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ORIGINAL ARTICLE

Extraversion and focus of attention on facial emotions: an experimental eye-tracking study

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BACKGROUND
Emotions and personality traits seem to be important factors affecting social attention. In the present study, we used eye-tracking equipment to investigate the differences between extraverts and introverts in visual attention to positive and negative emotions shown in human faces. We want to describe more detailed types of eye movements in this visual attention, and especially patterns of spatial and temporal fixations. Based on previous research we would expect that extraverts would be more attentive to faces showing positive emotions compared to introverts.

PARTICIPANTS AND PROCEDURE
Emotions and personality traits seem to be important factors affecting social attention. The current study investigated differences between extraverts' and introverts' visual attentional focus on positive and negative emotions expressed in human faces.

RESULTS
Compared to the introverts group, extraverts showed significantly longer average fixation duration (AFD) for whole faces perceived to express positive emotions. There were no significant differences between the groups for dwelling time (DT), entry time (ET), and first fixation (FF). However, the extraversion group showed significantly longer DT, FF and AFD attention towards the mouth area compared to the introverts.

CONCLUSIONS
Extraverts seem to show a selective visual attentional bias towards positive emotions in human faces, particularly towards the mouth area of smiling faces compared to introverts. The study showed that the visual mechanisms behind this selective attention were differences in temporal fixation patterns such as average fixation duration, dwelling time and first fixation time.

KEY WORDS
eye-tracking; experiment; extraversion; visual attention; emotions

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BACKGROUND

Emotions and personality traits seem to be important factors influencing visual attention, and most notably social attention (Ashton, Lee, Paunonen, & Diener, 2002; Kaspar & König, 2012). For instance, extraverts, introverts and individuals with an elevated score on Openness show differences in gazing behavior (Rauthmann, Seubert, Sachse, & Furtner, 2012). Extraverts also seem to be slow to shift attention away from positive, reward-inducing stimuli (Derryberry & Reed, 2002), suggesting an emotion-regulation strategy, whereby the focus of attention contributes towards facilitating a state of positive affect (Todd, Cunningham, Anderson, & Thompson, 2012). This affective-reactivity hypothesis links the positive affect in extraversion to the reward system of the brain (Smillie, Cooper, Wilt, & Revelle, 2012). In addition, evidence from both task-related and resting-state neuroimaging has shown that extraversion is linked to activation of several regions of the brain involved in processing of emotions, cognition and memory, attention, and visual processing: the dorsolateral and medial prefrontal cortex, the anterior cingulate cortex, amygdala, insula and precuneus (Lei, Yang, & Wu, 2015). Other researchers have described the role of heuristics in emotional attention (Belhekar, 2017). The use of heuristics differs between individuals, and occurs because of high cognitive load, which leads to the use of heuristics as a mental short cut to processing information. Hence, the use of heuristics may be less precise, but more effective. On the other hand, heuristics may also account for biases in processing. It has been shown that the use of heuristics is associated with positive affect and individuals in positive states are more likely to trust their emotional intuitions than individuals in a negative state (Eysenck & Keane, 2000). Therefore, when individuals experience positive affect, it could lead to shallow processing, increased use of heuristics and avoidance of risks, in order to maintain the positive state (Eysenck & Keane, 2000). Moreover, dynamic emotional expression is also an important part of our personality, especially at the trait level. Although people experience a variety of emotions in response to external and internal stimuli, it has become increasingly clear that personality factors have an important role in the experienced intensity and continuity of emotions over time (Kaspar & König, 2012; Lucas & Baird, 2004). Extraversion is strongly positively associated with continuous pleasant affect (Inglis, Obonsawin, & Hunter, 2018; Lucas & Baird, 2004), and the correlation between positive affect and extroversion is calculated to be .41, based on more than a dozen studies (Smillie et al., 2012). This positive association between extraversion and positive affect might be a consequence of an attentional bias towards valenced emotional stimuli (Amin, Constable, & Canli, 2004). It is, therefore, important to study more closely the association between emotions, personality factors and the role of emotional attention processing. It is of special interest to find out more about the visual factors behind this attention processing.

