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The Influence of False Cardiac Feedback on Autonomic Markers of Arousal

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Interoception plays a key role in experiencing emotions, as it provides information about bodily arousal. Cardiac feedback manipulation proved to be a useful tool for exploring interoceptive processes. However, previous research showed inconclusive results on the influence of synchronous and false cardiac feedback on autonomic arousal. In the present study, we measured the influence of accelerated false cardiac feedback on participants' heart rate, respiratory rate and heart rate variability. Furthermore, we were interested in the modulatory effect of interoceptive accuracy measured by the Schandry task. Participants' ECG and respiratory rate were recorded during experimental task involving presentation of synchronous and false auditory cardiac feedback. Contrary to our assumption, false cardiac feedback elicited deceleration of heart rate and reduction of heart rate variability. Interoceptive accuracy had no effect on either variable. According to participant's reports, cardiac and the respiratory deceleration may come from down-regulatory responses to the distorted feedback.

Key words: false cardiac feedback, interoception, heart rate, respiratory rate, autonomic arousal

Introduction

Our organism continuously monitors its internal state to ensure optimal energy expenditure in order to retain homeostatic balance. The ability to perceive the internal state and processes of one's body, such as heart rate (HR), temperature, oxygen level, etc., is labelled interoception (Barrett & Simmons, 2015; Seth,

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2013; Murphy, Brewer, Catmur, & Bird, 2017). Subjects with good interoceptive ability are better in perceiving their physiological condition and are more aware of their physiological changes (Garfinkel, Seth, Barrett, Suzuki, & Critchley, 2015). Interoception has been modeled as having three dimensions (Garfinkel et al., 2015, p. 66). One of the dimensions is interoceptive accuracy, which represents the objective accuracy in detecting bodily signals and it can be measured with objective methods, such as the Schandry task (Schandry, 1981).

Interoception plays an important role in experiencing emotions, since it provides information about bodily arousal (Wiens, 2005). For example, Wiens, Mezzacappa, and Katkin (2000) found that "good detectors" of their own heartbeat reported higher intensity of emotions than "poor detectors", while there was no difference in experience of emotional valence between both groups. The importance of interoception for adequate functioning is further illustrated by differences in interoceptive ability between patient groups. Patients with anorexia nervosa (Pollatos, Kurz et al., 2008), anxiety, social anxiety and panic disorder exhibit differences in interoceptive capacities (Stevens et al., 2011; Domschke, Stevens, Pfleiderer, & Gerlach, 2010). It has also been put forward that disturbances in adequate interoception are linked to depersonalization and dissociative disorders (Seth, Suzuki, & Critchley, 2012). Some studies suggest that some patients are better in the capacity to detect interoceptive signals (Stevens et al., 2011; Van der Does, Antony, Ehlers, & Barsky, 2000), while others place the difference on the metacognitive level of beliefs about such signals (Yoris et al., 2015).

The interoceptive representation of internal states can be experimentally manipulated to study how the representation of the physical state affects participants' performance in experimental tasks, their subjective arousal and physiological reaction (Kleint, Wittchen, & Lueken, 2015; Wild, Clark, Ehlers, & McManus, 2008). Interestingly, the effect of such manipulation on physiological reactions varies according to interoceptive capacities or psychiatric conditions. One way to manipulate the representation of the physiological state is through distorted external feedback, usually called *false cardiac feedback* (FCF). During false cardiac feedback, a person is exposed to a visual or an auditory cardiac feedback that is artificially accelerated, decelerated or shifted (also called asynchronous) (Gray, Harrison, Wiens, & Critchley, 2007). The person exposed to this feedback is not informed about the experimental manipulation.

Previous studies provided conflicting evidence on the influence of FCF on experienced arousal, measured by skin conductance and HR. Makkar and Grisham (2013) reported no significant effect of accelerated and decelerated FCF on the actual HR in groups of healthy low and high socially anxious participants. However, their results demonstrated that accelerated false feedback negatively affects mood, performance appraisals, and self-related cognition. Similarly, healthy participants in Kleint et al. (2015) reported a higher subjective arousal after the accelerated FCF conditions, although objective skin conductance did not differ. Conversely, Story and Craske (2008) reported that HR increased in response to increasing FCF in two extreme groups of healthy participants with and without elevated anxiety sensitivity. There was no significant difference in skin conductance. In sum, these results suggest that while the subject's reaction to FCF may not be recorded by physiological measures, they may nevertheless experience reportable subjective effects.

The extent of arousal during FCF could also be affected by other psychological factors, e.g. interoceptive accuracy. Higher interoceptive accuracy seems to correlate with one's ability to regulate arousal related to the emotional stimuli. Füstös, Gramann, Herbert, and Pollatos

(2012) showed that the more aware a person was of bodily processes (higher interoceptive accuracy), the more successful they were in down-regulating the emotional response to negative affect evoked by emotionally stimulating pictures. Kever, Pollatos, Vermeulen, and Grynberg (2015) found a similar link between interoceptive accuracy and emotion regulation – better detection of bodily signals facilitated the selection and implementation of emotion regulation strategies. Bogaerts, Notebaert, Van Diest, Devriese, De Peuter, and Van den Bergh (2005) found that participants with high negative affectivity have a reduced accuracy in the perception of respiratory symptoms. These results support the conclusion that in healthy subjects, the higher interoceptive awareness positively correlates with participants' ability to down-regulate their emotional response to negative affect. Further investigation of interoceptive accuracy can clarify how it affects regulation of physiological reaction during emotional response and could reveal how lower interoceptive ability in different groups of psychiatric patients impacts their emotional regulation.

The Present Study

The purpose of this study is to expand on the results of Kleint et al. (2015) and to test whether the reported and experienced change in arousal in response to false cardiac feedback is traceable in other physiological measures, such as the HR or respiration.

We recorded *heart rate* (HR) and *respiratory rate* (ResR) during two conditions: accelerated false cardiac feedback (FCF) and synchronous cardiac feedback (SCF). Since a decrease in *heart rate variability* (HRV) can be used as a measure of acute stress (e.g., Rieber et al., 2009; Dimitriev, Dimitriev, Karpenko, & Saperova, 2008), we also analyzed HRV as an indicator of experienced stress throughout the experiment. We used Schandry Mental Tracking Task to assess whether interoceptive accuracy influences the change in ResR, HR and HRV during FCF. As previously mentioned, studies suggest that higher interoceptive accuracy correlates with the ability to down-regulate emotional responses to negative affect (Füstös et al., 2012; Kever et al., 2015). The question is to what extent this down-regulation will be observable in HR, ResR and HRV and if it is possible that participants with higher interoceptive accuracy can, due to suggested down-regulation of negative affect, experience milder physiological response to false cardiac feedback.

Hypotheses

Three main hypotheses were investigated. It was hypothesized that 1) the heart rate (HR) and respiratory rate (ResR) will be higher in FCF blocks compared to SCF blocks; 2) participants' heart rate variability (HRV) will be smaller in FCF blocks than in SCF blocks; 3) participants with higher interoceptive accuracy scores will react to FCF with smaller changes in HR, ResR and HRV than participants with lower interoceptive accuracy scores.

Methods

Participants

In total, 36 subjects, mostly university students, were recruited via social network groups. Only healthy, right-handed subjects not suffering from any cardiac disease, neurological or psychiatric disorder were accepted to participate in the experiment. Due to technical issues (high number of artefacts in the HR recording), the data obtained from 9 participants had to be excluded from the analyses. The final sample for analyses included 27 subjects (10 males, mean age = 25.1, *SD* = 5.41). All subjects provided written informed consent prior to the experiment and were informed about the purpose of the study. This experiment was approved by the ethical committee of Masaryk University.

Experimental Design

The experiment had a 2x2 within-subject design with cardiac feedback condition (FCF/SCF) and IB condition (active/passive). During this experiment, participants performed the Intentional Binding (IB) task while the auditory cardiac feedback stimulation in the form of beeps was played through loudspeakers. Participants' electrocardiography (ECG), skin conductance and respiratory rate (ResR) were measured during this task. Schandry Mental Tracking Task (Schandry, 1981) was used for measuring the participants' interoceptive accuracy. A short demographic questionnaire was also included (age, education, etc.). In this study, only the physiological data (ECG, RR) from the IB task will be presented. Due to technical issues during the data acquisition and poor data quality, skin conductance data were excluded from the subsequent analyses.

Procedure

Prior to the experiment, the participants were asked to fill in an online demographic questionnaire. Upon their arrival, they were informed about how the experimental procedure would proceed. They were told that the experiment was aimed at studying the brain's reactions to the auditory feedback of their heart activity. Participants were not informed that the cardiac feedback may be manipulated.

Recording took place in a shielded EEG Lab. Electrodes for ECG and skin conductance and respiratory belt were placed on participants prior to both tasks. Electrocardiogram (ECG) and respiratory curve were recorded with a BrainProducts BrainAmp ExG MR amplifier with an AUX box (BrainProducts, GmbH, Germany) with a sampling frequency of 5 kHz per channel. The ECG signal was recorded via 2 electrodes placed on participants' chest – one on the lower sternum level, the other under the midpoint of the left armpit. For the purpose of the cardiac feedback, the acquired ECG was processed in real time via MATLAB (MathWorks) in blocks of 20ms (100 samples) of the ECG signal. The signal variance computed for each block separately constituted latent signal with the sample rate of 50Hz that contained peaks corresponding to heart beats. A short time before the IB task we manually set a threshold for heart beat detection that was controlled and adjusted when needed during the whole experiment. The respiratory curve was recorded via a pneumatic respiration belt sensor placed around the participants' chest.

First, participants undertook Schandry Mental Tracking Task which lasted approximately 10 minutes. The participants had to count their heartbeats during three different time periods (35, 45, and 25 s) only by concentrating on bodily feelings that can be associated with their heart. They were not allowed to take their pulse or to use any other means that could possibly help them in their estimation.

