and accurately as possible to prevent them from simply counting the presented faces. The experiment comprised a practice block of 16 trials and two experimental blocks of 50 trials each. Prior to each block (practice block and experimental blocks) we used a 9-point-calibration for calibrating the eye-tracker. Each calibration was followed by a 4-point validation. After a successful validation (participants' gaze was within 1° visual angle), participants started with the experimental trials. In case of a non-successful validation, we repeated calibration and validation.

In each trial, participants saw a crowd of 18 faces (each 1.4 cm x 1.9 cm). Faces were randomly allocated on the screen in front of a light-grey background (34.5 cm x 19.5 cm) to ensure naturalistic eye movements, which is not possible when presenting faces in a circle or matrix (due to systematic scanning paths: e.g. clockwise or row-wise). To avoid overlap between the pictures, we ensured a minimum distance between the edges of the pictures (minimum distance was 3.4 cm). Crowds contained a varying number of angry faces (6, 8, 10 and 12 angry faces), and crowds were either completely made up of attractive or unattractive faces. Moreover, crowds always contained the same number of female and male faces (e.g., in case of 10 angry and eight happy faces the crowd contained five female angry and five male angry expressions as well as four female happy and four male happy expressions). All presented face pictures within one trial were from different individuals.

Each block started with two warm-up trials. The eight trial combinations (attractiveness of presented faces x number of angry pictures) were presented six times in random order in each experimental block. Prior to each trial, a fixation cross was presented at the center of the screen before the crowd was shown. Only when participants fixated on this cross, the crowd appeared. If participants did not focus on the fixation cross until 5000 ms were exceeded, a recalibration started. The crowd remained visible until participants gave their response. If participants' responses were slower than 8000 ms, a message ("please try to respond faster") appeared. Participants could press the S-key and the K-key to indicate whether they perceived the crowd as predominantly happy or angry. The assignment of the emotions to the keys was balanced across participants. As a reminder, the words "happy" and "angry" appeared on the respective sides on the bottom of the screen. Subsequent to the eye-tracking experiment, participants rated the happy and angry faces on attractiveness, happiness, and anger on a 7-point Likert scale in a randomized sequence.

Analysis. A 2 (attractiveness: attractive, unattractive) × 2 (trial type: mainly happy, mainly angry[1]) repeated measures ANOVA was conducted to analyze responses, accuracy rates, response times, and proportion of fixations. The variable proportion of fixations incorporates the fixation durations on angry expressions relative to all fixation durations that occurred in a trial. A value of .50 therefore indicates that angry and happy expressions were fixated to the same degree. Values smaller (greater) than .50 represent a fixation shift towards happy (angry) expressions. For the analyses of the number of fixations, the emotion of the focused picture (happy vs. angry) served as an additional within-subjects factor. This way, we assessed how many faces of each type received at least one fixation during a trial (thus, the maximum possible number is 12 fixations of one emotional expression in one trial). We

[1] To ease interpretation of the results, trial types containing more happy faces (6 and 8 angry out of 18 faces) and those who consisted of more angry faces (10 and 12 angry out of 18 faces) were combined. When analyzing the data using the original four categories of trial type, findings were largely identical.

excluded responses faster than 500 ms and slower than 8000 ms from the response time analysis (0.51% of all trials). Additionally, we adjusted for participants' gender as a covariate in all analyses. If not reported in the text, gender did not show any significant main effects or interactions.

Results

Manipulation check. Attractiveness ratings were obtained in a 2 (emotional expression: happy, angry) × 2 (attractiveness: attractive, unattractive) × 2 (target gender: female, male) repeated measures ANOVA. There was a main effect of attractiveness, $F(1, 32) = 472.53$, $p < .001$, $\eta^2_p = .94$, 95% CI [.89, .95], emotional expression, $F(1, 32) = 15.53$, $p < .001$, $\eta^2_p = .33$, 95% CI [.11, .49], and gender, $F(1, 32) = 46.78$, $p < .001$, $\eta^2_p = .59$, 95% CI [.39, .70], confirming that attractive, happy and female targets were rated as being more attractive compared to the unattractive, angry and male targets. Moreover, we found a significant interaction between attractiveness and target gender, $F(1, 32) = 97.83$, $p < .001$, $\eta^2_p = .75$, 95% CI [.61, .82]. Follow-up pairwise comparisons revealed that there was a significant difference in perceived attractiveness between female and male attractive targets, $t(33) = 9.06$, $p < .001$, $d = 1.55$, whereas the unattractive male and female targets did not differ significantly, $t < 1$.

We ran the same analysis for the emotional intensity ratings. There was a significant main effect of attractiveness, $F(1, 32) = 32.24$, $p < .001$, $\eta^2_p = .50$, 95% CI [.28, .63], and gender, $F(1, 32) = 40.48$, $p < .001$, $\eta^2_p = .56$, 95% CI [.34, .68], showing that attractive and female targets were perceived as showing a higher emotional intensity. The main effects were qualified by an attractiveness × target gender interaction, $F(1, 32) = 15.89$, $p < .001$, $\eta^2_p = .33$, 95% CI [.12, .50] and an attractiveness × emotional expression interaction, $F(1, 32) = 71.26$, $p < .001$, $\eta^2_p = .69$, 95% CI [.52, .77]. Follow-up pairwise comparisons showed that female expressions were rated as more emotionally intensive compared to male faces both for attractive, $t(33) = 2.37$, $p = .024$, $d = .41$, and unattractive targets, $t(33) = 7.45$, $p < .001$, $d =$

1.28. However, this difference was much more pronounced for unattractive faces, *t*(33) = 3.96, $p < .001$, *d* = .68. Additionally, pairwise comparisons revealed that happiness was expressed more strongly on attractive compared to unattractive faces, *t*(33) = 8.37, $p < .001$, *d* = 1.44, whereas there was no difference for angry faces, *t*(33) = -1.90, *p* = .066, *d* = .33.

Mean and standard deviations of the attractiveness and emotional intensity ratings are summarized in Table 1.

Response time. We computed mean correct response times for each participant and each factorial combination. There was a significant interaction between attractiveness and trial type, *F*(1, 32) = 6.18, *p* = .018, η^2_p = .16, 95% CI [.02, .34]. Follow-up pairwise comparisons revealed that participants were faster when more happy faces were presented in attractive crowds compared to unattractive crowds, *t*(33) = 2.97, *p* = .006, *d* = .51, whereas there was no difference when more angry faces were shown, $t < 1$ (Figure 1).

Response. Mean responses (proportion of "angry" responses) were calculated for each participant and each factorial combination. A main effect of attractiveness, *F*(1, 32) = 32.53, $p < .001$, η^2_p = .50, 95% CI [.28, .63], and a main effect of trial type emerged, *F*(1, 32) = 315.00, $p < .001$, η^2_p = .91, 95% CI [.85, .93]. Attractive crowds were judged as "happy" and unattractive ones as "angry" more frequently (Figure 2). Trivially, participants evaluated crowds containing more happy faces as being happy more often compared to those with more angry faces.

Accuracy. Mean accuracies were calculated for each participant and each factorial combination. There was a main effect of trial type, *F*(1, 32) = 4.23, *p* = .048, η^2_p = .12, 95% CI [.00, .29], indicating slightly increased accuracy rates in trials with more angry faces. This main effect was qualified by an attractiveness × trial type interaction, *F*(1, 32) = 32.53, $p < .001$, η^2_p = .50, 95% CI [.28, .63]. Follow-up t-tests indicated that when more happy faces appeared in a crowd, participants showed higher accuracy rates for attractive crowds, *t*(33) =

6.31, $p < .001$, $d = 1.08$, and the reversed pattern when confronted with unattractive faces, $t(33) = -3.34$, $p = .002$, $d = .57$ (Figure 3).