Overall, there seems to be a dearth of empirical research investigating possible differences in visual attention bias between extraverts and introverts (Canli, 2004) and especially the role of perceptual and cognitive factors (Inglis et al., 2018). Therefore, measurement of visuo-motor reactions in connection with facial emotion processing could reveal differences in visual patterns between the two groups. Automatic eye movements such as saccades, pursuit movements and fixations are controlled by a complex interaction of neuronal systems involving several cortical and subcortical brain areas. The neuronal control systems and generators of eye movements have been studied over the years and are well described. For instance, fixations are controlled by the oculomotor nuclei in the brain stem, superior colliculus, reticular formation and cerebellum (Krauzlis, Goffart, & Hafed, 2017), but also other brain areas such the frontal eye field, the lateral intraparietal region and the LGN are involved (Wurtz, 2008). There is also a close connection between the amygdala complex and generators of eye movements suggesting that emotional experiences also affect eye movements (Corsi-Cabrera et al., 2016). Finally, eye movements can have a considerable effect on visual perception itself (Krauzlis et al., 2017).

In the present study, we used eye-tracking equipment to investigate the differences between extraverts and introverts in visual attention to positive and negative emotions shown in human faces. We want to describe more detailed types of eye movements in this visual attention, and especially patterns of spatial and temporal fixations. Based on previous research we would expect that extraverts would be more attentive to faces showing positive emotions compared to introverts.

PARTICIPANTS AND PROCEDURE

PARTICIPANTS

One hundred and sixty undergraduate students in social sciences were voluntarily recruited to the study. From this sample, we selected two subsamples of students: the ten participants who had the highest scores on the Extraversion scale, and the ten participants who had the lowest scores (less than 4).The two groups comprised the Extraversion group (*n* = 10) and the Introversion group (*n* = 10), respectively. Ideally, groups should have been larger, but the screening procedure involving this sample had only 10 subjects with an Introversion score below 4. These 10 subjects where matched against the 10 highest scoring extraverts. Both groups consisted of 8 women and 2 men aged 20-25 years. The present study was carried out in accordance with ethical principles in the Declaration of Helsinki (World Medical Association, 2001).

PERSONALITY TEST

We used the Norwegian version of the Big Five Inventory-44 (BFI-44; Engvik & Føllesdal, 2005) to measure personality traits. The BFI-44 consists of 44 statements which measure five dimensions: Extraversion (E), Agreeableness (A), Conscientiousness (C), Emotional Stability (ES) (Neuroticism reversed), and Openness to experience (O). The subjects' answers were registered on a 7-step Likert scale. The BFI shows alpha coefficients (α) between .75 and .90 and a test-retest reliability (*r*) between .80 and .90. Reliability estimates for the Norwegian edition are comparable to international reports (Engvik & Føllesdal, 2005). The alpha coefficients (α) of the present sample were as follows: Extraversion .83; Agreeableness .72; Conscientiousness .79; Emotional Stability .84; and Openness to experience .82.

ASSESSMENT OF FACIAL EMOTIONS

We used the Karolinska Directed Emotional Faces (KDEF) as visual stimuli conveying human emotions. The KDEF consists of 4900 pictures of human facial expressions by 70 amateur actors who display seven different facial expressions: happy, sad, angry, disgusted, surprised, fearful and neutral (Lundqvist, Flykt, & Öhman, 1998). For this study we selected the emotions happy, sad, angry, disgusted, and fearful. The emotion 'surprise' was excluded, as there is some uncertainty as to the valence of this emotion, and it may be perceived as both a positive and a negative emotion (Noordewier & Breugelmans, 2013). We randomly selected 16 negative and 16 positive emotion pictures from the KDEF. The emotions were displayed in 8 female and 8 male faces; i.e. the 8 women and 8 men each showed the emotions happy, sad, angry, disgusted and fearful. Slides were constructed with the same individual showing happy-sad, and later sad-happy, and with another individual with happy-angry, and later angry-happy, and so on. Every picture was presented in a straightforward angle (not profile), as individual differences might interfere with the participants' attention focus. The same person showed all the positive and negative emotions.