Second, they undertook the IB task, which lasted approximately 30 minutes and consisted of 4 blocks – 2 active and 2 passive (counterbalanced APAP/PAPA). Each section consisted of 12 trials. The trial was initiated by fixation cross screen. In following 2.6 sec long window, the action was performed either voluntarily by a participant (Active condition) or computer (Passive condition). The passive condition differed from the active by means of the action execution. In the active condition, action had a form of voluntary button press on a keyboard, while in the passive condition, participants remained passive and the computer-triggered action had a form of auditory click-sound. After a short delay (600, 900 or 1200 ms) an effect (sound) was presented followed by the grey reporting screen. In this final part, participants indicated perceived time delay between the action and effect by an interval reproduction method – holding the key for a duration corresponding to the perceived action-effect interval.

The participants listened to auditory cardiac feedback through loudspeakers during the whole experiment (a 100ms – 440 Hz sine wave). The feedback was presented in two different conditions – false cardiac feedback (FCF) and synchronous cardiac feedback (SCF). SCF corresponded to the participants' heartbeat, i.e. the beep was played immediately after cardiac R-wave detection. In the FCF, the beeps representing heart beats were accelerated. Inter-beep intervals were shortened to 70% of the interbeat intervals. These two types of cardiac feedback were played in alternating, twenty-seven-second long blocks, 48 blocks in total.

At the end of the experimental session, participants were debriefed and provided with the explanation of the real purpose of the experiment.

Statistical Analysis

The ECG was pre-processed in Brain Vision Analyzer 2.0 (BVA, Brain Products). We used a semi-automatic detection of R-waves implemented in BVA. By comparing a timing of real-time detected heart beats to a timing of the offline detected R-waves, we were able to check the accuracy of real-time detection and feedback itself. Whenever we found more than a single error of real-time detection during the 27-s block of any type of cardiac feedback, the block was discarded from the ensuing analyses. The error was defined as a timing difference bigger than 100ms. The median of discarded blocks was 2 out of 48 (lower quartile = 0; upper quartile = 8).

For the statistical analysis, a mean value of the HR in beats per minute (bpm) was calculated for each condition. The standard deviation of RR intervals (SDNN) and mean value of root mean square of successive RR interval differences (RMSSD) (Berntson, Lozano, & Chen, 2005) were used as indicators of heart rate variability in each condition. SignalPlant (Nejedly & Virgala, 2016) was used for the analysis of the respiratory curve recordings. Mean values of the ResR in breaths per minute (bpm) were calculated for each condition.

The interoceptive accuracy (IA) score was calculated as the mean score across three heartbeat perception intervals using the following transformation based on Pollatos, Traut-Mattausch et al. (2007, p. 935):

$$\frac{1}{3}\Sigma\left(1-\frac{|\text{recorded heartbeats}-\text{counted heartbeats}|}{\text{recorded heartbeats}}\right)$$

The interoceptive accuracy score (IA score) can vary from 0 to 1. High scores indicate strong interoceptive accuracy, i.e. only a small difference between the counted and the recorded heartbeats. The IA score was centered to the mean.

Due to the experimental design, 2x2 ANCOVA for repeated measures was used for analysis of heart rate, with feedback condition (false – synchronous) and IB condition (passive – active) and the IA score as a covariate. Dependent *t*-tests were used for heart rate post hoc analysis. In total, five tests were performed with subsequent pairs: FCF Passive vs. SCF Passive; FCF Active vs. SCF Active; FCF Passive vs. FCF Active; SCF Passive vs. SCF Active; difference in passive condition vs. difference in active condition. Bonferroni correction was used for *p*-value adjustment.

For the analysis of SDNN, 2x2 ANCOVA for repeated measures was also used. As a post hoc analysis, the dependent *t*-tests were used for SDNN. The same pairs and correction as in the analysis of HR were used. Bonferroni correction was also used for *t*-test *p*-values adjustment.

Due to the non-normal distribution of RMSSD and respiratory rate data, logarithmic transformation was used for normalization. The data were non-normally distributed even after logarithmic transformation. For this reason, Wilcoxon signed-ranks tests were used for the analysis. The same pairs as in post hoc tests were used and Bonferroni correction was also used.

Results

Heart rate in false blocks compared to synchronous blocks differed significantly [$F(1, 25) = 18.19$, $p < 0.001$, $\eta_p^2 = 0.42$]. Also, the interaction between feedback and IB condition was significant [$F(1, 25) = 6.30$, $p = 0.019$, $\eta_p^2 = 0.20$]. The HR in the IB condition differed more during the synchronous feedback blocks (Table 1, Figure 1, Figure 2) than during the false feedback blocks. There were no other significant results between other conditions and no significant interaction of any condition with IA score (Table 2).

The dependent *t*-tests showed that the FCF in the passive condition (FCF Passive vs. SCF Passive) did elicit a significant change in HR [$t(26) = -4.95$, $p < 0.001$, *Cohen's d* = -0.95]. The HR was slower during the FCF blocks (mean = 74.48, *SD* = 10.97) compared to the SCF blocks (mean = 75.35, *SD* = 11. 16) (Table 1, Figure 1, Figure 2). There were no other significant results in paired *t*-tests (Table 2).

Feedback condition had a significant effect on SDNN [$F(1, 25) = 12.36$, $p = 0.002$, $\eta_p^2 = 0.33$]. There were no other significant results between other conditions and no significant interaction of any condition with IA score (Table 2).

Dependent *t*-tests showed that the FCF in the passive condition (FCF Passive vs. SCF Passive) did elicit a significant change in SDNN [$t(26) = -2.80$, $p = 0.05$, *Cohen's d* = -0.54]. The SDNN was lower during the FCF blocks (mean = 52.00, *SD* = 15.98) compared to the SCF blocks (mean = 56.74, *SD* = 15.99) (Table 1, Figure 1, Figure 2). The SDNN during the FCF blocks in

Table 1 *Means and standard deviations of the heart rate (beats per minute), the respiratory rate (breaths per minute), SDNN (ms) and RMSSD (ms) for the Cardiac Feedback and the IB conditions in the IB task*

	Heart rate (bpm)		SDNN (ms)	
	Mean	*SD*	Mean	*SD*
SCF Active	74.90	11.31	54.86	14.72
SCF Passive	75.35	11.16	56.74	15.99
FCF Active	74.51	11.03	49.79	14.52
FCF Passive	74.48	10.97	52.00	15.98
Difference FCF A – SCF A	-0.39	0.89	-5.07	8.41
Difference FCF P – SCF P	-0.86	0.90	-4.74	8.80

	RMSSD (ms)		Respiratory rate (bpm)	
	Mean	*SD*	Mean	*SD*
SCF Active	33.83	13.65	17.27	2.31
SCF Passive	34.33	12.98	17,37	2.08
FCF Active	34.26	13.91	17.49	2.23
FCF Passive	35.93	15.02	17.15	2.42
Difference FCF A – SCF A	0.42	3.62	0.12	-1.04
Difference FCF P – SCF P	1.60	6.45	-0.13	-1.95

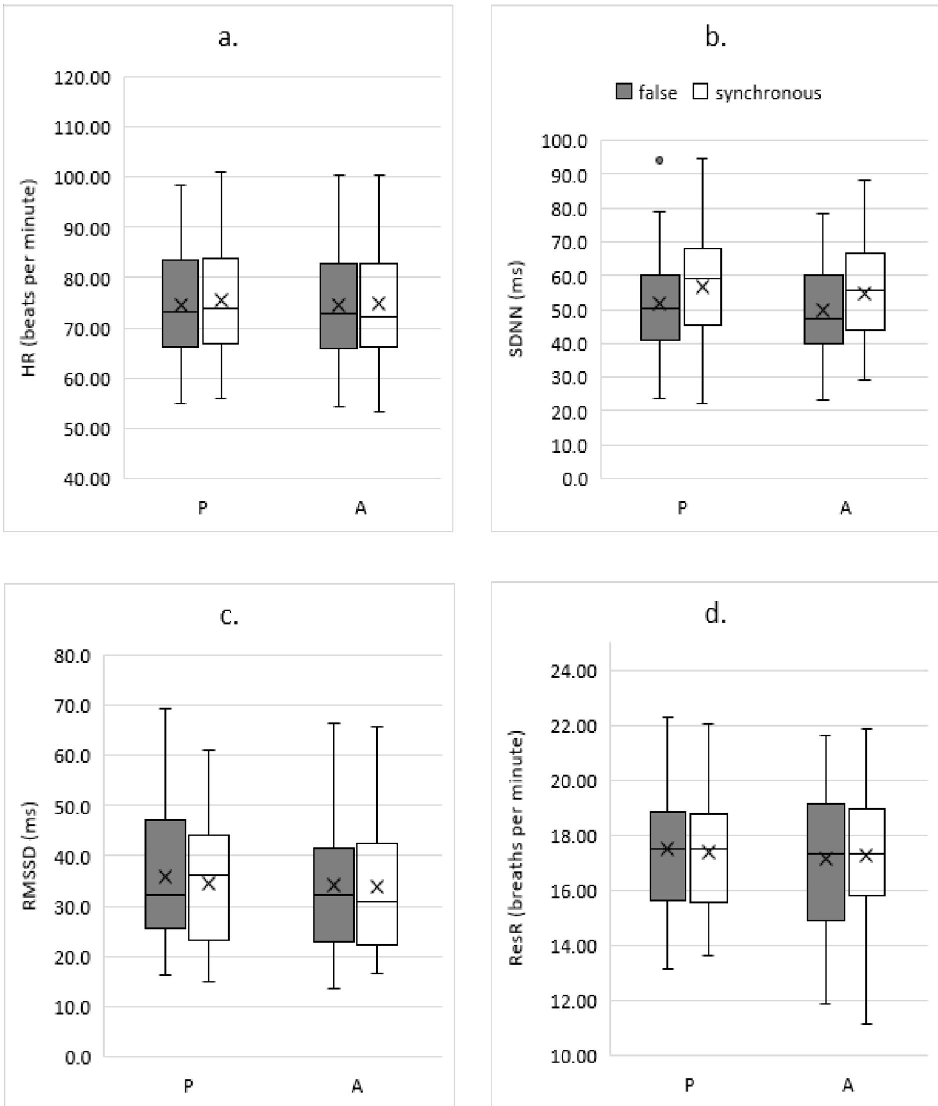

Figure 1 Mean (cross) and median a) heart rate (beats per minute), b) SDNN (ms), c) RMSSD (ms), d) respiratory rate (breaths per minute) for the Feedback and the IB condition in the IB task (box – first and third quartile, whiskers – minimum and maximum value).