Proportion of fixations. Proportion of fixations (fixation duration on angry faces divided by the fixation duration on all faces) was computed for each participant and each factorial combination. Again, we found a main effect of attractiveness, $F(1, 32) = 4.58$, $p = .040$, $\eta^2_p = .13$, 95% CI [.00, .30], showing that, in attractive crowds, fixations were longer on happy targets, whereas this was not the case for unattractive crowds (Figure 4). Trivially, in trials with more angry (happy) faces, the proportion of fixations shifted towards angry (happy) faces, $F(1, 32) = 1420.94$, $p < .001$, $\eta^2_p = .98$, 95% CI [.96, .98].

Number of fixations. The number of fixations assesses how many faces of each type received at least one fixation during a trial (thus, the maximum possible number is 12 fixations of one emotional expression in one trial). There was a main effect of emotional expression, $F(1, 32) = 8.30$, $p = .007$, $\eta^2_p = .21$, 95% CI [.04, .38], and attractiveness, $F(1, 32) = 10.20$, $p = .003$, $\eta^2_p = .24$, 95% CI [.05, .42], indicating that happy faces and unattractive faces were fixated more frequently compared to angry and attractive faces. Moreover, we found a significant interaction between attractiveness and emotional expression, $F(1, 32) = 4.65$, $p = .039$, $\eta^2_p = .13$, 95% CI [.00, .30]. Follow-up pairwise comparisons revealed that in unattractive crowds happy and angry expressions were fixated to the same degree, $t < 1$, whereas in attractive crowds significantly more happy faces were fixated, $t(33) = 3.85$, $p = .001$, $d = .66$ (Figure 5). Trivially, there was a significant interaction between emotional expression and trial type, $F(1, 32) = 301.35$, $p < .001$, $\eta^2_p = .90$, 95% CI [.84, .39], with more fixations on angry (happy) faces when more angry (happy) faces were presented. Lastly, an interaction between all factors emerged, $F(1, 32) = 4.55$, $p = .041$, $\eta^2_p = .13$, 95% CI [.00, .30].

Discussion

In Experiment 1, we assessed whether the attractiveness of the stimulus material has an effect on the happiness superiority effect in visual search, specifically in the MoC paradigm. We hypothesized a faster and more accurate perception of attractive crowds containing more happy faces and of unattractive crowds comprising more angry faces. We expected a response bias towards happiness in attractive and towards anger in unattractive crowds. Results revealed that participants judged crowds containing attractive faces as happy more often than crowds containing unattractive faces. Moreover, participants were faster and more accurate when crowds were both attractive and containing many happy faces. In line with the evaluative congruence account, we also found that participants evaluated unattractive crowds more frequently as angry, and that judgments were more accurate in trials with more angry targets presented. This is a novel finding, as the previous study testing this model (Lindeberg et al., 2018) only found support for part of the evaluative congruence account, showing an advantage for attractive-happy faces but not for unattractive-angry targets. Further extending previous findings, we included eye-tracking analyses that revealed that proportions of happy fixations were increased in attractive crowds and fixations occurred more frequently on happy facial expressions when attractive faces were presented.

Results generally supported our hypotheses and showed medium to large effect sizes, but are limited by the fact that target faces showed an imbalance between target gender and attractiveness. Thus, we cannot completely rule out the possibility that this gender-attractiveness disparity affected our results. Mirroring the findings by Lindeberg et al. (2018), the difference between attractiveness ratings was also larger for attractive female compared to attractive male faces. Furthermore, we found that participants rated happy attractive faces as more emotionally intense compared to happy unattractive faces. Although we believe that the emotion ratings were influenced by attractiveness to the same degree as was found in MoC task, other explanations might be possible as well. It is possible that the completion of the MoC task influenced the following ratings, because we observed the same pattern of results for the experiment and the ratings. Moreover, it is possible that unattractive targets showed less intense happy expressions than attractive targets. To address these issues, we chose different selection criteria for the stimulus material in the second experiment.

Experiment 2

In Experiment 1, the focus when choosing the stimulus material was to achieve the greatest possible attractiveness difference between unattractive and attractive targets. Although this approach leads to a larger difference in perceived attractiveness and maximizes the chances of finding an attractiveness effect, it has already been critically discussed by Lindeberg et al. (2018). It was revealed that this selection procedure leads to a greater difference in rated attractiveness for female compared to male targets. As target gender also influences emotion perception to a large degree, it might be the case that results from experiments using this selection method are somewhat confounded. Therefore, in Experiment 2, we used different selection criteria for the material to ensure that attractive female and male targets as well as unattractive male and female targets match with regard to their perceived attractiveness. Furthermore, we used the emotion intensity ratings for the neutral faces provided in the norming data of the Chicago Face Database to better match the attractive and unattractive face pictures.[2] Despite these modifications, the experimental setting and hypotheses in Experiment 2 were identical to Experiment 1.

Method

Participants. Based on the same power analysis as in Experiment 1, we recruited 34 adults (M_{age} = 23.26 years, *SD* = 5.66, range = 18-46; 53% female) via a large participant pool of Heidelberg University. Before starting with the experiment, participants received information about the upcoming task and provided written, informed consent. Again, participants could receive course credit or 5 Euros as compensation for their participation.

[2] Although the emotion ratings for the neutral expressions do not necessarily match the ratings of the actual emotions, it nevertheless provides a tendency that might influence the intensity of the emotional expressions.

Stimulus material. We again selected the stimulus material from the Chicago Face Database (Ma et al., 2015), considering only pictures of Caucasian men and women that provided both happy and angry expressions. In addition to the attractiveness ratings, happiness and anger ratings were taken into account when choosing the stimulus material. Happiness and anger ratings of the neutral face pictures of the unattractive and attractive male and female pictures were matched to control for possible emotional intensity differences between the pictures. Furthermore, we matched target gender and perceived attractiveness, so that attractive males and females as well as unattractive male and female had similar attractiveness rating. We again selected 18 female (9 attractive and 9 unattractive) and 18 male (9 attractive and 9 unattractive) individuals. When comparing the attractiveness ratings, the attractive female (M_{att} = 3.95, SD_{att} = 0.38; M_{happy} = 2.47, SD_{happy} = 0.49; M_{angry} = 2.60, SD_{angry} = 0.65; Models 6, 11, 13, 15, 16, 18, 21, 25 and 31) and unattractive female models (M_{att} = 2.79, SD_{att} = 0.17; M_{happy} = 2.41, SD_{happy} = 0.54; M_{angry} = 2.46, SD_{angry} = 0.76; Models 5, 7, 8, 19, 23, 28, 30, 36 and 37) as well as the attractive male (M_{att} = 3.89, SD_{att} = 0.46; M_{happy} = 2.63, SD_{happy} = 0.32; M_{angry} = 2.21, SD_{angry} = 0.39; Models 3, 4, 6, 9, 14, 15, 24, 29 and 33) and unattractive male models (M_{att} = 2.71, SD_{att} = 0.13; M_{happy} = 2.48, SD_{happy} = 0.67; M_{angry} = 2.39, SD_{angry} = 0.50; Models 12, 13, 20, 21, 23, 25, 32, 34 and 37) differed in rated attractiveness, respectively, but not with regard to happiness or anger. Lighting and visual contrast were similar across all faces in the set.

