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Eye-tracking of Facial Emotions in Relation to Self-criticism and Self-reassurance

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ABSTRACT

The study explores the relation between participants' level of self-criticism, self-reassurance, and eye gaze when looking at photographs of primary emotions. Participants completed The Forms of Self-Criticising/Attacking & Self-Reassuring Scale (FSCRS) and then a facial-emotion expression task while their eye movements were being recorded by an eye-tracker. The results indicate differences in people's eye-gaze patterns when viewing facial-emotion expressions in relation to the level of self-criticism and self-reassurance. Specifically, participants with higher self-reassurance look more frequently at the eye region and less frequently at other facial areas and beyond the emotional faces. However, individuals with higher self-hatred look at the outside of the face more frequently than at the eyes area, and higher self-inadequacy predicted the individual would look more frequently at the eyes than at other facial areas. The results are important for understanding the role of self-criticism in relation to facial-emotion expressions and gazing, as self-criticism is a key underlying factor of all kinds of psychopathologies. Following further research, the results could be used to develop more objective diagnostics for self-criticism screening than the existing self-rating scales.

Human Gaze

Research investigating the human gaze and emotional faces in relation to the level of self-reassurance and self-criticism is in the very early stages of development. However, there is no doubt that eye-contact generally serves several different but also crucial functions in human interaction. Kleinke (1986) summarized previous studies on gaze functions: providing information; regulation of interaction; expression of intimacy; exercising of social control; and facilitation of service and task goals. In addition, a person's gaze can provide us with information about emotions as well as signals about social involvement, empathy, control, dominance, and interpersonal adequacy (Horley et al. 2003). Thus,

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people naturally pay attention to facial emotions as they may signal information that is important to survival (Goren and Wilson 2006).

Emotions

Ekman (1992) is known for his theory of the six basic emotions that are allied with specific facial expressions: anger, fear, disgust, happiness, sadness, and surprise. Many studies have pointed to the universality of the facial expressions of emotions (e.g., Ekman and Cordaro 2011; Keltner and Ekman 2000) and their cultural nuances (e.g., Elfenbein and Ambady 2002; Lindquist and Barrett 2012); nonetheless, Ekman's theory has been criticized (e.g., Cohen 2005). A meta-analysis of 168 datasets examining judgments of facial emotions and other nonverbal stimuli indicated universal emotion recognition well above chance levels within and across different cultures (Elfenbein and Ambady 2002). However, there are studies showing that individuals with anxiety, depression, unhealthy perfectionism and feelings of self-inadequacy, but also self-critical people, have distinct difficulty recognizing and responding to positive/affirmative emotions and pay much more attention to negative/threatening emotional expressions (Gilbert et al. 2006; Gilbert and Procter 2006; Longe et al. 2010). It has also been found that different patterns of scanning emotional expressions may be responsible for the false recognition of emotion (e.g., Phillipou et al. 2015; Wang et al. 2012).

Gaze in the Emotion Recognition

Research identifying primary emotions suggests that the eyes and mouth are the two fundamental areas of the face that healthy people pay attention to when seeing and recognizing facial expressions (e.g., Henderson, Williams, and Falk 2005). By tracking eye movements in relation to the main regions of the human face, Schurgin et al. (2014) found that the eyes, upper nose, lower nose, upper lip, and nasion accounted for 88% of all fixations. Other regions accounted for less than 3% of fixations on the face. Wells, Gillespie, and Rotshtein (2016) emphasized that eye-region fixation is about three times greater than mouth fixation on emotional faces, and Schurgin et al. (2014) found that 35% of all fixations are accounted for by fixations on the eye area.

Lower levels of eye-contact are often found in clinical populations with a deficit in facial-expression recognition. Studies have tended to focus on attempting to explain eye-gaze biases among participants. Earlier studies of anxiety or social anxiety (see, for example, Daly 1978; Farabee et al. 1993) showed that individuals anxious in social interactions made less eye-contact with the interviewer than nonanxious participants did in order to receive social cues and to avoid rejection. Larsen and Shackelford (1996) stated that some people maintained direct, face-to-face contact during interaction, whereas others averted their gaze or turned their face while interacting. Gaze aversion has been associated with shyness, social anxiety, risk of schizophrenia, and negative social evaluations; moreover, gaze-averse people have been rated as more deceptive and less sincere (Larsen and Shackelford 1996).

Research by Horley et al. (2003) supported the idea that social phobia is characterized by eye avoidance in social interactions, reflecting an exaggerated social sensitivity. They examined how social-phobia clients processed facial expressions. The social-phobia participants tended to avoid facial features, particularly the eyes and to scan nonfeatures instead. Wang et al. (2012) explored the relation between shyness and face-scanning patterns. Researchers found that participants' shyness scores were negatively correlated with a fixation on the eyes regardless of the race of the person they were observing. The shyer the participants were, the less time they spent fixating on the eyes of people expressing emotions. Participants with high levels of shyness tended to fixate significantly more on the regions just below the eyes than did participants with low levels of shyness. This may be a way of avoiding direct eye-contact. We suppose that this pattern of eye-contact avoidance may be similar in self-critical people because self-criticism is significantly associated with shame-proneness (Gilbert 2000). Self-critical people can find it more difficult to look at the eyes but also at threat-related emotional expressions generally. In addition, McEwan et al. (2014) found that self-critical participants perceived more facial expressions (not just fear) as threatening; for example, they sometimes interpreted a happy expression as a threat or as a mocking expression and this led to avoidance. Furthermore, a study by Mansell et al. (2010) indicated that, compared to individuals low in social anxiety, those high in social anxiety exhibited an attentional bias for looking away from emotional (positive and negative) faces. They suggested that social anxiety could be associated with a reduced ability to process external social cues, which leads to gaze avoidance.

Self-Criticism

Blatt and Homann (1992) defined self-criticism as a form of self-concept which involves constant and harsh self-judgment and a chronic fear of criticism, disagreement, and rejection. Similarly, Straub (1990) saw self-criticism as the perception of being criticized, pushed down, imprisoned in the idea of not being good enough, and persistently not having the energy for new things and challenges in life. Moreover, Gilbert et al. (2004) pointed out that self-criticism comes in different forms and has different accompanying emotions. According to Gilbert et al. (2004), there are two forms of self-criticism: the first component is "being self-critical", overestimating errors and a feeling of inadequacy; and the second component involves the need to self-hurt and a feeling of self-contempt and self-hatred. By contrast, self-reassurance is having supportive, kind and caring reactions towards oneself when things go wrong.