Each emotion picture was presented on a laptop computer. The stimuli screen was 15" and had a resolution of 1920 × 1080 pixels. The pictures were presented in positive-negative pairs: i.e. one face (man or woman) showed a positive emotion in one half of the screen, and the same face showed a negative emotion in the other half. To reduce the tendency for participants to initially look towards one particular direction more than the other, all the pictures were counterbalanced; i.e. the picture sets were designed so that there were the same number of positive and negative emotions on the left side as the right side. In addition, to guide the participant's focus towards the middle of the screen before being presented with the next slide, a visual trigger point in the form of a cross was inserted in the center of the screen. To increase fixation, the participants had to look at this cross continuously for two seconds before the next picture set was presented. The pictures were presented in randomized order. Figure 1 shows an example of the pictures.

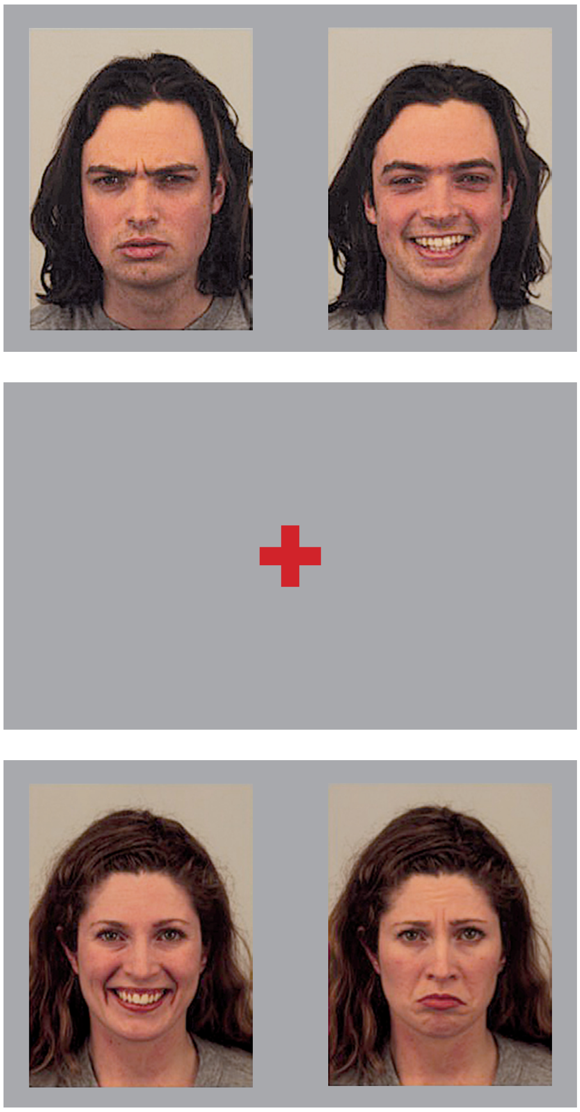

Figure 1. Two of the picture pairs used as the negative and positive stimuli in the experiment (material from KDEF). The red "cross" was displayed between each picture pair.

MEASUREMENT OF VISUAL ATTENTION

To assess visual attention towards emotional expressions, we measured participants' eye movement during the experiment using a mobile eye-tracker from SensoMotoric Instrument (SMI) RED 250. SMI Experiment Center 3.6 software was used to perform the experiment, and parameter detection from eye-tracking data was done by SMI BeGaze 3.6. Prior to the experiment, for each participant we conducted a 13-point technical calibration procedure in order to gain accurate measurements during the study.

For the study, the eye-tracker was placed below the computer screen. Area of interest (AOI) is an important technical factor. This is a pixel area on the computer screen placed over the picture (i.e. the eyes, mouth, or the whole face), and the parts outside the stimulus are ignored. AOIs were placed over the positive and negative pictures, including individual AOIs for the eyes and mouths. We measured four variables for each picture presented: dwelling time (DT), first fixation (FF), entry time (ET) and average fixation duration (AFD). DT measures all the saccades and fixations within the AOI or the general pictures in milliseconds. It starts when the participants first gaze in the picture AOI and ends when their gaze is averted. ET refers to the duration of the automatic eye movement before fixating the picture or the AOI. FF refers to the duration of the first fixation on the AOIs. AFD is the total fixation time that all pictured were presented divided by quantity of fixations in the experiment. All variables was measured in milliseconds (Instruments, 2012).

Between the presentations of each picture, a red cross was inserted in the middle of the screen (see Figure 1). The participants were requested to stare at this cross for two seconds to aid their focus in the center of the screen before the next picture was presented. All pictures were shown for five seconds, independently of where the participant gazed. Each experimental session lasted approximately four minutes.