As the attractiveness, happiness and anger ratings were only available for the neutral face expressions, the happy and angry expressions of the attractive and unattractive male as well as female individuals were additionally rated by 45 participants (M_{age} = 34.98 years, SD = 13.60, range = 19-59; 73% female).[3] We present the results for the attractiveness and emotional intensity ratings in the results section.

[3] There were several reasons why we decided to recruit a separate sample to rate the attractive and unattractive emotional face expressions. In the first experiment, ratings were collected after the MoC experiment, so it might be possible that the completion of the experimental task influenced the attractiveness and emotion ratings

Procedure. The experimental setup and procedure were identical to those in Experiment 1. The only difference was with regard to the stimulus material and that the emotional face expressions were rated prior to the study by an independent sample to prevent transfer effects.

Analysis. The analytic strategy was identical to that in Experiment 1. Again, we excluded responses faster than 500 ms and slower than 8000 ms from the response time analysis (0.43% of all trials).

Results

Manipulation check. Ratings from the 45 participants of the pretest were used to analyze perceived attractiveness and emotional intensity. There were main effects of attractiveness, $F(1, 43) = 169.28$, $p < .001$, $\eta^2_p = .80$, 95% CI [.70, .85], target emotion, $F(1, 43) = 40.79$, $p < .001$, $\eta^2_p = .49$, 95% CI [.30, .61], and target gender, $F(1, 43) = 14.15$, $p = .001$, $\eta^2_p = .25$, 95% CI [.08, .40], indicating that attractive, happy and female faces were rated as more attractive compared to unattractive, angry and male faces. Moreover, we found a significant interaction between target emotion and target gender, $F(1, 43) = 9.56$, $p = .003$, $\eta^2_p = .18$, 95% CI [.04, .34]. Follow-up pairwise comparisons revealed that happy faces were rated more attractively compared to angry faces both for female, $t(44) = 8.25$, $p < .001$, $d = 1.23$, and male faces, $t(44) = 6.74$, $p < .001$, $d = 1.00$, however, this difference was significantly larger for female faces, $t(44) = 2.76$, $p = .008$, $d = .41$.

With regard to emotional intensity, there was a significant main effect of target gender, $F(1, 43) = 13.48$, $p = .001$, $\eta^2_p = .24$, 95% CI [.07, .39], and participants' gender, $F(1, 43) = 9.64$, $p = .003$, $\eta^2_p = .18$, 95% CI [.02, .37], indicating that female faces were perceived as more emotionally intense and that female raters gave higher intensity ratings. The main effect of target gender was qualified by an interaction between target gender and target emotion,

afterwards. Furthermore, when measuring the ratings prior to the experiment, it might happen that the ratings influence the completion of the experimental task afterwards which is also not ideal. Collecting the ratings in a "pretest" therefore seemed appropriate.

F(1, 43) = 8.13, *p* = .007, η^2_p = .16, 95% CI [.03, .32]. Whereas happy and angry faces were perceived as equally intense in male faces, *t* < 1, angry female faces were rated more intensely compared to happy female faces, *t*(44) = -2.65, *p* = .011, *d* = .40. Furthermore, there was a significant interaction between attractiveness and target emotion, *F*(1, 43) = 34.89, *p* < .001, η^2_p = .45, 95% CI [.26, .58]. Happy attractive faces were rated more intensely than happy unattractive faces, *t*(44) = 3.76, *p* < .001, *d* = .56, whereas the reverse pattern was found for angry expressions, *t*(44) = -4.94, *p* < .001, *d* = .74. Lastly, a significant interaction between participants' gender and target gender emerged, *F*(1, 43) = 11.34, *p* = .001, η^2_p = .21, 95% CI [.05, .37]. Male participants rated female faces more emotionally intense compared to male face, *t*(44) = 4.56, *p* = .001, *d* = .68, whereas there was no such difference for female participants, *t* < 1.[4]

Mean and standard deviations of the attractiveness and emotional intensity ratings are summarized in Table 1.

Response time. We computed mean correct response times for each participant for each factorial combination. Again, there was a significant interaction between attractiveness and trial type, *F*(1, 32) = 10.39, *p* = .003, η^2_p = .25, 95% CI [.06, .42]. Follow-up pairwise comparisons showed that in attractive crowds participants were faster when crowds contained more happy compared to angry faces, *t*(33) = 2.57, *p* = .015, *d* = .44, whereas in unattractive crowds the pattern pointed towards the opposite direction, *t*(33) = -1.91, *p* = .065, *d* = .33 (Figure 6). Lastly, there was a significant effect of participants' gender, *F*(1, 32) = 4.55, *p* = .041, η^2_p = .12, 95% CI [.00, .34], indicating that women were faster in judging the mood of the crowd.

Response. We calculated mean responses (proportion of "angry" responses) for each participant and each factorial combination. Again, there was a main effect of attractiveness,

[4] The findings with regard to participants' gender need to be interpreted with caution as ratings from only 12 men were available.

$F(1, 32) = 68.62$, $p < .001$, $\eta^2_p = .68$, 95% CI [.50, .77], and of trial type, $F(1, 32) = 316.51$, $p < .001$, $\eta^2_p = .91$, 95% CI [.85, .93]. Participants tended to judge attractive crowds more often as happy, whereas they judged unattractive crowds more often as angry (Figure 7). Trivially, participants evaluated crowds dominated by happy faces as being happy more often compared to those containing more angry expressions.

Accuracy. Mean accuracies were calculated for each participant and each factorial combination. A main effect of trial type reached significance, $F(1, 32) = 5.37$, $p = .027$, $\eta^2_p = .14$, 95% CI [.01, .32], showing higher accuracy rates in trials with more angry expressions. This main effect was qualified by an attractiveness × trial type interaction, $F(1, 32) = 68.62$, $p < .001$, $\eta^2_p = .68$, 95% CI [.50, .77]. Follow-up t-tests revealed that accuracy rates were increased when more happy faces were presented in attractive compared to unattractive crowds, $t(33) = 6.50$, $p < .001$, $d = 1.11$, and the reversed pattern was found for angry expressions, $t(33) = -5.41$, $p < .001$, $d = .93$ (Figure 8).

Proportion of fixations. We computed the proportion of fixations (fixation duration on angry faces divided by the fixation duration on all faces) for each participant and each factorial combination. Trivially, the proportion of fixations shifted towards angry (happy) faces when crowds were dominated by angry (happy) faces, $F(1, 32) = 774.72$, $p < .001$, $\eta^2_p = .96$, 95% CI [.93, .97]. Lastly, an interaction between trial type and participants' gender emerged, $F(1, 32) = 7.19$, $p = .011$, $\eta^2_p = .18$, 95% CI [.02, .36].

Number of fixations. This measure indicates how many faces of each type received at least one fixation during a trial (thus, the maximum possible number is 12 fixations of one emotional expression in one trial). Trivially, a significant interaction between emotional expression and trial type was found, $F(1, 32) = 201.13$, $p < .001$, $\eta^2_p = .86$, 95% CI [.77, .90], with more fixations on angry (happy) faces when more angry (happy) faces were presented. Lastly, there was a significant interaction between attractiveness and trial type, $F(1, 32) = 9.31$, $p = .005$, $\eta^2_p = .23$, 95% CI [.05, .40]. A higher number of faces was fixated in attractive compared to unattractive crowds when more angry faces were presented, $t(33) = 2.38$, $p = .024$, $d = .41$, whereas there was no significant difference in crowds containing more happy faces, $t(33) = -1.69$, $p = .101$, $d = .29$.