There is also research to support the idea that a high level of self-criticism and a low level of self-compassion or self-reassurance are related to shame, feelings of inferiority, inadequacy, and failure or anxiety (Blatt and Homann 1992). Such people often feel sadness, hopelessness, loneliness, depressive, and other negative emotions (Kannan and Levitt 2013; Sears et al. 2011). Because there are strong ties between self-criticism on the one hand and depression, anxiety, social anxiety, shyness, and stress on the other (Cunha and Paiva 2012; Gilbert 2000; Gilbert et al. 2011; Powers, Koestner, and Zuroff 2007), we wanted to investigate participants' eye-movements as they looked at photographs of the primary facial expressions in relation to their level of self-criticism and self-reassurance. This has not been studied before.

Aim of the Study

The goal of this study was to ascertain whether there are any differences in the gaze of participants looking at facial expressions of primary emotions in relation to the level of self-criticism and self-reassurance. Generally, we hypothesized that self-reassurance was linked to a higher fixation on the eyes and that self-criticism was related to a lower fixation on the eyes.

(1) Higher Self-criticism (Inadequate Self and/or Hated Self FSCRS score) predicts a lower total fixation time on the eye area of a person exhibiting a primary-emotion facial expression (Daly 1978; Farabee et al. 1993; Horley et al. 2003; Wang et al. 2012).
(2) Higher Self-reassurance predicts a higher total fixation time on the eye area of a person exhibiting a primary-emotion facial expression (Daly 1978; Farabee et al. 1993; Horley et al. 2003; Wang et al. 2012).

Methods

The research sample consisted of 92 adult participants, 40 women and 52 men (M = 22.16 years, SD = 5.01). We selected young participants as self-criticism peaks in youth (Fichman, Koestner, and Zuroff 1996; Neff and McGeehee 2010). The participants were recruited from the general community through social media using convenience sampling. All the procedures in this study were performed in accordance with the ethical standards of the institutional research committee and the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all the participants of the study.

Measurement of Self-Criticism and Self-Reassurance

The Forms of Self-Criticism/Reassuring Scale (FSCRS; Gilbert et al. 2004). The FSCRS is a 22-item self-report measure requiring participants to rate a selection of positive and negative statements on a 5-point Likert scale ("Not at all like me" to "Extremely like me"). Items include, for example, "I am easily disappointed with myself." and "I am gentle and supportive with myself.". Positive items reflect the ability to self-reassure (referred to as Reassured Self [RS]) and negative items indicate self-critical thoughts and feelings (split into the subscales of Inadequate Self [IS] and Hated Self [HS]). Results from various countries (e.g., Castilho, Pinto-Gouveia, and Duarte 2015; Halamová, Kanovský, and Pacúchová 2017; Kupeli et al. 2013) have shown that the FSCRS has good reliability (Cronbach alfa = 0.75–0.85) and validity. This scale has been validated in 13 different nonclinical samples (Halamová et al. 2018).

Eye-Tracking Method

Tobii X2 60 eye trackers with I-VT Fixation Filter (Olsen and Matos 2012) were used to track participants' gaze. The Velocity–Threshold Identification (I-VT) fixation classification algorithm measures immediate emotional responses and these are captured before being cognitively perceived and interpreted by the rational argumentation of the participants. Pro X2-60 shows where the person is looking, with a sampling rate of 60 Hz. The eye trackers are designed to capture the timing and duration of fixations. The screen size was 52.5 × 32.5 cm and respondent distance was 60 cm from the screen; therefore, the visual angle of the screen was 46.86°. According to previous studies with the same conditions, the visual angle of the facial emotions presented should be approximately 8° (see Henderson, Williams, and Falk 2005). Thus, all the photos in our research study were 5.8 cm × 8.7 cm (width × height) with a resolution of 211 × 317 pixels. The Areas of Interests (AoI) on the face photographs were manually selected as the Area of Eyes (AOI1), Area of Face except the Eyes (AOI2), and Area Outside the Face (AOI3).

Database of Facial Expressions

Participants' reactions to emotional expressions obtained from a database of static images (photographs) were monitored. We selected a set of static images of emotions that we considered to be a sufficiently proportional representation of the stimulation material in terms of gender, age (younger and older stimuli in the database) and that had high validity (a high percentage of people recognizing the emotions in the database). The emotions contained within the Umeå University Database of Facial Expressions

(Samuelsson et al. 2012) are correctly identified 88% of the time. Other studies have confirmed the high accuracy with which the emotions are identified, and the validity and reliability of the database (Boettcher et al. 2013; Garrido et al. 2016).

Procedure

The participants read and signed the informed consent form for the eye-tracking study. The participants in the Tobii Pro program were shown pictures of people expressing primary-emotion facial expressions (anger, fear, sadness, surprise, joy, disgust, and neutral) in random order (a total of 42). Each photograph was viewed on the screen for 5 s. The set of photographs included young people (about 25 years of age), middle-aged people (about 45 years of age), and elderly people (over 65 years of age) experiencing emotions. Men and women were represented in each age group. The model photos selected had a clearly identifiable emotional expression (all the photos were above the hit rate of 39%), and were sex- and age-matched. The dimensions of the photographs on the screen were based on a simulation of an actual interaction situation between people. Subsequently, participants were asked to fill in the online FSCRS, which indicates the level of self-criticism and self-reassurance. The questionnaire also contained some socio-demographic questions.

Data Analysis

The data were analyzed using the R 3.5.1. program (R Core Team 2018), brms package (Bürkner 2017, 2018). Bayesian statistical models are increasingly used in psychology (Feinberg and Gonzalez 2012; Wagenmakers et al. 2018) to avoid many of the problems inherent in classical (frequentist) statistical procedures, for example, the very large samples required for the central limit theorem to apply, issues with the equality of (error) variances, the absence of outliers, and restrictions concerning error distribution. Bayesian statistical models are available in many statistical programs (e.g., Mplus and R) and the improved performance of computers today substantially reduces their main disadvantage, namely the extensive computational time and effort required.