PROCEDURE

The BFI-44 was handed out together with a consent form and a sheet to fill out additional necessary information of gender, age and contact information. All applicable participants took part in the experiment within a week from filling out the BFI-44.

After choosing the ten participants with the lowest Extraversion scores and the ten participants with the highest Extraversion scores, the participants were invited to the experiment by text message. When the participant entered the experiment lab (at Innlandet University College), they were instructed where to sit and informed that they were going to participate in an eye-tracking experiment. The information about the red cross, and that they had to look at it to move to the next slide, was given over the computer screen, to ensure that all participants received the same information, and that the researcher had a limited impact. Before the experiment began, two picture pairs with neutral emotional expressions were flashed on the screen to make sure the participant understood the practical implications of the experiment. After the two practice sets, the participants were asked over the screen if they had any questions, and to press "space" whenever they felt ready. The experimental condition contained eight picture sets, sixteen pictures in total. The picture sets were each shown for five seconds, and the experiment was finished after about four minutes.

STATISTICAL ANALYSES

In addition to descriptive statistics, we used multiple analysis of variance (MANOVA) with a full factorial model to test differences in visual attentional factors between the Extraversion and Introversion group. These analyses and the SMI-BeGaze data were analyzed using SPSS version 25.

RESULTS

Table 1 shows the results of the MANOVA analysis of the eye-tracking parameters DT, ET, FF and AFD for positive and negative emotions.

The results demonstrated that there were significant differences between the Extraversion group and Introversion group in AFD for positive emotions (F = 4.01, df = 1, p < .05, η^2 = .19, observed power = .48) and approaching significant differences in ET for positive emotions (F = 3.7, df = 1, p = .07, η^2 = .17, observed power = .46). There were no significant differences in DT and FF. These findings demonstrated that compared to introverts, extraverts tended to have longer fixations and, probably shorter ET for fixations on positive facial emotions compared to negative emotions.

There were no significant differences in AFD between the two groups in attention towards the negative stimuli, suggesting that the groups were equally attentive towards the negative stimuli. Finally, there were no significant differences between the groups in any of the gazing parameters for the eye region (the eye AOI).

There was a significant difference between the Extraversion group and Introversion group in DT on the mouth displaying the positive emotion (F = 5.5, df = 1, p < .05, η^2 = .3, observed power = 0.2). This suggests that the Extraversion group tended to gaze longer at the mouth displaying the positive emotion compared to the Introversion group. There was also a significant difference between groups in FF dura-

Table 1

Visual attention to pairs of positive and negative facial emotions. Differences in eye movement parameters (milliseconds) for the AOI whole face. Each picture of the pair was presented for 5 seconds. Multivariate analysis of variance (MANOVA)

	Extraversion group *n* = 10		Introversion group *n* = 10		Sig.
	M	*SD*	*M*	*SD*	
DT mouth negative ms	1053.70	210.70	1029.80	340.00	ns
DT mouth positive ms	1230.70	184.20	1019.40	376.40	ns
ET mouth negative ms	1214.90	396.00	1459.80	307.20	ns
ET mouth positive ms	1164.20	327.10	1478.90	400.60	.07
FF mouth negative ms	397.90	142.50	327.40	159.10	ns
FF mouth positive ms	348.70	78.70	329.90	129.40	ns
AFD mouth negative ms	400.40	123.80	319.10	134.00	ns
AFD mouth positive ms	382.90	58.90	308.90	99.50	*

Note. DT – dwelling time for saccades, ET – entry time for first saccade, FF – first fixation duration, AF – average fixation duration; **p* < .05; ms – milliseconds; Sig. – level of statistical significance.