Discussion

In Experiment 2, we replicated the main findings of Experiment 1 in a different sample and using new stimulus material that was better matched for attractiveness between female and male stimuli. Again, participants evaluated attractive crowds as happy more frequently than they evaluated unattractive crowds. Reversely, participants evaluated unattractive (compared to attractive) crowds more often as angry. Moreover, participants were faster and more accurate in judging attractive crowds dominated by happy faces and unattractive crowds dominated by angry expressions. These findings are in line with the evaluative congruence account, which suggests a facilitated perception when the presented emotion matches the evaluation of the respective social cue. Extending previous findings by Lindeberg et al. (2018), we found evidence supporting the evaluative congruence account not only for attractive, but also for unattractive faces.

In contrast to the findings for reaction times and choices, which were well in line with the findings from Experiment 1, eye-tracking results did not replicate as closely. In Experiment 1, we observed an increased proportion of fixations and larger number of fixations on happy attractive faces but this was not the case in Experiment 2. It is possible that the difference in material explains this discrepancy. As described above, we performed a new matching of the target material to reduce attractiveness differences between female and male faces that were present in Experiment 1. While successful in this regard, the new matching also resulted in smaller overall differences between attractive and unattractive targets. It is possible that the attention grabbing power of the attractive smiling faces was thereby diminished, leading to a similar allocation of attention to attractive and unattractive emotional face expressions.

Even though we were able match the perceived attractiveness of female and male targets in Experiment 2, we again found that happy attractive faces were rated as more emotionally intense compared to happy unattractive faces and the opposite for angry attractive and unattractive face pictures. This time, we collected ratings in a separate sample, ruling out the possibility that the completion of the MoC task influenced the consecutive rating. Furthermore, we consider it unlikely that, again, the emotional intensity of the happy (angry) unattractive faces was truly lower (higher) compared to the happy (angry) attractive faces as we used two different stimulus sets and controlled for emotional intensity when selecting the stimulus material from the Chicago Face Database. Therefore, the most plausible explanation might be that emotional intensity ratings are also influenced by the attractiveness of the target face. Using computer-generated emotional expressions matched by attractiveness, gender and emotional intensity would be necessary in future investigations to ensure equal intensities of the emotional faces.

General Discussion

The present study set out to test the influence of attractiveness on emotion perception when participants' task is to judge the overall mood of a crowd instead of detecting single emotional targets. The major advantage of using more than one emotional target is the fact that crowd and target effects are not confounded and that the evaluation of a crowd of faces is highly representative and close to everyday situations. Extending previous studies, the present study was the first to integrate eye-tracking. Eye-tracking is especially suited when using the MoC paradigm because it allows analyzing search strategies which are not stopped immediately when one target is found because all presented faces inform about the correct mood of the crowd. With the help of gaze analyses, it is possible to shed light on the question whether attractiveness effects on emotion perception occur on the attentional level or in the evaluation phase. According to the evaluative congruence account – which assumes a faster perception of an emotion when it matches the evaluation of a social cue (attractiveness herein)

– we expected a biased judgment toward happiness in attractive crowds and a biased judgement toward anger in unattractive crowds. Moreover, we expected higher fixation rates on happy faces in attractive crowds and conversely higher fixation rates on angry faces in unattractive crowds. Across both experiments, we found evidence for an influence of attractiveness on emotion perception. Participants consistently evaluated attractive crowds of faces as happy more frequently than they evaluated angry crowds. Moreover, their evaluations were faster and more accurate in crowds dominated by happy faces. These findings are in line with the evaluative congruence account (Hugenberg, 2005; Hugenber & Sczesny, 2006), according to which the happiness superiority effect is potentiated for positively evaluated attractive faces. The results of the two studies also corroborate recent evidence by Lindeberg et al. (2018), who also found attractive happy faces to be detected faster and more accurately compared to unattractive happy faces.

Therefore, the first novel contribution of the current study was to replicate facial attractiveness as a moderator of the happiness superiority effect when using the MoC paradigm (Bucher & Voss, 2018). Additionally, we were not only able to find support for the evaluative congruence account with regard to attractive crowds of faces, but also for unattractive facial expressions. In unattractive crowds, the opposite pattern was revealed, indicating that unattractive faces were evaluated as being angry more frequently and unattractive crowds containing more angry faces were judged faster and with a higher accuracy. In sum, the present findings support the evaluative congruence account with both unattractive and attractive faces. The reason why we were able to detect an anger superiority effect for the negatively evaluated unattractive faces might be the fact that in comparison to the identification of single emotions, the MoC paradigm leaves more scope for motives to bias performance as accuracy rates are essentially lower in this task. It is possible that ceiling effects in relatively easy tasks prevent from finding evidence for the evaluative congruence account in unattractive faces.

In the first experiment, participants rated attractive female faces as more attractive than attractive male faces, whereas there was no such difference with respect to unattractive male and female faces (and the same limitation afflicted studies by Lindeberg et al., 2018). To rule out the possibility that the happiness superiority effect for attractive crowds might be due to this dissimilarity, we matched female and male faces on attractiveness in the second experiment. Even though this led to smaller attractiveness differences between the unattractive and attractive faces, we were again able to demonstrate a happiness superiority effect for attractive crowds and an anger superiority effect for unattractive crowds. Hence, attractiveness appears to moderate emotion perception even when attractiveness differences are reduced and attractiveness is matched between female and male targets.

Extending previous studies, we combined the MoC paradigm with eye-tracking analyses, which allows shedding light on the underlying processes that lead to judgements by analyzing gaze movements. If the happiness superiority effect for attractive faces is observed in eye movements (e.g., an increased probability of fixations on positive emotional expressions in attractive crowds), this would point to biased perceptional preferences that guide decision making. Social cues that are evaluated positively and match the respective emotion might attract attention to a stronger degree. An alternative is that the influence of attractiveness on emotion judgments manifests during the evaluation phase (e.g., a positive reappraisal of ambiguous crowds of faces). Therefore, it is plausible that although participants extract the same information when inspecting the crowd of faces, the final decision might nevertheless be biased as expectations about emotional expressions of attractive and attractive people guide the judgment. Only in the first experiment, we found higher proportions of fixations and a larger number of fixations on happy attractive faces compared to unattractive faces. In the second experiment, we found no such evidence. One explanation might be the reduced attractiveness difference between the attractive and unattractive crowds as a result of the matching procedure. However, compared to the large effects with regard to accuracy, response and response times, only small effects on the eye-tracking variables were found in Experiment 1. Therefore, we argue that differences in mood judgements in attractive compared to unattractive crowds are only slightly influenced by attentional processes but manifest more strongly in the evaluation phase.

The present experiments entailed a number of limitations. First, we found that attractive happy and unattractive angry faces were rated as more emotionally intense compared to attractive angry and unattractive happy faces in both experiments. As we used different target faces in the two studies, we believe it to be unlikely that happiness was expressed more strongly in attractive faces and anger more intensely in unattractive face expressions. To us, it seemed more plausible that influences of attractiveness that were observed in the mood judgements MoC task also transfer to the emotional intensity ratings of the faces pictures afterwards. However, future studies should aim to incorporate material in which attractive and unattractive faces express respective emotions to the same degree. One possibility would be to use computer-generated faces that are closely matched in terms of emotionality, gender and attractiveness. Another option would be to use machine learning approaches to select attractive and unattractive faces that show the same emotional intensity.