First, we needed to specify the most appropriate model(s) for our data. Each participant was measured several times for three AOIs: eyes, other facial areas (except eyes), and areas outside the face. The participants were exposed to six different stimuli conveying seven different emotional states, producing 126 (3 x 6 × 7) measurements per respondent. This meant we had to fit a multilevel model to compensate for participants giving the same responses – we could not assume independence of errors for the individual responses and emotions.

The dependent variable was a continuous and bounded variable defined at unit interval (0, n). Eye-tracking measures do not have a normal distribution: they include fixation, duration, and most saccade measures, so they tend to have a skewed (typically right-skewed) distribution (Holmquist et al., 2011). Our data (see Figure 1) clearly exhibited this typical distribution. Holmquist et al. (2011) recommended log-normal or gamma distributions. Since our data contained many zeros, we had to use one of the two common methods for dealing with zero-inflated data, namely (1) modelling a zero-inflation parameter that represents the probability a given zero comes from the main distribution (zero-inflated models), or (2) modelling the zero and non-zero data with one model (the Bernoulli model), and then modelling the non-zero data with another (log-normal or gamma model). This class of models are called hurdle models. It is clear that zero-inflated models are not applicable: the zeros cannot come from the main distribution (log-normal or gamma) because they do not allow zero values. So we fitted the log-normal hurdle and gamma hurdle models.

Hurdle models consist of two submodels: the first estimates the probability of an identification other than zero (parameter α); the second estimates the probability of a longer fixation when the identification is greater than zero (parameter β). The logit-link function was employed to define the hurdle submodels. This link was

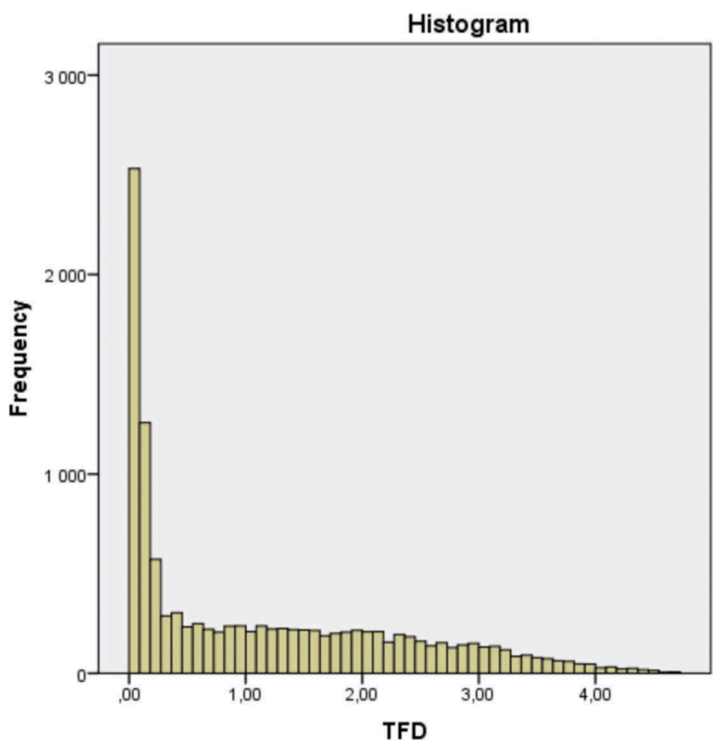

Figure 1. Distribution of data.

chosen to specify the relationship between the linear predictor and the response variable as the results are easily interpreted in terms of odds ratios, as in a logistic regression model. In the log-normal hurdle model, an identity link is employed to specify the relationship between the linear predictor and the response variable, and in the gamma hurdle model, a log link is employed to specify the relationship between the linear predictor and the response variable. To compensate for the fact that each participant was measured several times (and provided several observations), the participant's ID was included as the group-effect (or random-effect in the frequentist terminology).

For predicting the outcome, the same set of explanatory variables was used for the two submodels. These were IS, RS and HS scores, the difference between eyes fixation (baseline), face fixation and outside-face fixation, and the interactions between them. The first set of variables was the three raw IS, RS, HS scores (continuous predictors), the second set of variables was the contrast between the baseline (eyes fixation), face fixation, and outside-face fixation (a dummy variable indicating the difference between the eyes baseline and two other areas, a 3-level factor) and the third set of variables was the interactions (six interactions, a 9-level factor: scores at eyes baseline served as the reference level).

Our original intention was to fit the two Bayesian models, with this set of predictors and two group effects: ID to compensate for measurements from the same participants, and Emotions to compensate for measurements of the same emotional states. However, the differences among the emotions were extremely small (accounting for less than 0.0001 of variance) so we fitted two more parsimonious models without including emotions at the group level. We fitted four Bayesian models: (1) Model 1, log-normal hurdle model with predictors and one group effect (ID); (2) Model 2, log-normal hurdle model with predictors and two group effects (ID and Emotions); (3) Model 3, gamma hurdle model with predictors and one group effect (ID); and (4) Model 4, gamma hurdle model with predictors and two group effects (ID and Emotions).

There are several methods for selecting the best fitting Bayesian model. The most frequently used are DIC – deviance information criterion (Spiegelhalter et al. 2002) and WAIC – widely applicable information criterion (Watanabe 2010). However, from the Bayesian point of view, the DIC is not recommended since it is not an unbiased estimate of the true generalization utility (Piironen and Vehtari 2017). We, therefore, used the WAIC to select the best fitting model, the model with the largest ELPD (expected log pointwise predictive density) or the smallest WAIC (WAIC information criterion is ELPD multiplied by −2 to obtain a result on the deviance scale). The model with the smallest WAIC has the highest predictive accuracy of the models we compared. In addition, we used the predictive-distributions method of stacking (Yao et al. 2018) to compare the weights of all the models.