Table 2

Visual attention to pairs of positive and negative emotions of the AOI mouth area in the face. Differences in eye movement parameters (milliseconds). Each picture of the pair was presented for 5 seconds, multivariate analysis of variance (MANOVA)

	Extraversion group *n* = 10		Introversion group *n* = 10		Sig.
	M	*SD*	*M*	*SD*	
DT mouth negative ms	305.20	72.20	298.80	234.20	ns
DT mouth positive ms	534.60	148.80	289.60	242.20	*
ET mouth negative ms	1992.20	677.80	2167.90	767.60	ns
ET mouth positive ms	1762.60	661.40	2195.90	908.60	ns
FF mouth negative ms	215.90	47.50	171.80	103.40	ns
FF mouth positive ms	324.40	66.70	175.10	114.30	*
AFD mouth negative ms	219.20	52.70	179.70	111.10	ns
AFD mouth positive ms	333.40	58.60	167.90	102.70	*

Note. DT – dwelling time for saccades, ET – entry time for first saccade, FF – first fixation duration, AF – average fixation duration; **p* < .05; ms – milliseconds; Sig. – level of statistical significance.

tion on the mouth displaying the positive emotion ($F = 9.4$, $df = 1$, $p < .05$, $\eta^2 = .4$, observed power = 0.8), demonstrating that the Extraversion group had significantly longer FF than the Introversion group. Finally, the Extraversion group also had significantly longer AFD on the mouth displaying the positive emotion ($F = 14.4$, $df = 1$, $p < .05$, $\eta^2 = .5$, observed power = 0.9); indicating that they tended to sustain their focus on the mouth displaying the positive emotion compared to the Introversion group.

There were no significant differences for the negative stimuli in the different AOIs, which indicates that the two groups are somewhat equal in their attention towards the negative stimuli at the AOIs, which is in line with the previous finding of no difference in attention towards the general negative stimuli without the AOIs. There was no significant difference in ET to the AOIs around the positive stimuli mouth, which suggests that the groups have similar entry time to the mentioned AOI.

DISCUSSION

The results confirmed our initial suggestion that the Extraversion group was more attentive to positive emotional faces compared to the Introversion group. We also showed the visual mechanisms behind this selective attention in terms of spatial and temporal patterns of fixations: the Extraversion group had significantly longer average fixation duration (AFD) on the whole faces expressing positive emotions and gazed longer at the mouth area of smiling faces; i.e. had longer dwelling time (DT) and longer first fixations (FF). There were no significant differences between the groups in gazing behavior for the eye area of the faces, which is interesting. Indeed, the mouth is a key element in facial expression, and particularly smiling during a positive emotional state (Eysenck & Keane, 2000). Apparently, smiling faces are more rewarding for extraverts than introverts (Smillie et al., 2012). Gazing longer at smiles could also have a cognitive memory effect since positive facial emotions seem to be related to broadened cognition (Johnson, Waugh, & Fredrickson, 2010).

It has been proposed that extraverted individuals experience more positive emotions than introverts (Smillie et al., 2012) and score significantly higher on dimensions of happiness, quality of social relationships and emotion regulation abilities than introverts (Cabello & Fernandez-Berrocal, 2015). Therefore, a tendency to focus more on positive than negative emotional stimuli could increase positive mood such as happiness and joy, thus reinforcing a state of positive affectivity. In the long run this repeated positive affectivity could become a part of the extraverted emotional and behavioral style. This emotional style can also have positive outcomes in terms of health and wellbeing. For instance, there is empirical evidence showing that extraversion is positively associated with self-efficacy and quality of life (Pocnet, Dupuis, Congard, & Jopp, 2017). The present study gives further evidence to the fact that certain personality traits may alter visual attention, processing of emotional information and consequently also alter behavior.

STRENGTHS AND LIMITATIONS

To the best of our knowledge, this is the first study to use eye-tracking technology to explore selective visual attention to different emotional expressions in extraverts and introverts. We also show the visual mechanisms behind this selective attention in terms of differences in spatial and temporal fixation patterns. Data obtained from the SMI eye-tracker reflects neuro-biological reactions related to the facial stimuli presented and could enhance our understanding of the perceptual and cognitive mechanisms involved in processing emotional facial expressions.

Limitations of the study are the small sample size and the gender distribution. Both groups consisted of 80% females and 20% males, and although the difference between the groups was not significant, the gender distribution was unrepresentative for the general population. This study should, therefore, be repeated on a larger sample size with more equal distribution of gender.

CONCLUSIONS

Extraverts seem to show a selective visual attentional bias towards positive emotions in human faces, particularly towards the mouth area of smiling faces compared to introverts. The study showed that the visual mechanisms behind this selective attention were differences in temporal fixation patterns such as average fixation duration, dwelling time and first fixation time.

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