A further limitation of our studies is that we did not account for the possibility of the influence of stereotypes on emotion judgements (Bijlstra et al., 2010). It is possible that attractiveness- or sex-related stereotypes may partly account for the effect of attractiveness on emotion perception. Future studies could assess this by investigating whether the effect of attractiveness on emotion perception is moderated by attractiveness or gender-related stereotypes. It might be possible that the attractiveness effect only occurs for those participants who hold those specific stereotypes (e.g. those participants who evaluate attractive individuals more favorably compared to unattractive ones and associate attractiveness with more beneficial outcomes). Moreover, we did not investigate participants' own attractiveness, which may also play a role when judging the mood of attractive and unattractive crowds. Previous studies suggest that the degree to which individuals perceive another person's attractiveness is strongly influenced by their own attractiveness (Sim, Saperia, Brown, & Berinieri, 2015). Therefore, future investigations could address the attractiveness of the participants as an additional moderator. Especially individuals who perceive themselves as highly attractive might judge attractive crowds more favorably compared to unattractive crowds whereas this might not be the case for persons who rate themselves as being less attractive.

The findings of both experiments suggest that attractiveness plays a major role when judging the mood of a crowd of faces. Therefore, a broader implication of these studies is that it is highly necessary to control for attractiveness, when investigating the influence of other social cues (e.g. gender or race) on emotion perception. It is possible that past studies have confounded constructs such as target gender and attractiveness, and therefore the selection of the stimulus material may have exaggerated or underestimated effects of social cues on emotion perception (Lindeberg et al., 2018). Hence, controlling for attractiveness when selecting targets appears to be highly important.

Conclusion

In both experiments, we were able to demonstrate the influence of attractiveness on emotion perception when using multiple emotional targets. We replicated the happiness superiority effect for mood judgements, indicating that mood judgements were biased towards the happy response in attractive crowds and towards the angry response in unattractive crowds. Furthermore, participants evaluated attractive (unattractive) crowds containing more happy (angry) expressions faster and more accurately, which corroborates the evaluative congruence account. Additionally, eye-tracking analyses revealed that there is also a small effect of attractiveness on gaze movements, though this was present only in Experiment 1. Specifically, we observed higher fixation rates on happy attractive targets, implying that attractiveness plays a role even in the early stages of perception. Beyond supporting the evaluative congruence account, the results imply that face attractiveness should be carefully considered when selecting material for future studies that examine emotion perception.

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Table 1

Attractiveness and emotional intensity ratings for happy and angry female and male faces from both experiments.

	Female		Male	
Experiment	Happy	Angry	Happy	Angry
Experiment 1				
Attractiveness				
Attractive	5.63 (.69)	5.06 (.86)	3.99 (1.23)	3.52 (1.04)
Unattractive	2.76 (1.07)	2.13 (.84)	2.66 (1.13)	2.11 (1.04)
Emotional intensity				
Attractive	5.59 (.73)	5.41 (.73)	5.36 (.55)	5.35 (.63)
Unattractive	5.20 (.66)	5.69 (.64)	4.76 (.73)	5.23 (.71)
Experiment 2				
Attractiveness				
Attractive	4.55 (.76)	3.70 (.96)	4.17 (.94)	3.52 (1.10)
Unattractive	3.40 (.84)	2.51 (.82)	3.13 (.84)	2.36 (.75)
Emotional intensity				
Attractive	5.18 (.69)	5.19 (.74)	5.11 (.71)	4.97 (.88)
Unattractive	4.92 (.69)	5.42 (.80)	5.08 (.71)	5.23 (.75)

Note. Values in parantheses represent 1 *SD*.

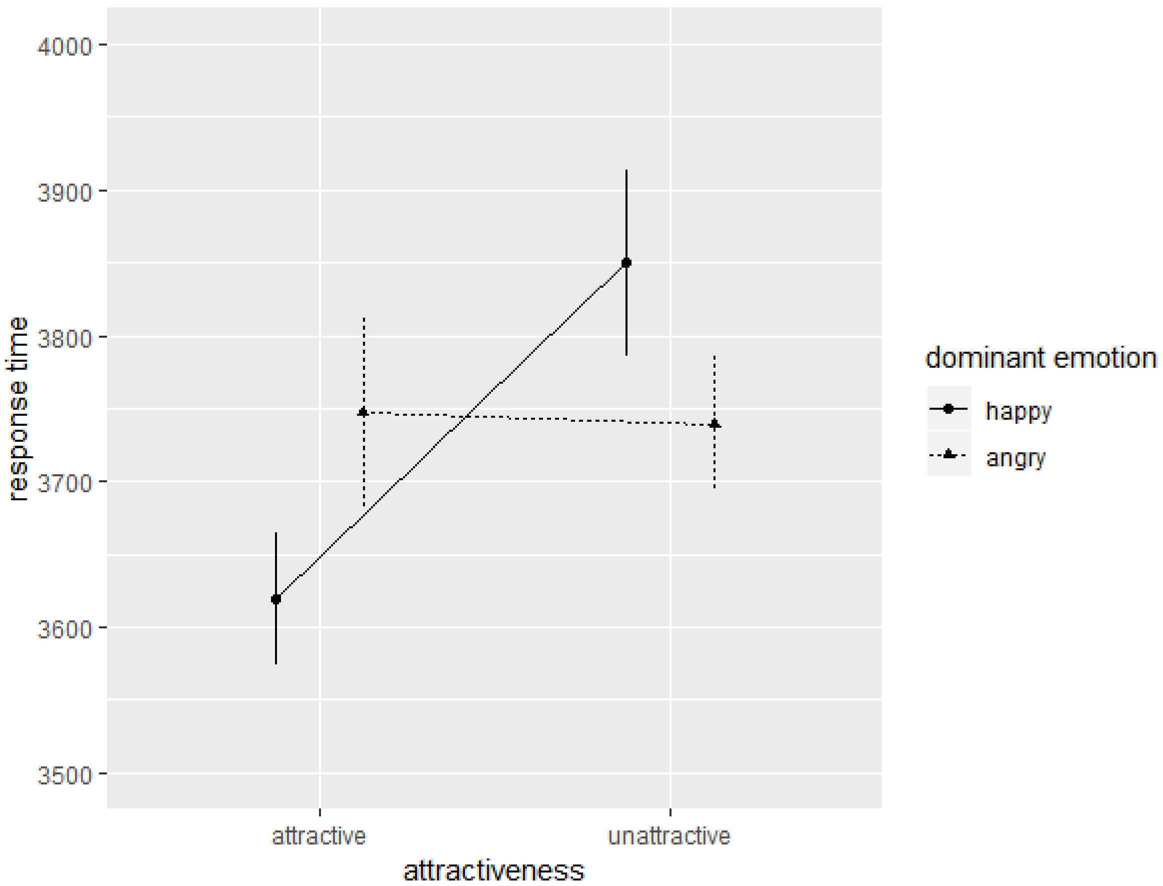

Figure 1. Interaction effect of dominant emotion and attractiveness on response times. Trials with 10 and 12 happy expressions were combined as well as trials with 10 and 12 angry expressions. Error bars indicate standard errors.