After selecting the most accurate model, we checked its convergence. There are various diagnostic tools to assess the successful convergence of Bayesian models: (1) Gelman–Rubin diagnostics (Gelman and Rubin 1992) – the Rhat value for all the parameters should be close to 1 at convergence, and values substantially above 1 (larger than 1.10) indicate a lack of convergence; (2) Heidelberger–Welch diagnostics (Heidelberger and Welch 1983), which uses the Cramer-Mises statistics to test whether the sampled values come from a stationary distribution. The half-width test was subsequently calculated; (3) Geweke diagnostics (Geweke 1992), which tests the equality of the means of the first part (10%) and the last part (50%) of a Markov chain. If the distribution is stationary, the two means are equal. Geweke statistics is a standard Z-score: values above 1.96 (or below −1.96) indicate a lack of stationarity; (4) Raftery–Lewis diagnostics (Raftery and Lewis 1995), which tests the accuracy of the estimation of quantile q (usually q = 0.025). The minimum length is the required sample size for a chain with no correlation between consecutive samples. Estimate I (the "dependence factor") summarizes the extent to which the autocorrelation inflates the required sample size. Values larger than 5 indicate the autocorrelation is too strong; (5) Visual inspection of the traceplots. See the Appendices for the R codes for all the diagnostics. We reported all the relevant diagnostic results, and the numerical details are given in the Appendices. Each model was fitted with four Markov chains, each with 5,000 iterations, and 2,500 burn-in (discarded) iterations, so the overall number of sample iterations was 10,000. Higher posterior density (credible) intervals (95%) were reported for each parameter. Since the model link is logit, we reported the odds ratio for the population parameters.

Results

So the results correspond with the data analysis we report them in the following order: (a) selection of the model, (b) diagnostics of the selected model, and (c) parameters of the selected model.

(a) Selection of the model. We report all the parameters in all the models in Table 1. In Table 2, we can see Model 3 (gamma hurdle model with ID group effect) had the lowest WAIC information criterion; its predictive accuracy was, therefore, the highest of the models. All the other models (Model 1, Model 2, Model 4) were less accurate. It also had the highest predictive weight. We retained Model 4 and proceeded to diagnose convergence, because although it was the most accurate of the models that by no means entails that the model converged successfully: it could be the case that it was merely the best of very bad models: it could still have had very poor convergence. We had to check all the relevant convergence diagnostic tools before we could begin interpreting its parameters.

Table 1. Parameters of models.

	Population effects	Group effect	Distribution
Model 1	IS+RS+HS+AOI2+ AOI3+ IS:AOI2+ IS:AOI3+ RS:AOI2+ RS:AOI3+ HS:AOI2+ HS:AOI3	ID	log-normal
Model 2	IS+RS+HS+AOI2+ AOI3+ IS:AOI2+ IS:AOI3+ RS:AOI2+ RS:AOI3+ HS:AOI2+ HS:AOI3	ID + Emotions	log-normal
Model 3	IS+RS+HS+AOI2+ AOI3+ IS:AOI2+ IS:AOI3+ RS:AOI2+ RS:AOI3+ HS:AOI2+ HS:AOI3	ID	gamma
Model 4	IS+RS+HS+AOI2+ AOI3+ IS:AOI2+ IS:AOI3+ RS:AOI2+ RS:AOI3+ HS:AOI2+ HS:AOI3	ID + Emotions	gamma

Note. FSCRS = The Forms of Self-Criticism/Reassuring Scale. RS = Reassured self. IS = Inadequate self. HS = Hated self. AOI1 = Area of Eyes. AOI2 = Area of Face except the Eyes. AOI3 = Area Outside the Face.

Table 2. WAIC information criteria and predictive weights for models.

	WAIC (SE)	ELPD_WAIC (SE)	$ELPD\_WAIC_{diff}$	WEIGHT
Model 1	28721.2 (267.4)	−14360.6 (133.7)	N/A	16.8%
Model 2	28725.5 (267.4)	−14362.7 (133.7)	2.3	0%
Model 3	27814.1 (243.0)	−13907.1 (121.5)	−455.6	83.1%
Model 4	27836.6 (243.0)	−13918.3 (121.5)	11.2	0.1%

Note. WAIC = widely applicable information criterion. SE = standard error. ELPD = expected log pointwise predictive density.

(b) Diagnostics of the selected model. The Gelman–Rubin diagnostics showed that all the parameters had Rhat values pf 1.00, indicating excellent convergence. All the parameters passed the Heidelberger–Welch diagnostics in the stationarity tests and only 3 of the 27 parameters failed in the halfwidth mean tests (see Appendices). All 27 parameters passed the Geweke diagnostics, the absolute value was below 1.96 for all of them (see Appendices). The Raftery–Lewis diagnostics showed that no dependence factor reached 5, indicating successful convergence using this model as well (see Appendices). The visual inspection of the traceplots also showed excellent convergence (see traceplots in the Appendices). To conclude, this model converged successfully, and the estimation of parameters was accurate. The effect size – Bayesian R square (the variance of the predicted values divided by the variance of predicted values plus the variance of the errors, see Gelman et al. 2018) – was 0.47, which is quite high.

c) Parameters of the selected model. We then inspected the parameter estimations of the selected model: The parameter estimates, together with the corresponding errors of estimation, 95% credible interval and odds ratios (OR), where applicable, are summarized in Table 3.

Estimating the Probability of Identification (Hurdle Model)

Checking the results from Table 3 related to the hurdle part of the model, we could see that all the participants had looked more frequently at the areas outside the face than they had at the eyes area (the odds ratio is higher than 4

Table 3. Parameter estimates, estimation errors, 95% credible interval and odds ratio.

	Estimate	EE	95% CI		OR
α (hurdle)					
IS	0.02	0.02	−0.03	0.06	1.01
HS	−0.04	0.05	−0.14	0.06	0.96
RS	0.03	0.03	−0.02	0.08	1.03
AOI2	0.40	0.55	−0.70	1.47	1.49
AOI3	**1.39**	**0.38**	**0.67**	**2.14**	**4.06**
IS:AOI2	−0.01	0.02	−0.05	0.03	0.99
IS:AOI3	−0.01	0.01	−0.04	0.01	0.99
HS:AOI2	−0.06	0.05	−0.15	0.03	0.94
HS:AOI3	**0.10**	**0.03**	**0.05**	**0.16**	**1.11**
RS:AOI2	**−0.08**	**0.02**	**−0.12**	**−0.03**	**0.92**
RS:AOI3	**−0.03**	**0.01**	**−0.06**	**−0.01**	**0.97**
Constant	**−2.69**	**0.68**	**−4.03**	**−1.37**	**0.07**
σ (group effect-id)	1.04	0.09	0.88	1.23	-
β (gamma)					
IS	0.02	0.01	−0.01	0.04	-
HS	0.00	0.02	−0.04	0.05	-
RS	0.02	0.01	−0.01	0.04	-
AOI2	**0.86**	**0.11**	**0.65**	**1.06**	-
AOI3	**−1.39**	**0.11**	**−1.61**	**−1.17**	-
IS:AOI2	**−0.01**	**0.00**	**−0.02**	**−0.01**	-
IS:AOI3	0.00	0.00	−0.01	0.01	-
HS:AOI2	0.00	0.01	−0.03	0.01	-
HS:AOI3	**0.03**	**0.01**	**0.01**	**0.05**	-
RS:AOI2	−0.01	0.00	−0.01	0.01	-
RS:AOI3	0.00	0.00	−0.01	0.01	-
Constant	**−0.32**	**0.30**	**−1.05**	**−0.17**	-
shape (gamma)	1.78	0.02	0.85	0.87	-
σ (group effect-id)	0.50	0.04	0.30	0.43	-
Bayes R^2	0.47	0.01	0.46	0.48	-