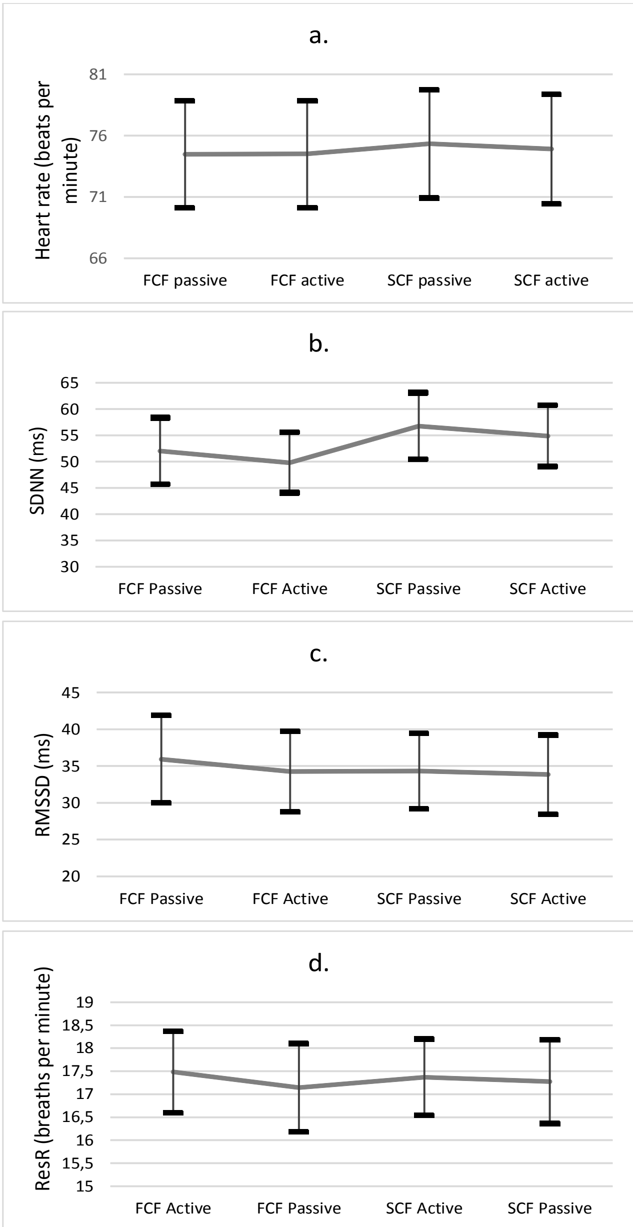

Figure 2 Mean and 95% confidential interval a) heart rate (beats per minute), b) SDNN (ms), c) RMSSD (ms), d) respiratory rate (breaths per minute) for each condition in the IB task.

Table 2 *ANCOVA and Post hoc t-tests results for heart rate (bpm) and SDNN (ms)*

	ANCOVA					Post hoc analysis							
	effects	DF	F	*p*	η_p^2	groups	*t*	*p*	*p* corr.	mean	SE	95% CI - lower	95% CI - upper
Heart rate (bpm)	Feedback	1	18.19	.000	0.42	FCF P-SCF P	-4.95	.000	.000	-0.86	0.17	-1.22	-0.50
	Feedback * IA score	1	0.20	.656	0.01	FCF A-SCF A	-2.29	.03	.12	-0.39	0.17	-0.74	-0.04
	IB	1	0.44	.513	0.02	FCF P-FCF A	-0.09	.93	3.80	-0.03	0.30	-0.65	0.59
	IB * IA score	1	0.14	.715	0.01	SCF P-SCF A	1.299	.21	.92	0.44	0.34	-0.26	1.14
	Feedback * IB	1	6.30	.019	0.20	dif P-dif A	-2.49	.02	.08	-0.47	0.19	-0.86	-0.08
	Feedback * IB * IA score	1	1.47	.237	0.06								
SDNN (ms)	feedback	1	12.36	.002	0.33	FCF P-SCF P	-2.796	.01	.04	-4.74	1.70	-8.22	-1.25
	Feedback * IA score	1	0.10	.75	0.004	FCF A-SCF A	-3.13	.004	.016	-5.07	1.62	-8.40	-1.74
	IB	1	1.63	.21	0.06	FCF P-FCF A	1.47	.16	.64	2.21	1.50	-0.89	5.30
	IB * IA score	1	0.05	.82	0.002	SCF P-SCF A	0.89	.38	1.52	1.87	2.10	-2.44	6.18
	Feedback * IB	1	0.03	.86	0.001	dif P-dif A	0.18	.86	3.44	0.33	1.90	-3.50	4.20
	Feedback * IB * IA score	1	0.13	.72	0.005								

Table 3 *Wilcoxon signed-ranks test results for RMSSD (ms) and respiratory rate (bpm)*

	Groups	Z	*p*	*p* corrected	r
RMSSD	SCF P-FCF P	-1.52	0.13	0.52	- 0.29
	SCF A-FCF A	-0.74	0.46	1.84	0.14
	FCF A-FCF P	-1.24	0.22	0.88	- 0.24
	SCF A-SCF P	-0.66	0.51	2.04	- 0.13
	dif Active-dif Passive	-0.64	0.52	2.08	0.12
Respiratory rate	SCF P-FCF P	-0.63	0.53	2.12	- 0.12
	SCF A-FCF A	-0.60	0.55	2.20	0.12
	FCF P-FCF A	-1.44	0.15	0.60	- 0.23
	SCF P-SCF A	-0.34	0.74	2.96	- 0.06
	dif Active-dif Passive	-1.08	0.28	1.12	-0.21

the active condition (FCF Active vs. SCF Active) (mean = 49.79, *SD* = 14.52) was also significantly lower [$t(26) = -3.13$, $p = 0.02$, *Cohen's d* = -0.60] than in the SCF blocks (mean = 54.86, *SD* = 14.72) (Table 1, Figure 1, Figure 2). There were no other significant results in paired *t*-tests (Table 2).

For the RMSSD, Wilcoxon tests showed no significant difference in HRV between conditions. The exact values are stated in Table 3. Spearman's correlation was run to determine the relationship between IA score and RMSSD in all conditions (FCF Passive, FCF Active, SCF Passive, SCF Active). There was no significant correlation between any condition and IA. Correlation coefficients did not exceed 0.29 and *p*-values were higher than 0.52.

For the respiratory rate analysis, Wilcoxon tests showed no difference in respiratory rate between conditions. The exact values are stated in Table 3. Spearman's correlation was also run to determine the relationship between IA and ResR in all conditions (FCF Passive, FCF Active, SCF Passive, SCF Active). Correlation coefficients did not exceed 0.23 and *p*-values were higher than 0.6 in all conditions.

Discussion

This experiment investigated the changes in the HR, ResR and HRV measured as SDNN and RMSSD induced by FCF. The participants were exposed to alternating blocks of synchronous and accelerated false auditory cardiac feedback during two experimental tasks. The results demonstrated that false cardiac feedback affected the participants' HR, but in the opposite direction than hypothesized. There was a significant interaction between feedback and IB condition – the difference between FCF and SCF was greater in the passive condition than in the active condition. Although the HR was slower in the FCF blocks compared to the SCF blocks, the HRV measured as SDNN showed a conflicting result, being greater in the SCF blocks. This trend was not observed in HRV measured by RMSSD. Since RMSSD is an indicator of the short-term variability and SDNN reflects the overall variation within the RR interval series (Tarvainen et al., 2014), the results from these two analyses are not completely interchangeable. Interoceptive accuracy had no influence on any of the variables.

It was hypothesized that accelerated FCF would provoke an acceleration of HR and ResR and a decrease in HRV. Even though the HRV, measured as the SDNN, decreased in reaction to the FCF, the expected increase in the actual HR and ResR was not observed. In contrast, the FCF triggered a deceleration of the actual HR. After listening to the false heart beats, some participants reported that they tried to calm down when they noticed the change in the feedback. The aforementioned discrepancy between the hypothesis and the observed effect on HR could be due to the participants' successful attempt to down-regulate their HR during the FCF blocks.

There was a significant interaction between feedback and IB condition in HR. The HR was highest during synchronous feedback in the passive condition. This effect could be caused by varying attentional demands between the conditions of the task. The stimuli in the IB task were in auditory form, as well as the cardiac feedback and in the active condition, and also participants needed to pay more attention to the stimuli of the IB task than in the passive condition. Therefore, the effect of the cardiac feedback on the HR could have been mitigated in the active condition due to the separation of auditory attention.

Our results are contradictory to previous studies investigating the effect of FCF on physiological functions, which suggested that FCF had no effect on the participants' HR (Makkar & Grisham, 2013) or on skin conductance (Kleint et al., 2015). In contrast, Story and Craske (2008) reported that healthy participants had a higher HR in the false-feedback blocks compared to the true-feedback blocks. There was no study with a similar effect to ours with FCF triggering a deceleration of HR.

There was no correlation between interoceptive accuracy and HR, ResR and HRV. This is in contrast with Füstös et al. (2012), who found that individuals with a better interoceptive ability were more successful in down-regulating their emotional response to negative affect. The discrepancy in our findings might be due to the difference in auditory stimuli, which might have triggered a smaller negative affect that failed to trigger this down-regulatory reaction.