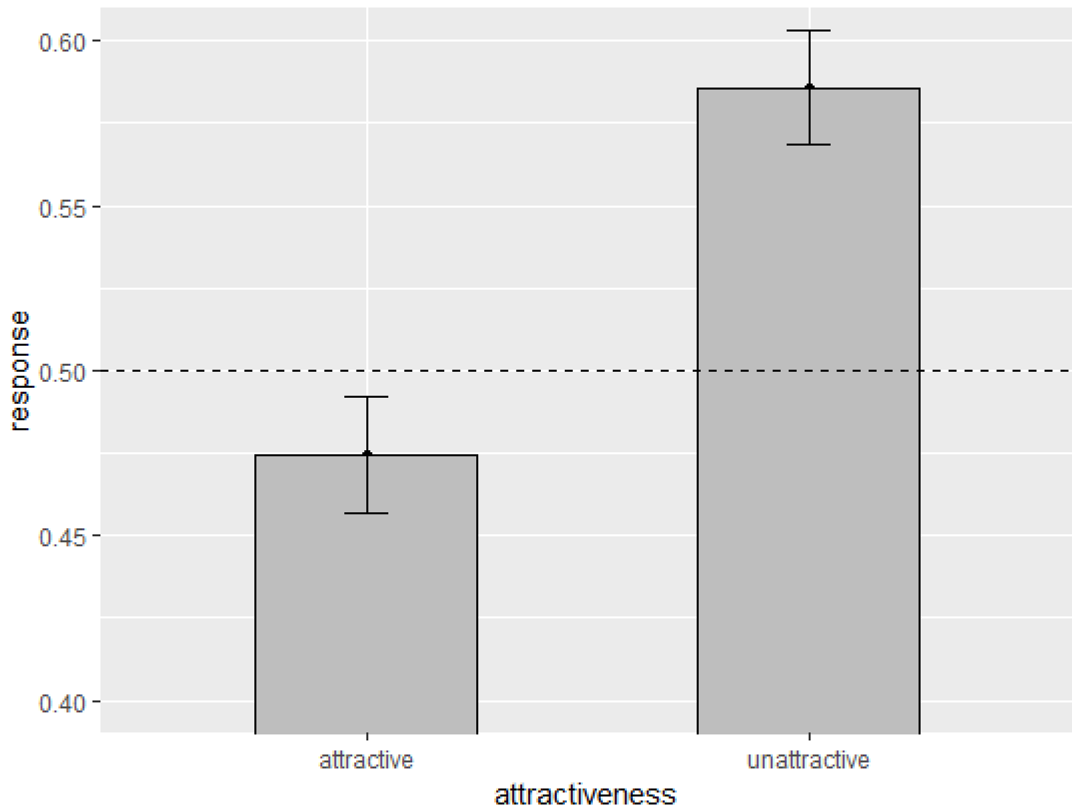

Figure 2. Main effect of attractiveness on response tendency (0 = happy, 1 = angry). Error bars indicate standard errors.

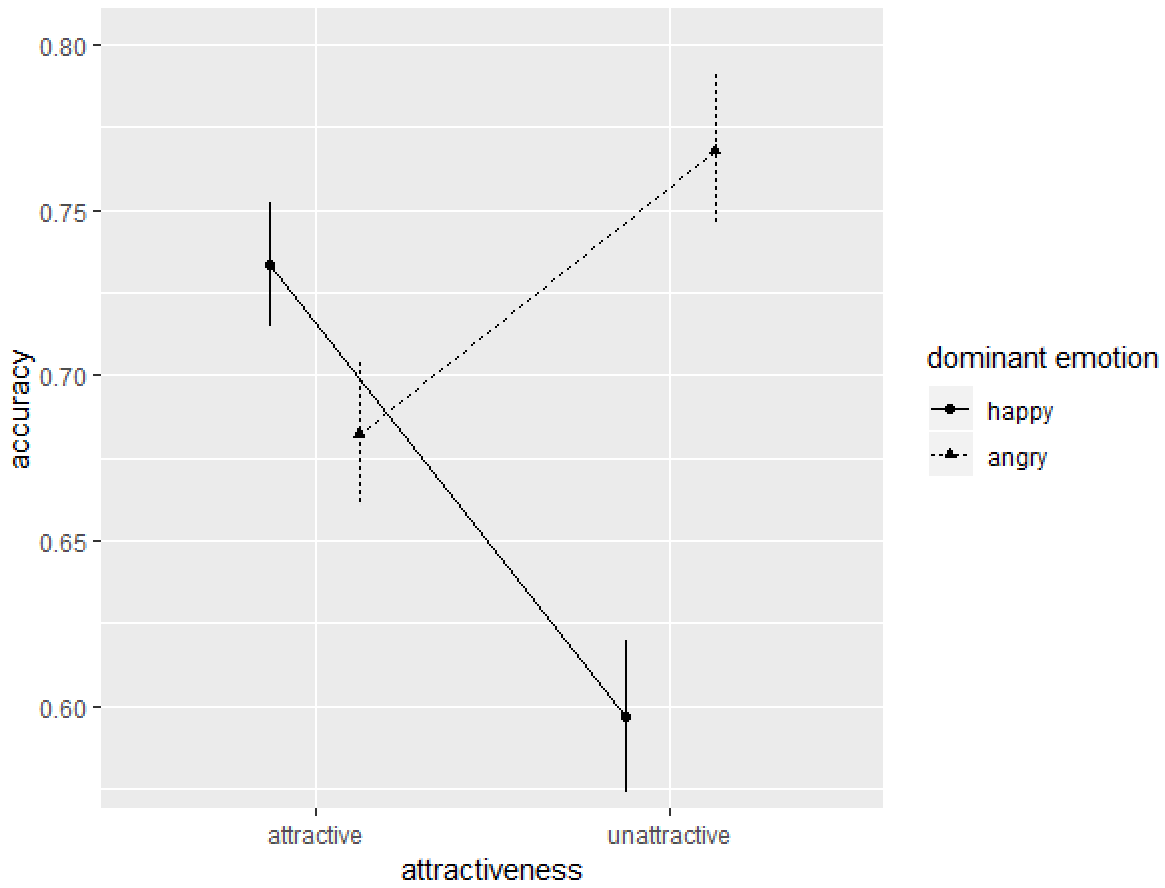

Figure 3. Interaction effect of dominant emotion and attractiveness on accuracy (0 = false, 1 = correct). Trials with 10 and 12 happy expressions were combined as well as trials with 10 and 12 angry expressions. Error bars indicate standard errors.