Note. N = 92. EE = estimation error. CI = credible interval. OR = odds ratio. FSCRS = The Forms of Self-Criticism/Reassuring Scale. RS = Reassured self. IS = Inadequate self. HS = Hated self. AOI1 = Area of Eyes. AOI2 = Area of Face except the Eyes. AOI3 = Area Outside the Face.

which means that the probability of looking outside the face is four times higher than the probability of looking at the eyes). However, this effect was at least partly caused by the participants with higher HS: the probability of them looking outside the face was 11% higher than the probability of them looking at the eyes area. On the other hand, participants with higher RS looked at other face areas and looked outside the face less frequently which means that they looked at the eyes areas more often. All other effects were negligible.

Estimating the Probability of Longer Gazes (Gamma Model)

When we analyzed the gamma part of the model (comparing gazing only, without zeros), the picture was slightly different. All the participants looked more frequently at other face areas than they did at the eyes area, but they also looked less frequently at the areas outside the face than they did at the eyes area. Participants with higher IS looked at other face areas less frequently than they did at the eyes area. On the other hand, participants with higher HS looked outside the face more frequently than they did at the eyes area. All other effects were negligible.

Discussion

The purpose of this study was to explore the scanning patterns exhibited by self-critical and self-reassured participants when observing facial expressions of primary emotion. The results indicate that participants with higher IS looked at other face areas less frequently than they did at the eyes area, which means that the eye region is more frequently scanned by participants with a higher level of inadequate self. On the other hand, participants with higher HS looked outside the face more frequently than at the eyes area. The eyes area was avoided more by those with a higher level of hated self. In addition, participants with higher RS looked at other face areas and outside the face less frequently, which means that people who are more self-reassured looked at the eyes area more often.

In line with previous findings, the results support the idea that the level of Hated Self plays a predictive role regarding total fixation duration on the eyes. The findings indicate that self-critical people (with more intense hatred levels) avoided the eye region. Following findings on the pattern of avoiding eye contact in shy (Wang et al. 2012), neurotic (Perlman et al. 2009), anxious (Wang and Yue 2011), social anxious (Horley et al. 2003), and depressive individuals (Sears et al. 2011), we have found that self-critical people exhibit a similar pattern when scanning facial expressions. We think Hated Self is an indicator of a critical, toxic level of self-criticism and self-hate. This is indicated by the FSCRS (Gilbert and Irons 2004) items (e. g. *"I do not like being me"; "I have become so angry with myself that I want to hurt or injure myself"*) and it may be the reason for the significant relation with gazing. Hated Self is focused on self-critical anger and self-disgust. It captures a destructive, disgust-based response characterized by self-dislike, punishment and the desire to self-hurt and these feelings increase the probability that the person will look at the outside of an emotional face rather than at the eye area. Gilbert et al. (2004) underlined the tendency of self-critical people to adapt their activities as much as they can and to avoid blame and shame. Therefore, people with higher HS may avoid the eye area because it is the most confrontational and pain-indicating region of the face. Öhman (1986) also stated that the eyes are the most fear-inducing feature in situations where the individual is being socially appraised by others. In line with this, self-critical participants (with higher HS) tend to inspect areas of the face more than the eyes because there is a risk they will experience judgment and feeling guilty, ashamed, or unaccepted. Our results were also consistent with the explanation of eye gaze provided by Wyland and Forgas (2010). They implied that looking into other people's eyes is a sign of trustworthiness. We deduced that self-critical individuals with the feelings of self-disgust had difficulty expressing unconditional trust to others; they may be suspicious of them and fear the other person's emotions will be insincere or too hurtful to process. Their caregiving system is not sufficiently developed for them to be affiliative and soothing even via fixating on the confrontational eye region.

Interestingly, Inadequate Self, one of the subscales of self-criticism, exhibited a different pattern from Hated Self. Following more research, it is possible this could be used to distinguish between varyingly pathological forms of self-criticism. Participants with higher IS looked at other face areas less frequently than they did at the eyes area. They did not avoid the eye area as much as the participants with stronger HS, but they did not look outside face area as much as people with higher RS. Once again, the results indicate that it is important to distinguish between the self-critical components. High levels of inadequate feelings are characterized by the belief that the person deserves self-criticism. This is because they remember and compare their setbacks and are disappointed by them, constantly comparing themselves with the high standards of others (Gilbert et al. 2004). Based on Gilbert's model of self-criticism (Gilbert et al. 2004), Inadequate Self is associated with a sense of inferiority. It is related to the processes of social comparison and the desire to fit into a particular group. Therefore, people with higher IS may fixate more on the eyes area in order to explore the facial expression in a desire to be more in line with social norms and to fit in with social standards and context. The eyes and the mouth are the two fundamental areas of the face that healthy people pay attention to when recognizing facial expressions (e.g. Henderson, Williams, and Falk 2005; Wegrzyn et al. 2017). Findings have also indicated that the eye region is crucial to individuals with a higher Inadequate Self score. In the case of the majority of the primary emotions, the eyes are an important source of information (e.g. Eisenbarth and Alpers 2011; Schurgin et al. 2014; Smith et al. 2005). As individuals with higher IS are more suspicious, inferior and apprehensive, they tended to scan the eye region more carefully than other areas of interest on human faces.