Our experiment has several limitations. First, no baseline recordings for HR, ResR and HRV were acquired. Due to that, it was impossible to compare HR, ResR and HRV during the resting state with changes during the synchronous and the false feedback. Second, the sinus tone form of the feedback could have been perceived as less authentic by the participants. A study by Kleint et al. (2015) showed that participants reacted more to false feedback in the form of a heartbeat tone than to sinus tone stimulation. It is possible that a heartbeat form of auditory stimulation would have been perceived as more authentic and would have triggered different cardiac and respiratory changes. Third, participants' ability to discriminate between FCF and SCF was not explored systematically. Participants were questioned if they noticed changes in the feedback but more detailed questioning was not included in the debriefing. For that reason, the assumption that the observed decrease of heart rate during FCF is due to participants' effort to calm-down was based on information gathered during debriefing. Finally, our task could have been more challenging for the participants because both the false feedback and the stimuli used in the IB task were in an auditory modality.

Conclusion

The present study broadens findings about the possible effects of FCF on cardiac activity of healthy subjects. FCF elicited a change of HR in the opposite direction than was observed in previously published single study (Story & Craske, 2008), possibly due to the successful downregulation of participants' heartbeat in reaction to accelerated cardiac feedback. Therefore, factors affecting participants' reaction to FCF should be considered in future studies, e.g. the levels of participant's awareness of cardiac feedback falsity or the negative affect associated with various auditory forms of cardiac feedback.

References

Barrett, L. F., & Simmons, W. K. (2015). Interoceptive predictions in the brain. *Nature Rewiews Neuroscience, 16*(7), 419–429. doi: 10.1038/nrn3950

Berntson, G. G., Lozano, D. L., & Chen, Y. J. (2005). Filter properties of root mean square successive difference (RMSSD) for heart rate. *Psychophysiology*, *42*(2), 246–252. doi: 10.1111/j.1469-8986.2005.00277.x

Bogaerts, K., Notebaert, K., Van Diest, I., Devriese, S., De Peuter, S., & Van den Bergh, O. (2005). Accuracy of respiratory symptom perception in different affective contexts. *Journal of Psychosomatic Research*, *58*(6), 537–543. doi: 10.1016/j.jpsychores.2004.12.005

Dimitriev, D. A., Dimitriev, A. D., Karpenko, Y. D., & Saperova, E. V. (2008). Influence of examination stress and psychoemotional characteristics on the blood pressure and heart rate regulation in female students. *Human Physiology*, *34*(5), 617–624. doi: 10.1134/S0362119708050101

Domschke, K., Stevens, S., Pfleiderer, B., & Gerlach, A. L. (2010). Interoceptive sensitivity in anxiety and anxiety disorders: An overview and integration of neurobiological findings. *Clinical Psychology Review*, *30*(1), 1–11. doi: 10.1016/j.cpr.2009.08.008

Füstös, J., Gramann, K., Herbert, B. M., & Pollatos, O. (2012). On the embodiment of emotion regulation: Interoceptive awareness facilitates reappraisal. *Social Cognitive and Affective Neuroscience*, *8*(8), 911–917. doi: 10.1093/scan/nss089

Garfinkel, S. N., Seth, A. K., Barrett, A. B., Suzuki, K., & Critchley, H. D. (2015). Knowing your own heart: Distinguishing interoceptive accuracy from interoceptive awareness. *Biological Psychology*, 104, 65–74. doi: 10.1016/j.biopsycho.2014.11.004

Gray, M. A., Harrison, N. A., Wiens, S., & Critchley, H. D. (2007). Modulation of emotional appraisal by false physiological feedback during fMRI. *PLoS one*, *2*(6), e546. doi: 10.1371/journal.pone.0000546

Kever, A., Pollatos, O., Vermeulen, N., & Grynberg, D. (2015). Interoceptive sensitivity facilitates both antecedent- and response-focused emotion regulation strategies. *Personality and Individual Differences*, *87*, 20–23. doi: 10.1016/j.paid.2015.07.014

Kleint, N. I., Wittchen, H. U., & Lueken, U. (2015). Probing the interoceptive network by listening to heartbeats: An fMRI study. *PloS one*, *10*(7), e0133164. doi: 10.1371/journal.pone.0133164

Makkar, S. R., & Grisham, J. R. (2013). Effects of false feedback on affect, cognition, behavior, and postevent processing: The mediating role of self-focused attention. *Behavior Therapy*, *44*(1), 111–124. doi: 10.1016/j.beth.2012.07.005

Murphy, J., Brewer, R., Catmur, C., & Bird, G. (2017). Interoception and psychopathology: A developmental neuroscience perspective. *Developmental Cognitive Neuroscience*, *23*, 45–56. doi: 10.1016/j.dcn.2016.12.006

Nejedly, P., & Virgala, J. (2016). Physiocrate: A SignalPlant Toolbox for Respiratory, Blood Pressure and EMG Signal Analysis. *Student EEICT*, pp. 53–55. doi: 10.1088/0967-3334/37/7/N38

Pollatos, O., Kurz, A. L., Albrecht, J., Schreder, T., Kleemann, A. M., Schöpf, V., Kopietz, R., Wiesmann, M., & Schandry, R. (2008). Reduced perception of bodily signals in anorexia nervosa. *Eating Behaviors, 9*(4), 381–388. doi: 10.1016/j.eatbeh.2008.02.001

Pollatos, O., Traut-Mattausch, E., Schroeder, H., & Schandry, R. (2007). Interoceptive awareness mediates the relationship between anxiety and the intensity of unpleasant feelings. *Journal of Anxiety Disorders*, *21*(7), 931–943. doi: 10.1016/j.janxdis.2006.12.004

Rieber, N., Betz, L., Enck, P., Muth, E., Nikendei, C., Schrauth, M., Werner, A., Kowalski, A., & Zipfel, S. (2009). Effects of medical training scenarios on heart rate variability and motivation in students and simulated patients. *Medical Education*, *43*(6), 553–556. doi: 10.1111/j.1365-2923.2009.03374.x

Seth, A. K. (2013). Interoceptive inference, emotion, and the embodied self. *Trends in Cognitive Sciences, 17*(11), 565–573. doi: 10.1016/j.tics.2013.09.007

Seth, A. K., Suzuki, K., & Critchley, H. D. (2012). An interoceptive predictive coding model of conscious presence. *Frontiers in Psychology*, *2*(395). doi: 10.3389/fpsyg.2011.00395

Schandry, R. (1981). Heart beat perception and emotional experience. *Psychophysiology*, *18*(4), 483–488. doi: 10.1111/j.1469-8986.1981.tb02486.x

Stevens, S., Gerlach, A. L., Cludius, B., Silkens, A., Craske, M. G., & Hermann, C. (2011). Heartbeat perception in social anxiety before and during speech anticipation. *Behaviour Research and Therapy*, *49*(2), 138–143. doi: 10.1016/j.brat.2010.11.009

Story, T. J., & Craske, M. G. (2008). Responses to false physiological feedback in individuals with panic attacks and elevated anxiety sensitivity. *Behaviour Research and Therapy*, *46*(9), 1001–1008. doi: 10.1016/j.brat.2008.06.001

Tarvainen, M. P., Niskanen, J. P., Lipponen, J. A., Ranta-Aho, P. O., & Karjalainen, P. A. (2014). Kubios HRV – heart rate variability analysis software. *Computer Methods and Programs in Biomedicine*, *113*(1), 210–220. doi: 10.1016/j.cmpb.2013.07.024

Van der Does, A. J. W., Antony, M. M., Ehlers, A., & Barsky, A. J. (2000). Heartbeat perception in panic disorder: A reanalysis. *Behaviour Research and Therapy, 38*(1), 47–62. https://www.researchgate.net/publication/38306318_Heartbeat_perception_in_panic_disorder_A_reanalysis

Wiens, S. (2005). Interoception in emotional experience. *Current Opinion in Neurology, 18*(4), 442–447. doi: 10.1097/01.wco.0000168079.92106.99

Wiens, S., Mezzacappa, E. S., & Katkin, E. S. (2000). Heartbeat detection and the experience of emotions. *Cognition & Emotion, 14*(3), 417–427. doi: 10.1080/026999300378905

Wild, J., Clark, D. M., Ehlers, A., & McManus, F. (2008). Perception of arousal in social anxiety: Effects of false feedback during a social interaction. *Journal of Behavior Therapy and Experimental Psychiatry*, *39*(2), 102–116. doi: 10.1016/j.jbtep.2006.11.003

Yoris, A., Esteves, S., Couto, B., Melloni, M., Kichic, R., Cetkovich, M., Favaloro, R., Moser, J., Manes, F., Ibanez, A., & Sedeño, L. (2015). The roles of interoceptive sensitivity and metacognitive interoception in panic. *Behavioral and Brain Functions*, *11*(1), 1–6. doi: 10.1186/s12993-015-0058-8

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Guilt- and Shame-Proneness and Their Relation to Perceptions of Dating Infidelity

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This paper explores how proneness to guilt and shame is related to perceptions of dating infidelity. Research data was collected from 805 participants from Slovakia. Attitudes toward extradyadic behaviors were measured by the Perceptions of Dating Infidelity Scale. Guilt- and shame-proneness were assessed by the Guilt and Shame Proneness Scale (GASP). Results indicated that guilt- and partially shame-proneness were associated with less permissive perceptions of dating infidelity. A moderating effect of age was found in both subscales of guilt-proneness and perceptions of sexual infidelity. Gender moderated the association between perceptions of deceptive behavior and negative self-evaluations of shame-proneness, such that this association was positive for women and negative for men.

Key words: guilt- and shame-proneness, infidelity, attitudes, perceptions of dating infidelity

Introduction

Infidelity has been traditionally regarded as a topic of interest for both researchers and laypeople, and it has been a hot topic in romantic relationships, given its hurtful nature. According to a large study carried out by Widmer and Tras (1998), proneness towards infidelity as reflected upon sexual attitudes has been found to be strikingly high among Western European countries (Sweden, Norway, Finland, the Netherlands, West Germany, and France). Besides Western European trends, infidelity is reputed to be strikingly high in Thailand and large parts of South America (Schmitt et al., 2004).