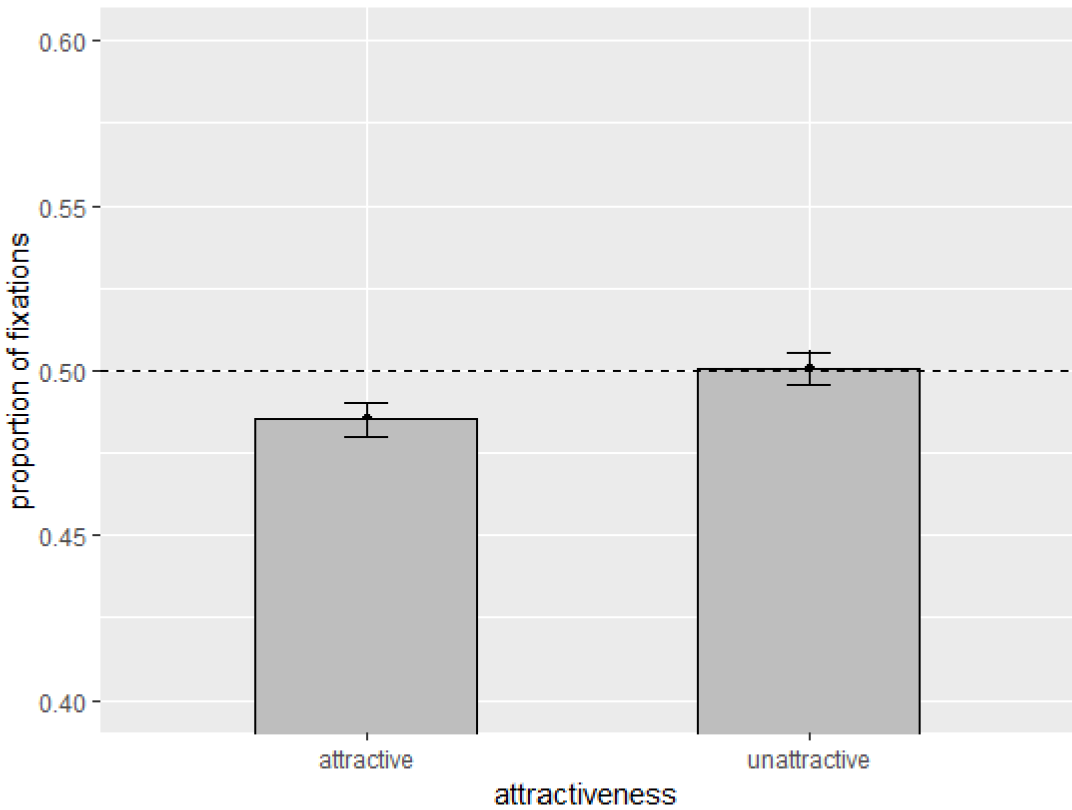

Figure 4. Main effect of attractiveness on proportion of fixations (0 = happy, 1 = angry). Error bars indicate standard errors.

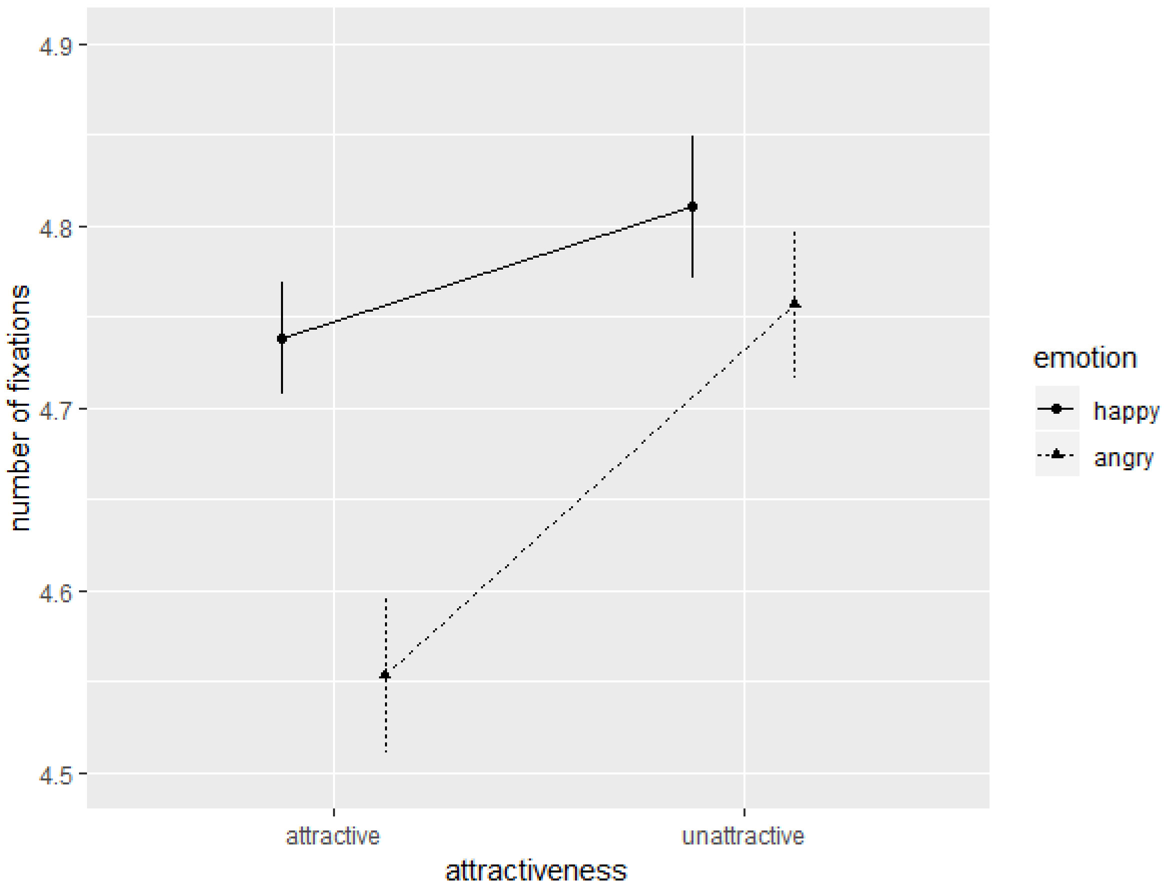

Figure 5. Interaction effect of target emotion and attractiveness on number of fixations. Error bars indicate standard errors.

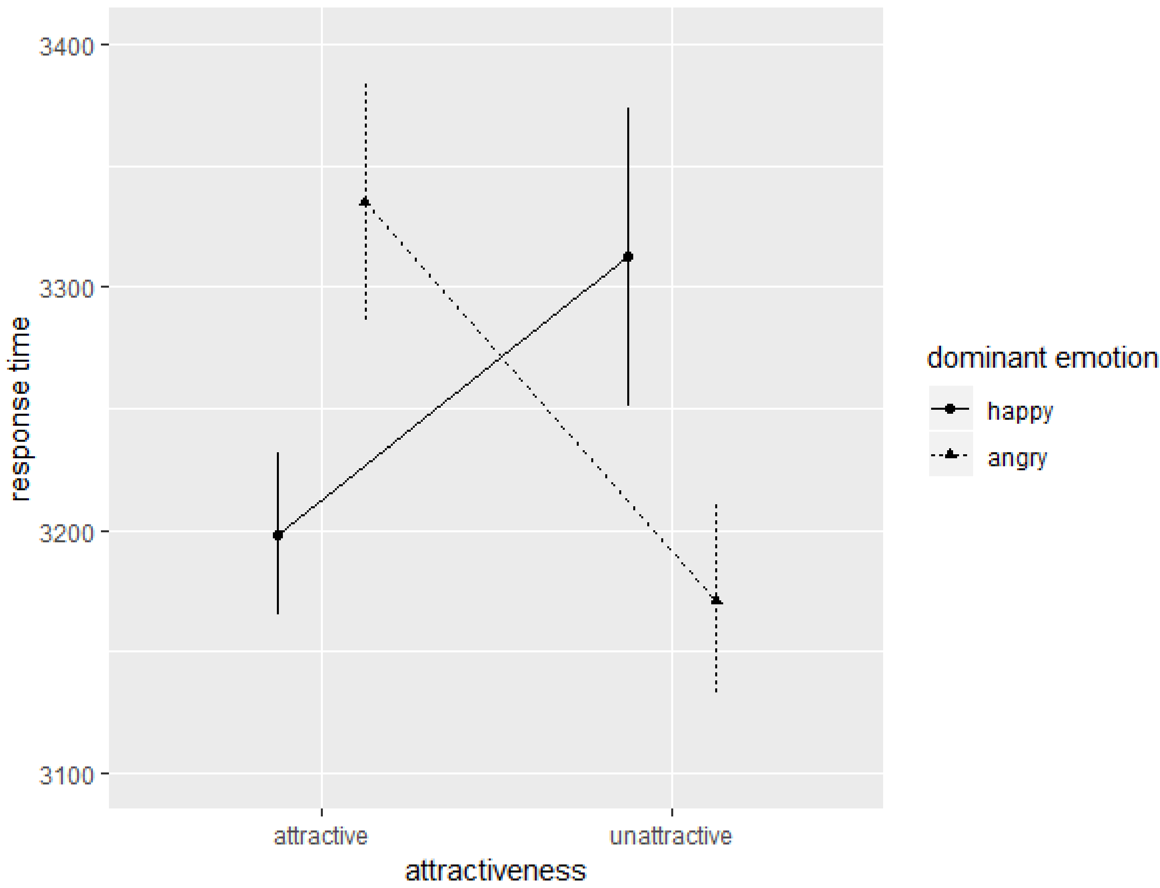

Figure 6. Interaction effect of dominant emotion and attractiveness on response times. Trials with 10 and 12 happy expressions were combined as well as trials with 10 and 12 angry expressions. Error bars indicate standard errors.