Last, but not least, participants with higher RS looked at other areas of the fact and outside the face less frequently than they looked at the eyes. Self-reassured people look at the eyes areas more often than other areas of the face and the area outside the face. Thus, self-reassured people had the tendency to fixate their gaze on emotional faces more, which is an indicator of positive self-attitude. It involves warm acceptance, compassion and the understanding that failures are part of the human experience. In contrast to those with a self-critical tendency, they focus on positive experience, memories rather than flaws and mistakes and on tolerating vulnerability and self-care (Gilbert et al. 2004). In relation to personality traits, Wu et al. (2014) reported that extraversion and agreeableness were related to a greater fixation on the eyes. Cowan (2015) has similarly demonstrated an association between empathetic concern and dwell-time percentage on the eye-region. Empathy as resonance with another's suffering was one of the fundamental components of (self) compassion (Strauss et al. 2016) and self-reassurance, and these results supported the idea that self-reassured people maintain more intensive eye contact than self-critical people do. The results are also in line with those of Wyland and Forgas (2010), who found support for the idea that people gaze more into the eyes of those who are more trustworthy which evokes a higher level of self-reassurance as well. Another example of an eye-contact predictor comes from studies showing that people gazed more at the eyes after receiving positive evaluations or feedback (e.g. Jones and Cooper 1971; Silk et al. 2012). Eye-tracking analyses by Silk et al. (2012) revealed attentional biases towards accepting feedback and away from rejecting feedback, suggesting that adolescents are sensitive to rejection feedback and seek to anticipate and avoid attending to rejection stimuli. According to Kupeli et al. (2013) self-reassurance is related to compassionate and supportive feelings towards oneself and that this capacity for perceiving warm nonverbal cues from other faces and one from oneself may cause increased eye gaze in general.

Limitations

Although the advances and availability of computer technology make laboratory situations feel more like ordinary ones, we should be careful about making conclusions about facial expressions in social interactions based on laboratory research. If we expect a reaction to emotion expressions on PC, participants might not be motivated enough compared to face-to-face emotion expression. In addition, the convenient sample of participants consisted mostly of young participants recruited from the general nonclinical population. Their levels of self-criticism toward themselves do not show extreme levels; thus, the generalizations should consider this fact. Our results could be compared with the eye-tracking of older participants in further research. Further, the manual method of defining AOIs is very subjective, so this can be considered a limitation. We had to define the Areas of Interests on the facial photographs manually due to the technical parameters of the eye-tracking equipment.

Further Research

This study is a contribution to the knowledge on the relation between self-criticism and self-reassurance gaze patterns and scanning emotional faces, which is an area that had not been previously studied. Eye-tracking studies are increasingly being used in efforts to understand how people behave. However, these studies tend to be costly and time-consuming. Some of the main reasons are the difficulty finding participants, the costs of the equipment and analysis process. Consequently, eye-tracking studies are typically conducted using a small number of participants (e.g., Eraslan, Yesilada, and

Harper 2018; Kredel et al. 2017). We tried to overcome this issue by using a large sample, of 92 participants.

We explored the relation between self-criticism and self-reassurance and participants' eye fixation movements, especially on the eye region of the stimuli. Peterson and Eckstein (2012) and Wells, Gillespie, and Rotshtein (2016) have emphasized the role the eyes play in emotional expression recognition. Thus, our first step in analyzing eye movements was to thoroughly investigate the eye region. The lips are another significant facial feature; healthy people pay a lot of attention to the lips when identifying facial expressions (e.g., Henderson, Williams, and Falk 2005; Wegrzyn et al. 2017), so this area could perhaps be considered in further research.

Previous findings had indicated that when exploring and interpreting self-criticism in its entirety, each component should be investigated carefully and independently. This is because patterns of avoiding and directing eye gaze appear to be unique for each of the subscales. Thus, we could not simply conclude that people who are more self-critical and less self-reassured avoided looking directly into the eyes when identifying facial expressions in others. As our results have demonstrated, the predictive role of the FSCRS scale should be accounted separately for each subscale.

We selected a dataset of facial expressions that had on average an 88% rate of correctly interpreted emotions, which is a high level of high accuracy (Samuelsson et al. 2012). However, Schurgin et al. (2014) found that when facial expressions are more neutral, participants fixated on the eyes more frequently. Since the intensity of the emotions displayed by the stimuli seems to be a significant factor in fixation patterns, we recommend that future investigations explore the issue using pictures of various intensities and compare the results obtained from different conditions.

In our analysis of the identification of emotions by self-critical and self-reassuring people, and differences in the identification of emotions, we did not look at variables such as gender or age. In the future research, we would like to compare the gaze preference for certain areas of the face in self-critical/self-reassured participants and focus on participants' rates of successful recognition. So far, we can compare the results of eye-tracking research on constructs similar to self-criticism, for example, shyness (Wang et al. 2012), depression (Sears et al. 2011), neuroticism (Perlman et al. 2009), anxiety (Wang and Yue 2011), or social anxiety (Daly 1978; Farabee et al. 1993). In relation to self-reassurance, our findings are in line with constructs such as extraversion (Wu et al. 2014), empathy (Cowan 2015), or trustworthiness (Wyland and Forgas 2010).

Further research is needed to continue identifying more objective indicators for these constructs because self-reporting questionnaires are prone to social desirability bias and therefore not ideal. The implications of this study may be used for diagnostic purposes. Mele and Federici (2012) consider eye-tracking to be an appropriate tool for detecting eye movements and analyzing human processing of visual information for diagnostic applications. The findings are also applicable to testing the effectiveness of interventions designed to reduce self-critical thoughts, feelings, and behavior.

Conclusion

To sum up, our research findings showed the following pattern: Participants with higher RS looked at other facial areas and outside the emotional faces less frequently than they looked at the eye region, which was the area they scanned the most. On the other hand, people with higher HS had a higher probability of looking outside the face than of looking at the eyes area. However, having a higher IS level predicted the participant would look less at other facial areas (e.g., the nose, mouth) than looking directly at the eyes. In line with these findings, we are not able to conclude that self-reassurance predicts the individual will look at the eyes more frequently nor that self-criticism predicts the individual will look at the eyes less frequently. Instead, our findings highlight the importance of distinguishing between the two components of self-criticism: Inadequate Self as the more salubrious form of self-criticism; and Hated Self as the more pathological form. The analysis of the FSCRS components revealed unique and distinctive scanning patterns in relation to facial-emotion expressions which have not been previously studied. The implications of this study could be useful either for diagnostic purposes or for testing the effectiveness of interventions for inhibiting self-critical and cultivating self-compassionate/self-reassuring responding.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

The authors declare that they have no potential conflicts of interests.