Infidelity (colloquially, cheating) most commonly assumes a breach of sexual agreement. According to Berman and Frazier (2005), infidelity is a sexual or romantic involvement with someone other than one's primary partner, which is concealed from the partner, because it would be unacceptable to him/her. Researchers deal with two kinds of infidelity – sexual and emotional. Sexual infidelity is considered as engaging in sexual intercourse with somebody other than one's partner, whereas emotional infidelity is considered as "falling in love" or sharing

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a deep emotional bond with someone other than one's partner (Whitty & Quigley, 2008). There is some overlap between the two, as sexual infidelity may involve emotional involvement and vice versa.

A key-defining characteristic of a monogamous relationship is that, typically, certain behaviors are considered as acceptable only for the two individuals involved in the relationship. (Luo, Cartun, & Snider, 2010). When an individual engages in such exclusive behaviors with someone outside the primary relationship without their partner's consent, such behaviors are termed extradyadic (e.g., Luo, Cartun, & Snider, 2010). These may comprise diverse behaviors including deep kissing/tongue kissing," oral contact with nipples, oral sex with or without orgasm, and masturbation to orgasm in the presence of another person. (Randall & Byers, 2003). Thus, its operationalization and measurement has been miscellaneous across studies (Blow & Hartnett, 2005). Moreover, research has shown that there are inconsistencies in individuals' perceptions of which non-sexual behaviors are indicative of cheating (Wilson, Mattingly, Clark, Weidler, & Bequette, 2011). Cheating is often associated with extradyadic types of behavior that usually serve as a means of attracting another sexual partner. Although extradyadic forms of behavior do not necessarily mean that an individual wants to cheat, they usually reflect a certain propensity for cheating. Infidelity is the final result of extradyadic behaviors which commonly undermines the trust between partners and leads to the termination of the relationship. In our study, we abide by the taxonomy of different behaviors developed by Wilson et al. (2011) – authors of the Perceptions of Dating Infidelity Scale (PDIS) – which clearly defines all three types of extradyadic behaviors: as deceptive, ambiguous, and explicit. Permissive attitudes towards extradyadic behaviors are understood as a general indication for the tendency toward infidelity (Wilson et al., 2011). Moreover, Hackathorn, Mattingly, Clark, and Mattingly (2011) found that PDIS-ambiguous scores predicted the likelihood of engaging in similar behaviors over a one-month follow-up. Presently, there are three recognized factors that predict more permissive attitudes toward infidelity – the history of infidelity, age, and staying in a romantic relationship for a longer period of time (Toplu-Demirtas & Fincham, 2017; Silva, Saraiva, Albuquerque, & Arantes, 2017).

Shame as a psychological construct is a primary self-conscious emotion. In recent decades, it has been investigated mostly in social and personality psychology. More recently and in a cumulative rate, shame has been researched in a domain of clinical psychology and psychopathology. From the phenomenological perspective, feelings of shame are most closely connected with failure, embarrassment, estrangement, vulnerability, worthlessness, hopelessness, and personal inadequacy, and split within self-structure arising during unpleasant social situations (Ramsey, 1988; Wheeler, 1997). Regarding intimate relationships, shame is connected with unsatisfied body image, sexual inadequacy, sexual activity outside of the romantic relationship, abandonment by the intimate partner, and being a victim of intimate violence or violence perpetration (O'Sullivan & Meyer-Bahlburg, 2003; Gruber, Hansen, Soaper, & Kivisto, 2014).

Guilt is often explored in psychological research as a covariate alongside shame. Baumeister, Stillwell, and Heatherton (1994) define guilt as a subjectively unpleasant emotional state, linked with objections towards one's own actions, deeds, circumstances, or intentions. Guilt is understood as an adaptive emotion based on an individual's own negative evaluation of his/her behavior and actions (Gilbert, 2001). Guilt motivates an individual toward reparative actions of previous behavior, considered wrong by them, others, or social norms.

Shame and guilt are related to infidelity through many aspects. For instance, the direct disclosure of an affair from an unfaithful partner is hard to make, due to the anticipation of unwanted feelings associated with shame (Allen, 2018). Furthermore, presenting a cheating partner with the evidence of his/her infidelity makes one feel shame as well (Allen, 2018). In such situations, the feeling of shame relates primarily to one's Self, as one is aware that exposing himself/herself to the partner makes him/her uncomfortable. Besides, when experiencing betrayal shame usually occurs on the part of the betrayed partner. Rejection felt by a betrayed partner will usually result in feelings of inadequacy or unattractiveness and probably give rise to shame.

The pattern of guilt entangled with infidelity is, however, different. Guilt should be a primary consequence of extradyadic behavior, since unfaithful individuals will likely perceive themselves as breaking a prior commitment or social contract (Fisher, Voracek, Rekkas, & Cox, 2008). Oftentimes, feelings of guilt in the unfaithful partner arise as an outcome of seeing how hurt the other partner is. Thus, guilt differs from shame, in the sense that the attention resulting from guilt is directed at the partner and possible reparation of infidelity is sought. The resulting aversive emotional state arising from guilt may cause infidelity to be regarded as an objectionable social transgression, making it unappealing and less likely to be repeated (Fisher et al., 2008). However, the experience of guilt does not appear to depend on the partner's knowledge of the infidelity (Spanier & Margolis, 1983). Mongeau, Hale, and Alles (1994) found that the more intentional the infidelity, the less guilt the cheaters feel; thus, the degree of experiencing guilt over infidelity is inversely related to the intention of infidelity. However, only one study has been conducted about guilt and perceptions of dating infidelity. Wilson et al. (2011) found that participants who perceived the set of extradyadic behaviors as cheating were significantly more likely to indicate feeling greater guilt regarding hypothetical cheating scenarios.

A crucial point of our theoretical model is justifying how guilt- and shame-proneness can predict perceptions of dating infidelity. We contemplate how guilt-proneness may predict less permissive perceptions of dating infidelity through links with several personality variables. First, guilt-proneness was found to be the strongest predictor of trustworthiness (Levine, Bitterly, Cohen, & Schweitzer, 2018); it has been correlated with honesty-humility around .50, indicating that people low in guilt-proneness are generally dishonest (Cohen, Panter, & Turan, 2012b). Second, guilt-proneness is modestly related to conscientiousness and agreeableness, stressing that people low in guilt-proneness tend to be more unreliable than high guilt-prone persons (Cohen, Panter, & Turan, 2012b). Trustworthy people feel greater responsibility for the well-being of others and are more authentic and honest. Cheaters often blame victims for causing their infidelity and since they violate trustworthiness within a relationship, they may be perceived as untrustworthy and dishonest (Weeks, Fife, & Peterson, 2016). Such persons may develop more permissive perceptions of dating infidelity, since their behavior within intimate relationships may encompass overt or hidden signs of less predictability, honesty, and reliability, which may give rise to infidelity. Additionally, individuals low in honesty-humility were found to be susceptible to commit infidelity, since they are willing to act against relationship rules to fulfil their personal desires, acting as a motivator (Carmody & Gordon, 2011; McKibbin, Miner, Shackelford, Ehrke, & Weekes- Shackelford, 2014; Lee et al., 2013). Alternately, highly agreeable and conscientious individuals may imply lesser incentives for infidelity, since they have more perseverance in intimate relationships, regardless of conflicts, and are better at resisting seduction (Barta & Kiene, 2005; Jonason, Teicher, & Schmitt, 2011). Moreover, Shackelford, Besser, and Goetz (2008) reasoned that less agreeable and conscientious individuals are less satisfied in their marriage, resulting in higher likelihood of infidelity.

Based on the attachment perspective, we scrutinize why shame-proneness appears to be a possible predictor of perceptions of dating infidelity. According to Mikulincer and Shaver (2007), a child's intense shame experience in close relationships may impact working models and thus possibly affect later intimate relationships. Research shows that adult shame-prone individuals are more likely to be characterized with higher attachment anxiety, as there exists broader evidence supporting a link between adult attachment anxiety and shame-proneness (Lopez et al., 1997; Gross & Hansen, 2000; Wei, Shaffer, Young, & Zakalik, 2005; Heflin, 2015). Individuals with higher attachment anxiety are more likely to desire constant and long-term relationships (Davis, Shaver, & Vernon, 2004); they tend to experience separation from their partner in a harsher way (Fraley & Shaver, 1998); being more sensitive to relationship threats, they are likely to have less permissive attitudes toward infidelity (Kruger et al., 2013). Some research shows that attachment anxiety is related to (Ong, Poon, Sibya, & Macapagal, 2014) or predicts less permissive attitudes toward infidelity (Kruger et al., 2013; Stewart, 2017). According to Stewart (2017), some behaviors presented in the Perceptions of Dating Infidelity Scale may be perceived as more indicative of infidelity for anxiously attached individuals, because they represent possible instability, abandonment, and rejection on the part of the committed partner. Thus, attachment anxiety, related to the fear of losing one's partner, appears to confer a somewhat greater sensitivity in reaching the perception that a person's fidelity is in question (Kruger et al., 2013). Alternately, heightened sensitivity to threats and rejection is just one characteristic mechanism of shame-prone people (Dickerson, Gruenewald, & Kemeny, 2009); hence, it seems to be the best-fitting parallel between shame-proneness and attachment anxiety. Since shame-prone individuals characterized with higher attachment anxiety are more sensitive to social cues representing a perceived threat for their relationships, they are likely to perceive extradyadic behaviors as cheating and, thus, their perceptions of dating infidelity are more likely to be less permissive. In fact, this appears to be the best reasoning why shame-proneness may predict less permissive perceptions of dating infidelity.

Despite up-to-date, strong evidence that men engage in sexual infidelity more than women (Tafoya & Spitzberg 2007; Labrecque & Whisman, 2017), no gender differences were actually found across studies in perceptions of sexual infidelity as measured by PDIS (Mattingly, Wilson, Clark, Bequette, & Weidler, 2010; Hackathorn et al., 2011; Wilson et al., 2011; Silva et al., 2017). These studies found that women rated ambiguous behaviors as more indicative of cheating than men. More distinct are gender differences in guilt-proneness, as women were found to be more guilt-prone than men (Cohen, Wolf, Panter, & Insko, 2011; Cohen, Panter, & Turan, 2012a; Cohen, Panter, Turan, & Morse, 2012). Concerning shame-proneness, only shame negative self-evaluations were detected to be more prominent in women (Cohen et al., 2011). Based on these studies, we examined gender as a moderator as well.