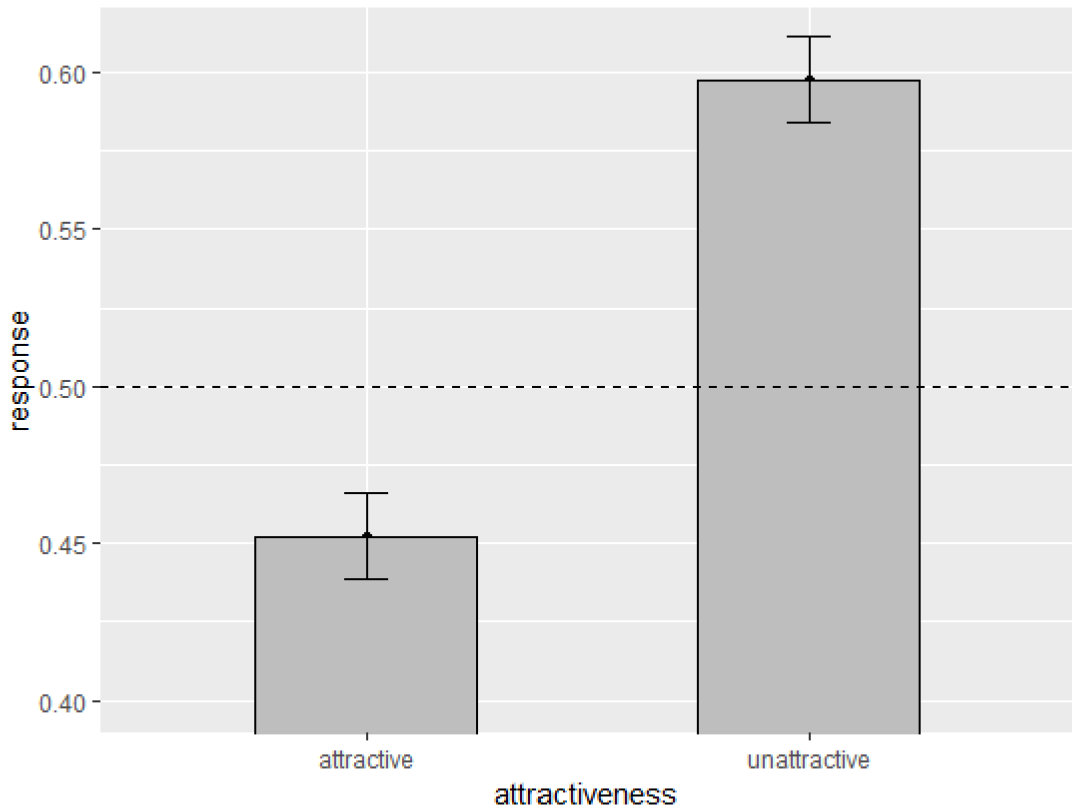

Figure 7. Main effect of attractiveness on response tendency (0 = happy, 1 = angry). Error bars indicate standard errors.

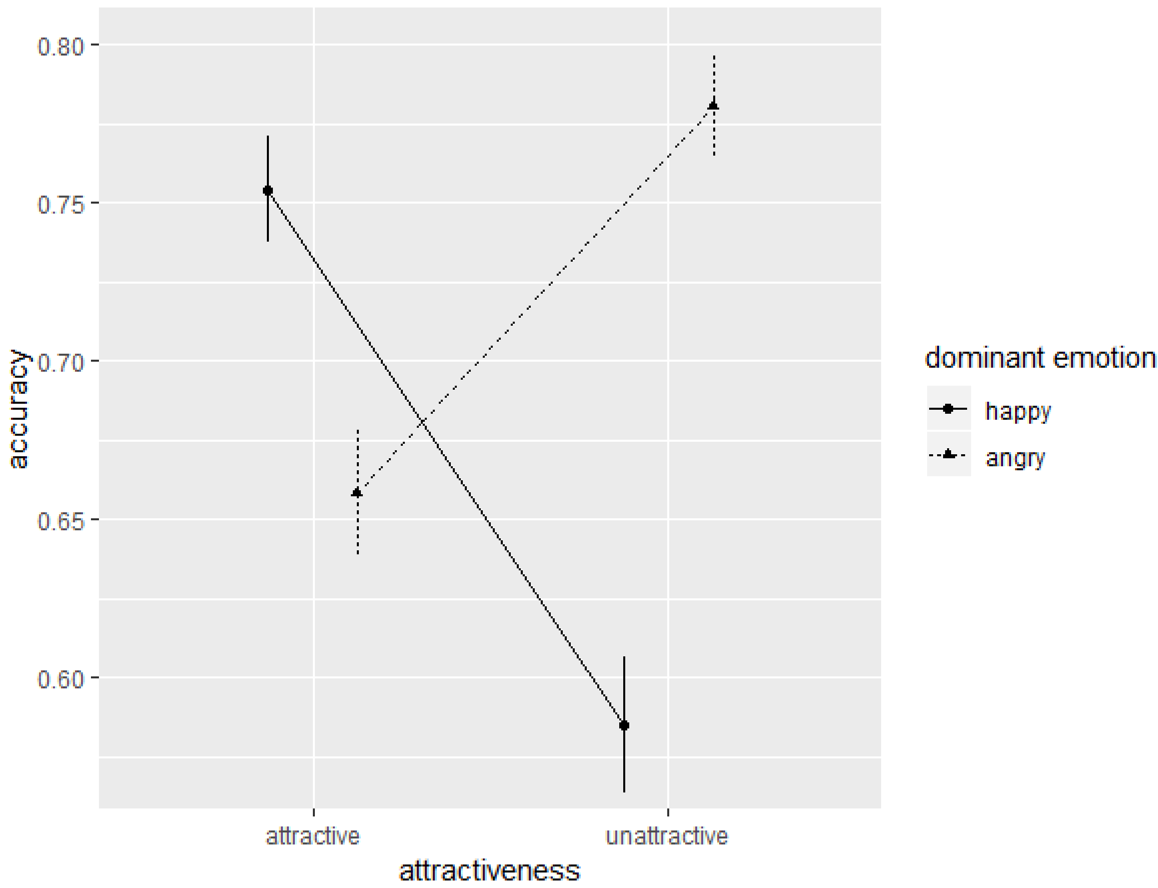

Figure 8. Interaction effect of dominant emotion and attractiveness on accuracy (0 = false, 1 = correct). Trials with 10 and 12 happy expressions were combined as well as trials with 10 and 12 angry expressions. Error bars indicate standard errors.

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