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Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Availability of data and materials

In order to comply with the ethics approvals of the study protocols, data cannot be made accessible through a public repository. However, data are available upon request for researchers who consent to adhering to the ethical regulations for confidential data.

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Appendices

Appendix A. R codes for the model, parameters, and diagnostics

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library(brms)
library(coda)
bf0 = bf(TFD ~ IS+HS+RS+AOI+AOI:IS+AOI:HS+AOI:RS+ (1|ID), hu ~ IS+HS+RS+AOI
+AOI:IS+AOI:HS+AOI:RS+(1|ID))
bf1 = bf(TFD ~ IS+HS+RS+AOI+AOI:IS+AOI:HS+AOI:RS+ (1|ID) + (1|Emo), hu ~ IS+HS
+RS+AOI+AOI:IS+AOI:HS+AOI:RS+(1|ID) + (1|Emo))
fit1 = brm(bf0, data = data, chains = 4, iter = 5000, family = hurdle_lognormal())
fit2 = brm(bf1, data = data, chains = 4, iter = 5000, family = hurdle_lognormal())
fit3 = brm(bf0, data = data, chains = 4, iter = 5000, family = hurdle_gamma())
fit4 = brm(bf1, data = data, chains = 4, iter = 5000, family = hurdle_gamma())
waic1 = waic(fit1)
waic2 = waic(fit2)
waic3 = waic(fit3)
waic4 = waic(fit4)
compare_ic(waic1,waic2,waic3,waic4)
loo_model_weights(fit1, fit2,fit3,fit4)
bayes_R2(fit3)
summary(fit3)
samples = as.mcmc(fit3,combine_chains = TRUE)
heidel.diag(samples)
geweke.diag(samples)
raftery.diag(samples)
```

Appendix B. Heidelberger-Welch diagnostics

	Stationarity test	start iteration	p-value		Halfwidth test	Mean	Halfwidth
b_Intercept	passed	1	0.230778	b_Intercept	passed	-3.23e-01	1.39e-02
b_hu_Intercept	passed	1	0.499895	b_hu_Intercept	passed	-2.69e+00	2.45e-02
b_IS	passed	1	0.655885	b_IS	passed	1.67e-02	5.20e-04
b_HS	passed	1	0.150372	b_HS	failed	6.37e-04	1.15e-03
b_RS	passed	1	0.856031	b_RS	passed	1.61e-02	5.32e-04
b_AOI2	passed	1	0.669812	b_AOI2	passed	8.57e-01	2.41e-03
b_AOI3	passed	1	0.496598	b_AOI3	passed	-1.39e+00	2.62e-03
b_IS:AOI2	passed	1	0.412435	b_IS:AOI2	passed	-1.23e-02	7.12e-05
b_IS:AOI3	passed	1	0.855490	b_IS:AOI3	passed	4.92e-03	8.05e-05
b_HS:AOI2	passed	1	0.323717	b_HS:AOI2	failed	8.21e-05	1.61e-04
b_HS:AOI3	passed	1	0.342079	b_HS:AOI3	passed	-3.21e-02	1.87e-04
b_RS:AOI2	passed	1	0.362855	b_RS:AOI2	passed	-5.95e-03	8.83e-05
b_RS:AOI3	passed	1	0.660822	b_RS:AOI3	failed	-7.92e-04	9.61e-05
b_hu_IS	passed	1	0.473956	b_hu_IS	passed	1.57e-02	8.93e-04
b_hu_HS	passed	1	0.350806	b_hu_HS	passed	-3.97e-02	1.99e-03
b_hu_RS	passed	1	0.299326	b_hu_RS	passed	3.39e-02	9.45e-04
b_hu_AOI2	passed	1	0.151625	b_hu_AOI2	passed	3.96e-01	1.29e-02
b_hu_AOI3	passed	1	0.889334	b_hu_AOI3	passed	1.39e+00	8.93e-03
b_hu_IS:AOI2	passed	1	0.364029	b_hu_IS:AOI2	passed	-1.06e-02	4.18e-04
b_hu_IS:AOI3	passed	1	0.733866	b_hu_IS:AOI3	passed	-1.34e-02	2.41e-04
b_hu_HS:AOI2	passed	1	0.513034	b_hu_HS:AOI2	passed	-5.74e-02	1.00e-03
b_hu_HS:AOI3	passed	1	0.492858	b_hu_HS:AOI3	passed	1.05e-01	6.10e-04
b_hu_RS:AOI2	passed	1	0.350759	b_hu_RS:AOI2	passed	-7.58e-02	4.93e-04
b_hu_RS:AOI3	passed	1	0.924606	b_hu_RS:AOI3	passed	-3.15e-02	3.22e-04
sd_subject__Intercept	passed	1	0.880347	sd_subject__Intercept	passed	5.04e-01	1.96e-03
sd_subject__hu_Intercept	passed	1	0.504170	sd_subject__hu_Intercept	passed	1.04e+00	3.70e-03
shape	passed	1	0.209145	shape	passed	1.78e+00	3.89e-04

Note. FSCRS = The Forms of Self-Criticism/Reassuring Scale. RS = Reassured self. IS = Inadequate self. HS = Hated self. AOI1 = Area of Eyes. AOI2 = Area of Face except the Eyes. AOI3 = Area Outside the Face.

Appendix C. Geweke diagnostics

Fraction in 1st window = 0.1
Fraction in 2nd window = 0.5

b_Intercept	b_hu_Intercept	b_IS
0.45901	-1.51968	-0.37856
b_HS	b_RS	b_AOI2
-0.11917	0.26310	0.36109
b_AOI3	b_IS:AOI2	b_IS:AOI3
0.16252	0.56820	-0.19053
b_HS:AOI2	b_HS:AOI3	b_RS:AOI2
-0.81218	-0.23241	-0.61613
b_RS:AOI3	b_hu_IS	b_hu_HS
0.15681	0.31412	1.18363
b_hu_RS	b_hu_AOI2	b_hu_AOI3
0.66788	1.17415	-0.11823
b_hu_IS:AOI2	b_hu_IS:AOI3	b_hu_HS:AOI2
-0.04615	-0.51140	-0.87756
b_hu_HS:AOI3	b_hu_RS:AOI2	b_hu_RS:AOI3
-0.33233	-1.03359	0.32186
sd_subject__Intercept	sd_subject__hu_Intercept	shape
0.48242	-0.35131	-0.03909

Note. FSCRS = The Forms of Self-Criticism/Reassuring Scale. RS = Reassured self. IS = Inadequate self. HS = Hated self. AOI1 = Area of Eyes. AOI2 = Area of Face except the Eyes. AOI3 = Area Outside the Face.

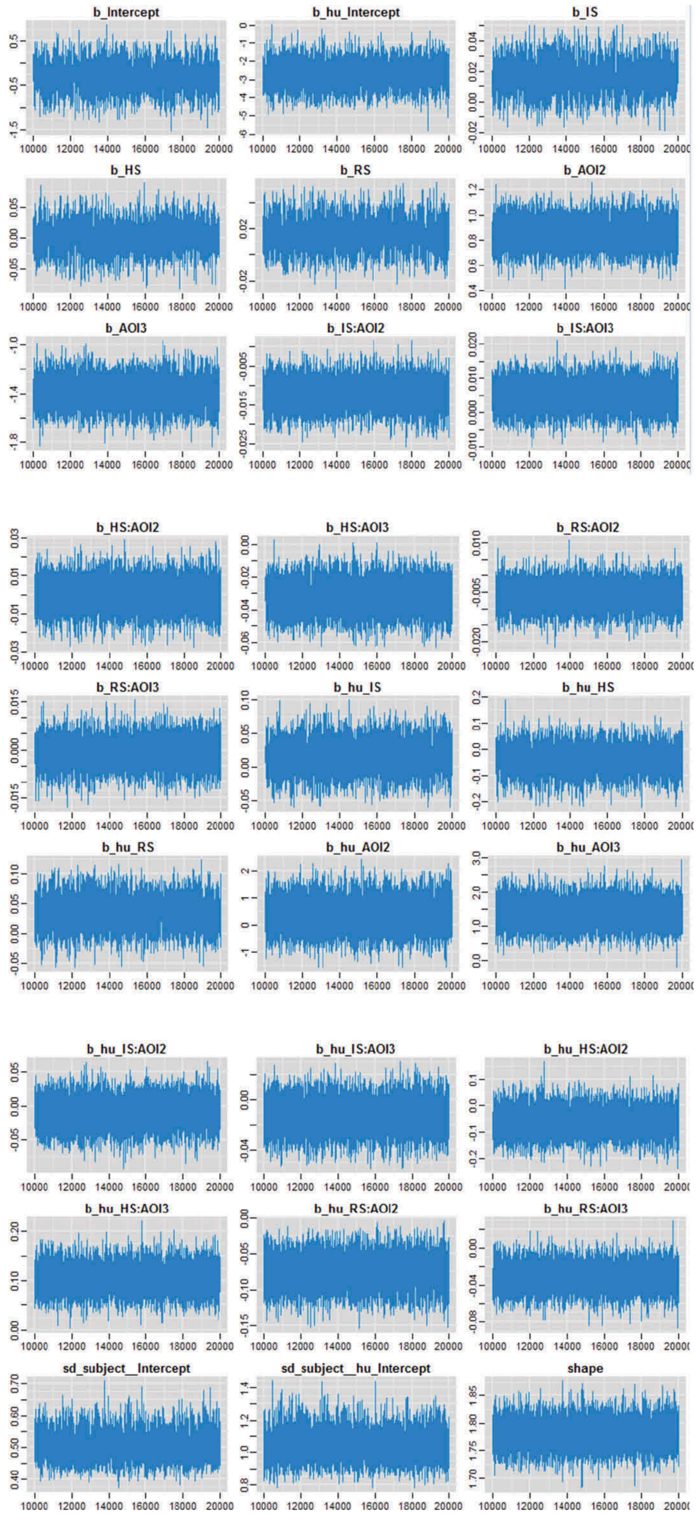
Appendix D. Raftery-Lewis diagnostics