Similar to gender, age may be expected to be a moderator. The General Social Survey 2000–2016 in the USA showed that with increasing age, the frequency of extramarital sex increases and reaches a peak at 60 (Wolfinger, 2017). Furthermore, Silva et al. (2017) found a modest association between permissiveness of attitudes toward infidelity and age. However, regarding perceptions of dating infidelity, these authors found that only permissive perceptions of sexual infidelity correlated with age. Contrary to this finding, Cuñas & Koval (2018) found permissive perceptions of only emotional infidelity to increase significantly with age.

Concerning guilt-proneness, age differences are well documented across various studies indicating that guilt-proneness increases with age (Orth, Robins, & Soto, 2010; Tangney, Stuewig, Mashek, & Hastings, 2011; Cohen et al., 2011). Less clear are the age differences in shame-proneness. Orth, Robins, and Soto (2010) found shame-proneness decreases with age, even though other studies indicate that the overall shame-proneness is unrelated to age (Tangney et al., 2011; Orth, Robins, & Soto, 2010). Therefore, age is more likely to moderate the association between guilt-proneness and perceptions of sexual infidelity in our study.

Our study has three aims. First, it tests the hypothesis of an existing positive significant relationship between guilt-proneness and less permissive perceptions of both sexual and emotional infidelity. Second, it tests whether there exists a significant relationship between shame-proneness and permissive perceptions of dating infidelity. Third, it tries to detect if age and gender moderate any of these possible significant relationships.

Method

Participants

The data was gathered from a sample of 805 participants from Slovakia: 271 males (34%) and 534 females (66%); their mean age was 28.1 years (*SD* = 8.74, range 18-83). In most cases, participants were sent an appeal through Facebook messenger to fill out the questionnaire. Other responses were collected by placing the questionnaire in well-visited Facebook groups. Additionally, a small number of participants directly asked to respond via email to participate in our study. The data was acquired in May and June 2018.

Measures

The following scales used were freely available without the need for permission from the original authors. Both scales were double translated to preserve the intact meaning of all items. To measure attitudes towards sexual and emotional infidelity, we administered the *Perceptions of Dating Infidelity Scale* (PDIS) (Wilson et al., 2011). This assesses the degree to which specific behaviors are considered infidelity. It consists of 12 Likert-type scaled items (0 = never cheating to 6 = always cheating). It has three subscales (factors) designated as ambiguous (e.g., "Talking by phone or internet with someone other than your partner"), deceptive (e.g., "Lying to your partner"), and explicit (e.g., "Giving and/or receiving oral sex with someone other than your partner"). The individual score is assessed on the basis of the average of each of the subscales separately. Ambiguous behaviors are those in which the individual's motivations seem unclear but may be benign. Deceptive behaviors are those in which the individual's behaviors are mainly internal or hidden and assist in deceiving one's partner. Explicit behaviors are those where the individual clearly breaks the agreement of monogamy by engaging in sexual behaviors with someone other than his/her romantic partner. The explicit subscale is supposed to measure the perceptions of sexual infidelity, whereas the ambiguous and deceptive subscales measure perceptions of emotional infidelity. The PDIS thus reflects individual attitudes toward extradyadic behaviors. On the individual level, this set of behaviors may be considered from harmless to disruptive for intimate relationships, and a lower score indicates permissive attitudes toward extradyadic behaviors. Original Cronbach coefficient alphas are α = .83; .72; .81 for explicit, deceptive, and ambiguous behavior, respectively. In this study, the internal consistency of PDIS reached the following values: ambiguous α = .89; deceptive α = .67, and explicit α = .89.

To assess the individual degree of guilt- and shame-proneness, we used the *Guilt and Shame Proneness Scale* – GASP (Cohen et al., 2011), an inventory based on tenets of another test called Test of Self Conscious Affect – TOSCA (Tangney & Dearing, 2002). GASP is a scale consisting of four subscales: Guilt Negative Behaviour Evaluations (GNBE), Guilt-Repair (GR), Shame Negative Self-Evaluations (SNSE), and Shame-Withdraw (SW). Respondents are required to imagine themselves in situations where they have committed personal transgression and then asked to mark the likelihood they would act or feel in the way described. GASP consists of 16 items ranked on a seven point Likert-type scale: from 1 (very unlikely) to 7 (very likely). Guilt-NBE items describe feeling bad about how the respondent acted (e.g., "You would feel that the way you acted was pathetic."). They describe action tendencies (i.e., behavior or behavioral intentions) focused on correcting or compensating for the transgression (e.g., "You would try to act more considerately toward your friends."). Shame-NSE items describe feeling bad about oneself (e.g., "You would feel like a bad person."). Shame-withdraw items describe action tendencies focused on hiding or withdrawing from public (e.g., "You would avoid the guests until they leave."). The benchmark on the test quality parameter is established on .60 of each subscale (Cohen et al., 2011). In this study, the internal consistency of GASP reached the following values: guilt-negative behavior evaluation α = .71; guilt-repair α = .67; shame-negative-self-evaluation α = .65, and shame-withdraw α = .65. These values are almost identical to the values found by Cohen et al. (2011) in their second study.

Results

The data was analyzed using IBM SPSS Statistics. We used the correlational research design to assess the proximity of relationships between guilt- and shame-proneness and perceptions of dating infidelity. The proximity of the relationship was assessed for 5% and 1% levels of statistical significance. Analysis of results and descriptive characteristics are pre-

Table 1 *List of study variables with their possible score ranges, mean scores, standard deviations, and correlation matrix of the variables of perceptions of dating infidelity, guilt- and shame-proneness*

Variable	Mean	SD	AMB	DCP	EXP	NBE	GR	NSE	SW
AMB (0-36)	16.3	9.23							
DCP (0-12)	6.5	3.09	**.35****						
EXP (0-24)	23.0	2.99	**.35****	**.25****					
NBE (4-28)	22.3	5.17	**.12****	**.24****	**.14****				
GR (4-28)	21.3	4.41	**.12****	**.20****	**.14****	**.51****			
NSE (4-28)	23.5	4.78	**.15****	**.14****	**.15****	**.50****	**.51****		
SW (4-28)	11.7	4.70	**.22****	**.12****	-.07	-.05	-.04	.06	

Note. AMB – Ambiguous, DCP – Deceptive, EXP – Explicit, NBE – Negative Behavior-Evaluation, GR – Guilt-Repair, NSE – Negative Self-Evaluation, SW – Shame-Withdraw. ** $p \leq .01$, * $p \leq .05$.

sented in Table 1, which shows perceptions of dating infidelity having significant positive correlations with guilt- and shame-proneness.

We conducted moderation analysis, focusing on the moderation role of age and gender in the relationship between perceptions of dating infidelity and guilt- and shame-proneness. The moderation effect was estimated using Process 3.1 developed by Hayes (2018).

The computational macro for path analysis is based on moderation providing coefficient estimations using ordinary least squares regression for continuous variables. The results of the moderation analysis are presented in Table 2.

Twenty-four analyses were carried out. To reduce the chances of obtaining false-positive results (type I errors), a Bonferroni correction was additionally conducted. The Bonferroni correction is used to reduce the chances of obtaining false-positive results (type I errors) when multiple pairwise tests are performed on a single set of data (Bland & Altman, 1995). In Table 2, we presented only the significant results. Models 1 to 3 included perceptions of dating infidelity as the outcome variable with gender or age as the moderators. The moderation effect of age was found to be significant in the subscale explicit of perceptions of dating infidelity and guilt-proneness, including negative behavior-evaluation ($F(3,801) = 23.05$, $p < 0.01$, $R^2 = 0.080$) and guilt-repair ($F(3,801) = 21.83$ $p < 0.01$, $R^2 = 0.076$). The moderation effect of gender was detected as significant between the subscale deceptive of perceptions of dating infidelity and negative self-evaluations of shame proneness ($F(3,207) = 5.17$, $p < 0.05$, $R^2 = 0.070$). Moderation effect of age in the relationship between the subscale explicit and guilt-proneness is graphically presented in Figure 1. Moderation effect of gender in the relationship between subscale deceptive and negative self-evaluations is also graphically presented in Figure 2.

Table 2 *Results of moderation analysis with perceptions of dating infidelity as the outcome variable, guilt- and shame-proneness as predictor variables, gender and age as moderators*

Predictors	Coeff	SE	95% confidence intervals	R-square whole model	R-square increase due to interaction
Model 1 – perceptions of dating infidelity as dependent variable					
NBE	-0.140	0.064	(-0.256, -0.006)		
AGE	-0.065	0.013	(-0.090, -0.040)	0.080	**0.001****
EXP x NBE	0.008	0.002	(0.004, 0.013)		
Model 2 – perceptions of dating infidelity as dependent variable					
GR	-0.124	0.077	(-0.275, 0.027)		
AGE	-0.062	0.014	(-0.090, -0.034)	0.076	**0.001****
EXP x GR	0.009	0.003	(0.004, 0.014)		
Model 3 – perceptions of dating infidelity as dependent variable					
NSE	0.798	0.257	(0.292, 1.304)		
GENDER	2.814	1.178	(0.492, 5.135)	0.070	**0.024***
DCP x NSE	-0.461	0.202	(-0.860, -0.062)		

Note. DCP – Deceptive, EXP – Explicit, NBE – Negative Behavior-Evaluation, GR – Guilt-Repair, NSE – Negative Self-Evaluation.
**$p \leq .01$, *$p \leq .05$.

Figure 1 Moderation effect of age in the relationship between explicit and guilt-proneness.

Figure 2 Moderation effect of gender in the relationship between deceptive and shame NSE.

Discussion

The first contribution of our study was a discovery of a significant positive relationship between guilt-proneness and less permissive perceptions of emotional and sexual infidelity, which confirmed our hypothesis. Presented findings are consistent with a previous study by Wilson et al. (2011), who found that participants who reported less lenient perceptions of both types of infidelity reported a more frequent feeling of guilt than what they imagined when first engaging in extradyadic behaviors. Furthermore, Stuewig, Tangney, Mashek, Forkner, and Dearing (2009) found that guilt-proneness was significantly negatively associated with the number of sexual partners and risky sexual behaviors. In later longitudinal study, Stuewig, Tangney, Folk and Dearing (2014) found that children being identified with higher guilt-proneness at the fifth grade were less likely to have unprotected sex and were more likely to use birth control pills as teens. At the age of 18–21, they were reported to have fewer sexual partners.

There are several possible ways to explain our findings regarding guilt-proneness. First, both subscales of guilt-proneness in previous studies were found to have a modest inverse relationship with making unethical decisions (Cohen et al., 2011; 2012). Generally, infidelity involves morality issues. It is considered unethical; but extradyadic behaviors are less clearly defined as right or wrong (Selterman & Koleva, 2015). Second, some studies show a significant to moderately strong correlation between honesty-humility and both subscales of guilt-proneness (Cohen et al., 2011; 2012b; 2014). Lacking honesty in an intimate relationship may create dubious and ambiguous circumstances and cases, where either partner may engage in extradyadic behaviors, which often lead to cheating. Here, honesty is important for preventing a partner from continuous cheating on the other. Third, there is a link between guilt-proneness, conscientiousness, and infidelity. Previous research has clearly shown that higher conscientiousness is significantly related to weaker susceptibility to infidelity, as cited in a large review of personality factors' influence on infidelity by Jia, Ing, and Chin (2016). Moreover, various studies have found an existing significant to modest relationship between conscientiousness and guilt-proneness (Cohen et al., 2011; 2014; Fayard, Roberts, Robins, & Watson, 2012). The aforementioned results suggest that people with higher guilt-proneness tend to be more honest, make fewer unethical decisions, and are more conscientious; this in turn results in having less permissive perceptions of dating infidelity. Interestingly, among all three types of extradyadic behaviors, guilt-proneness has the strongest relationship with perceptions of deceptive behaviors (lying to the partner/withholding information).

In current research, despite the overall likeability of theme-infidelity among researchers, there has not been a single study showing the evidence of its significant association with shame-proneness. Although there exist some studies by Stuewig et al. (2009; 2014), these have focused only on the risk factors for later infidelity among high-schoolers. However, in these two longitudinal studies, shame-proneness did not correlate with considered risk factors for eventual susceptibility to infidelity later in young adulthood. Our study is thus the first that has shown a significant relationship between shame-proneness and attitudes towards infidelity; higher shame-prone participants attained a significantly higher score on both subscales of perceptions of emotional infidelity, which reflects less permissive attitudes toward specific extradyadic behaviors. However, regarding perceptions of sexual infidelity, only negative self-evaluations were significantly associated. We can speculate why shame withdrawal tendencies in our study were not related to permissive attitudes toward sexual infidelity.

In comparison with permissive perceptions of emotional infidelity, permissive perceptions of sexual infidelity appear to be more closely involved with decision making of unclear morality and dishonesty. Making an unethical decision is more constrained in shame-prone people with negative self-evaluations, whereas individuals characterized with higher shame-withdrawal tendencies are, on the other hand, more open to unethical decisions and less honest (Cohen et al., 2011; Cohen, Panter, & Turan, 2012b; Cohen, Panter, Turan, Morse, & Kim, 2014).

The link between shame-proneness and less permissive perceptions of emotional infidelity can be supported by following mechanisms. Higher shame-proneness involves more interpersonal difficulties, which may lead to weaker opportunities to attract multiple sexual partners. This results in lowering chances to engage in both types of infidelity later (Stuewig & Tangney, 2007). When a highly shame-prone and shy person enters an intimate relationship because of less general experience in relationships, they may perceive a romantic partner too valuable. Such a person usually feels less attractive, creates far less opportunities for intimate relationships, and the loss of the current relationship may have a much harder impact. These factors, as perceived in the mind of such individual, may result in less susceptibility to at least emotional infidelity, because such individuals might not want to risk a clash in their intimate relationship on account of getting too intimate with another person.

In need for a better discussion, we were concerned about the results of all the conducted moderation analyses. Regarding this, age was detected only as a significant moderator of the relationship between guilt-proneness and perceptions of sexual infidelity; this relationship turned out to be the weakest among young Slovak adults. Overall, young adults in our sample attained higher score on guilt-proneness than older adults. This is quite surprising, because this finding completely diverges from previous research (Orth, Robins, & Soto, 2010; Tangney et al., 2011; Cohen et al., 2011). We do not have any plausible explanation of why guilt-proneness among Slovaks goes in the opposite direction than past research has clearly defined.

As seen in the first figure, the relationship between guilt-proneness and perceptions of sexual infidelity increases with age and is the highest among the group of older adults. However, in young adults, guilt-proneness remains strikingly high and unrelated to perceptions of sexual infidelity. Anticipation of feeling guilty among young adults does not predict how perceptions of sexual infidelity are going to be shaped over time. It may be concluded that perceptions of sexual infidelity among young adults may better reflect hidden cheating tendencies than a longer history of cheating on their past or present partners. The results provided by the first diagram make us contend that among middle-aged and older adults, guilt-proneness has a stronger relationship with less permissive perceptions of sexual infidelity than among young adults. High guilt-prone middle-aged and older adults tend to consider sexual behaviors with someone besides their partner as cheating to a greater extent than low guilt-prone middle-aged and older adults. Therefore, lenient perceptions of sexual infidelity in these age groups appear to reflect more accurately the chances of cheating in the past. In this sense, with increasing age, there is a higher likelihood of feeling guilty following a hypothetical engagement in extradyadic sexual activities. As people mature, they tend to develop better sensitivity for anticipation of feeling guilty towards possible involvement in extradyadic sexual activities. Our findings indirectly indicate that with increasing age, guilt-proneness may be increasingly more related to history of sexual infidelity. Hence, we speculate that long-term sexual infidelity may have a cumulative repressive effect on guilt-proneness, as it creates dubious moral identity of the actor. We additionally argue that unrestricted sex drive among regularly cheating people might be related to a slight decrease in guilt-proneness in a long run. Although high sex drive did not correlate with guilt-proneness in a study by Gilliland, South, Carpenter, and Hardy (2011), their sample consisted of men characterized by hypersexual behavior of rather unsatisfied sex drive. This discernibly differs from adults whose sex drive is very high, but satisfied thanks to a larger history of cheating.

The second figure depicts that there is a major gender gap in negative self-evaluations of shame-proneness among participants with permissive perceptions of deceptive behavior. It may reflect a tendency of unfaithful men to fear that their deceptive behavior will be uncovered. Women generally know better what other people think and feel (Wacker, Bolte, & Dziobek, 2017); they have better episodic verbal memory and remember personal experiences better than men (Herlitz & Rehnman, 2008). Hence, women are thought to be better at uncovering their partner's lies and inconsistencies in behavior. If male infidelity tends to be more easily uncovered, then men happen to be proven unfaithful more often and hence feel shame more frequently. These feelings of shame, if experienced more regularly, may gradually lead to a harder impact on the self, due to shame-proneness. Although further research is needed, our results may mildly suggest that women are more likely to be cleverer at covering up their infidelity and fear less that their deceptive behaviors will be uncovered. This may boost their confidence and self-esteem to engage in further deceptive behaviors.

There are several missing aspects of our study that need to be pointed out. Although during collection of results we controlled for relationship status (single, in free relationship, in relationship, married, or divorced), we decided to concentrate on it in a future study, owing to the length of the expected results and discussion. Up-to-date research cited by Silva et al. (2017) shows that it is unclear if relationship status is related to attitudes toward infidelity, because previous studies concluded divergent results. Another missing aspect of our study may be examining the history of extradyadic behaviors or infidelity. Although there is evidence that prior history of infidelity leads to more permissive attitudes toward extradyadic behaviors (Martins et al., 2016, Moreno & Kahumoku-Fessler, 2018), we decided to avoid enquiring about the history of infidelity for several reasons. First, since many participants were single or divorced, they could not have been asked about the degree of involvement in extradyadic behaviors during their current relationship, unlike in the recent study (e.g., Martins et al., 2016). Second, to obtain information about the history of participants' infidelity, a single question about being unfaithful in previous relationships (e.g., Martins et al., 2016) did not seem to be sufficient to address the history. Our specific data collection strategy was not suitable for enquiring about a more detailed history of infidelity, owing to potential ethical issues regarding highly sensitive information.

Conclusion

This study is the first that examined the relationship between guilt- and shame-proneness and perceptions of dating infidelity. Until today, it is the third study to have conducted moderation analysis with perceptions of dating infidelity. Results derived from a large sample size of different developmental stages will hopefully trigger future studies in exploring how guilt- and shame-proneness is intertwined with attitudes towards infidelity. Until now, besides the Big Five personality factors and the six-dimensional model of human personality – HEXACO, there exists a lack of research about personality traits associated with attitudes towards infidelity.

References

Allen, T. (2018). In covenant: A grounded theory exploration of what helps evangelical marriages recover after sexual infidelity by the husband. (Doctoral dissertation). Retrieved from https://digitalcommons.liberty.edu/doctoral/1766.

Baumeister, R., Stillwell, A., & Heatherton, T. (1994). Guilt: An interpersonal approach. *Psychological Bulletin, 115*(2), 243–267.

Barta, W., & Kiene, S. (2005). Motivations for infidelity in heterosexual dating couples: The roles of gender, personality differences, and sociosexual orientation. *Journal of Social and Personal Relationships*, *22*(3), 339–360.

Berman, M., & Frazier, P. (2005). Relationship power and betrayal experience as predictors of reactions to infidelity. *Personality and Social Psychology Bulletin*, *31*(12), 1617–1627.