```
Quantile (q) = 0.025
Accuracy (r) = +/- 0.005
Probability (s) = 0.95
```

	Burn-in (M)	Total (N)	Lower bound (Nmin)	Dependence factor (I)
b_Intercept	10	10946	3746	2.92
b_hu_Intercept	5	6025	3746	1.61
b_IS	10	11470	3746	3.06
b_HS	12	13808	3746	3.69
b_RS	7	8197	3746	2.19
b_AOI2	3	4558	3746	1.22
b_AOI3	4	5231	3746	1.40
b_IS:AOI2	3	4197	3746	1.12
b_IS:AOI3	3	4129	3746	1.10
b_HS:AOI2	3	4558	3746	1.22
b_HS:AOI3	3	4232	3746	1.13
b_RS:AOI2	3	4338	3746	1.16
b_RS:AOI3	4	4832	3746	1.29
b_hu_IS	6	6462	3746	1.73
b_hu_HS	8	8872	3746	2.37
b_hu_RS	6	7195	3746	1.92
b_hu_AOI2	4	4954	3746	1.32
b_hu_AOI3	4	4792	3746	1.28
b_hu_IS:AOI2	4	4713	3746	1.26
b_hu_IS:AOI3	3	4558	3746	1.22
b_hu_HS:AOI2	3	4232	3746	1.13
b_hu_HS:AOI3	3	4483	3746	1.20
b_hu_RS:AOI2	3	4483	3746	1.20
b_hu_RS:AOI3	4	4635	3746	1.24
sd_subject__Intercept	8	10064	3746	2.69
sd_subject__hu_Intercept	8	10076	3746	2.69
shape	9	14580	3746	3.89

Note. FSCRS = The Forms of Self-Criticism/Reassuring Scale. RS = Reassured self. IS = Inadequate self. HS = Hated self. AOI1 = Area of Eyes. AOI2 = Area of Face except the Eyes. AOI3 = Area Outside the Face.

Appendix E. Traceplots of estimated parameters



Note. FSCRS = The Forms of Self-Criticism/Reassuring Scale. RS = Reassured self. IS = Inadequate self. HS = Hated self. AOI1 = Area of Eyes. AOI2 = Area of Face except the Eyes. AOI3 = Area Outside the Face.