Bland, J. M., & Altman, D. G. (1995). Multiple significance tests: The Bonferroni method. BMJ. *Clinical Research, 310*(6973), 170.

Blow, A., & Hartnett, K. (2005). Infidelity in committed relationships II: A substantive review. *Journal of Marital and Family Therapy*, *31*(2), 217–233.

Carmody, P., & Gordon, K. (2011). Offender variables: Unique predictors of benevolence, avoidance, and revenge? *Personality and Individual Differences*, *50*(7), 1012–1017.

Cohen, T., Wolf, S., Panter, A., & Insko, C. (2011). Introducing the GASP scale: A new measure of guilt and shame proneness. *Journal of Personality and Social Psychology*, *100*(5), 947–966.

Cohen, T., Panter, A., & Turan, N. (2012a). Predicting counterproductive work behavior from guilt proneness. *Journal of Business Ethics*, *114*(1), 45–53.

Cohen, T., Panter, A., & Turan, N. (2012b). Guilt proneness and moral character. *Current Directions in Psychological Science*, *21*(5), 355–359.

Cohen, T., Panter, A., Turan, N., & Morse, L. (2012). *Workplace experiences and character traits: The WECT Project*, *84*(3), 582–593.

Cohen, T., Panter, A., Turan, N., Morse, L., & Kim, Y. (2014). Moral character in the workplace. *Journal of Personality and Social Psychology, 107*(5), 943–963.

Cuñas, A., & Koval, S. (2018). Percepción de la infidelidad de adultos en el Área Metropolitana de Buenos Aires. *Universitas Psychologica*, *17*(2), 1–9.

Davis, D., Shaver, P., & Vernon, M. (2004). Attachment style and subjective motivations for sex. *Personality and Social Psychology Bulletin*, *30*, 1076–1090.

Dickerson, S., Gruenewald, T., & Kemeny, M. (2009). Psychobiological responses to social self threat: Functional or detrimental? *Self and Identity*, *8*(2), 270–285.

Fayard, J., Roberts, B., Robins, R., & Watson, D. (2012). Uncovering the affective core of conscientiousness: The role of self-conscious emotions. *Journal of Personality*, *80*(1), 1–32.

Fisher, M., Voracek, M., Rekkas, V., & Cox, A. (2008). Sex differences in feelings of guilt arising from infidelity. *Evolutionary Psychology*, *6*(3), 436–446.

Fraley, C., & Shaver, P. (1998). Airport separations: A naturalistic study of adult attachment dynamics in separating couples. *Journal of Personality and Social Psychology*, *75*(5), 1198–1212.

Gilbert, P. (2001). *Overcoming Depression. A step-by-step approach to gaining control over depression*. 2nd ed. New York: Oxford University Press.

Gilliland, R., South, M., Carpenter, B., & Hardy, S. (2011). The roles of shame and guilt in hypersexual behavior. *Sexual Addiction & Compulsivity. The Journal of Treatment & Prevention*, *18*(1), 12–29.

Gross, C., & Hansen, N. (2000). Clarifying the experience of shame: The role of attachment style, gender, and investment in relatedness. *Personality and Individual Differences*, *28*(5), 897–907.

Gruber, D., Hansen, L., Soaper, K., & Kivisto, A. (2014). The role of shame in general, intimate and sexual violence. In G. Lockhart (Ed.), *Psychology of Shame*: *New Research* (pp. 39–62). New York: Nova Science.

Hackathorn, J., Mattingly, B., Clark, E., & Mattingly, M. (2011). Practicing what you preach: Infidelity attitudes as a predictor of fidelity. *Current Psychology*, *30*(4), 299–311.

Hayes, A. (2018). Partial, conditional, and moderated moderated mediation: Quantification, inference, and interpretation. *Communication Monographs*, *85*(1), 4–40.

Heflin. S. (2015). Attachment and shame coping style: A relationship mediates by fear of compassion. (Doctoral dissertation). Retrieved from https://mospace.umsystem.edu/xmlui/bitstream/handle/10355/46440/HeflinAttShaCop.pdf?sequence=1.

Herlitz, A., & Rehnman, J. (2008). Sex differences in episodic memory. *Current Directions in Psychological Science*, *17*(1), 52–56.

Jia, T., Ing, K., & Chin, M. (2016). A review of personality factors on infidelity. *Journal Psikologi Malaysia, 30*(1), 126–141.

Jonason, P., Teicher, T., & Schmitt, D. (2011). The TIPI's validity confirmed: Associations with sociosexuality and self-esteem. *Individual Differences Research*, *9*(1), 52–60.

Kruger, D., Fisher, M., Edelstein, R., Chopik, W., Fitzgerald, C., & Stout, S. (2013). Was that cheating? Perceptions vary by sex, attachment anxiety, and behavior. *Evolutionary Psychology*, *11*(1), 159–171.

Labrecque, L., & Whisman, M. (2017). Attitudes toward and prevalence of extramarital sex and descriptions of extramarital partners in the 21st century. *Journal of Family Psychology, 31*(7), 952–957.

Lee, K., Ashton, M., Wiltshire, J., Bourdage, J., Visser, B., & Gallucci, A. (2013). Sex, power, and money: Prediction from the dark triad and honesty–humility. *European Journal of Personality*, *27*(2), 169–184.

Levine, E., Bitterly, T., Cohen., T., & Schweitzer, M. (2018). Who is trustworthy? Predicting trustworthy intentions and behavior. *Journal of Personality and Social Psychology, 115*(3), 468–494.

Lopez, F., Gover, M., Leskela, J., Sauer, E., Schirmer, L., & Wyssmann, J. (1997). Attachment styles, shame, guilt and collaborative problem-solving orientations. *Personal Relationships*, *4*, 187–199.

Luo, S., Cartun, M., & Snider, A. (2010). Assessing extradyadic behavior: A review, a new measure, and two new models. *Personality and individual differences*, *49*(3), 155–163.

Martins, A., Pereira, M., Andrade, R., Dattilio, F. M., Narciso, I., & Canavarro, M. (2016). Infidelity in dating relationships: Gender-specific correlates of face-to-face and online extradyadic involvement. *Archives of Sexual Behavior*, *45*(1), 193–205.

Mattingly, B., Wilson, K., Clark, E., Bequette, A., & Weidler, D. (2010). Foggy faithfulness: Relationship quality, religiosity, and the Perceptions of Dating Infidelity Scale in an adult sample. *Journal of Family Issues*, *31*(11), 1465-1480.

McKibbin, W., Miner, E., Shackelford, T. K., Ehrke, A., & Weekes-Shackelford, V. A. (2014). Men's mate retention varies with men's personality and their partner's personality. *Personality and Individual Differences*, *56*(1), 62–67.

Mikulincer, M., & Shaver, P. (2007). *Attachment in adulthood, first edition: Structure, dynamics, and change.* New York: The Guilford Press.

Mongeau, P., Hale, J., & Alles, M. (1994). An experimental investigation of accounts and attributions following sexual infidelity. *Communication Monographs*, *61*(4), 326–344.

Moreno, N., & Kahumoku-Fessler, E. (2018). Understanding infidelity: How perceptions of infidelity behaviors vary by sex and one's own infidelity experiences. *The American Journal of Family Therapy*, *46*(2), 107–121.

Ong, A., Poon, P., Sibya, S., & Macapagal, E. (2014). Gender, adult attachment styles, and the tendency to commit dating infidelity: A mixed methods study. *Phillippine Journal of Psychology*, *47*(11), 93–116.

Orth, U., Robins, R., & Soto, C. (2010). Tracking the trajectory of shame, guilt, and pride across the life span. *Journal of Personality and Social Psychology*, *99*(6), 1061–1071.

O'Sullivan, L., & Meyer-Bahlburg, H. (2003). African-American and Latina inner-city girls' reports of romantic and sexual development. *Journal of Social and Personal Relationships*, *20*(2), 221–238.

Ramsey, E. (1988). From guilt through shame to AA: A self-reconciliation process. *Alcoholism Treatment Quarterly*, *4*(2), 87–107.

Randall, H., & Byers, E. (2003). What is sex? Students' definitions of having sex, sexual partner, and unfaithful sexual behavior. *Canadian Journal of Human Sexuality*, *12*(2), 87–96.

Selterman, D., & Koleva, S. (2015). Moral judgement of close relationship behaviors. *Journal of Social and Personal Relationships*, *32*(7), 922–945.

Shackelford, T., Besser, A., & Goetz, A. (2008). Personality, marital satisfaction, and probability of marital infidelity. *Individual Differences Research*, *6*(1), 13–25.

Schmitt, D., Alcalay, L., Allik, J., Angleitner, A., Ault, L., Austers, I., et al., (2004). Patterns and universals of mate poaching across 53 nations: The effects of sex, culture, and personality on romantically attracting another person's partner. *Journal of Personality and Social Psychology*, *86*(4), 560–584.

Silva, A., Saraiva, M., Albuquerque, P., & Arantes, J. (2017). Relationship quality influences attitudes toward and perceptions of infidelity. *Personal Relationships*, *24*(4), 718–728.

Spanier, G., & Margolis, R. (1983). Marital separation and extramarital sexual behavior. *The Journal of Sex Research*, *19*(1), 23–48.

Stewart, C. (2017). Attitudes, attachment styles, and gender: Implications on perceptions of infidelity. (Doctoral dissertation). Retrieved from https://digitalscholarship.unlv.edu/cgi/viewcontent.cgi?article=4175&context=thesesdissertations.

Stuewig, J., & Tangney, J. (2007). Shame and guilt in antisocial and risky behaviors. In J. Tracy, R. Robins, & J. Tangney (Eds.), *The self-conscious emotions: Theory and research* (pp. 371–388). New York: The Guilford Press.

Stuewig, J., Tangney, J., Mashek, D., Forkner, P., & Dearing, R. (2009). The moral emotions, alcohol dependence, and HIV risk behavior in an incarcerated sample. *Substance Use & Misuse*, *44*(4), 449–471.

Stuewig, J., Tangney, J., Folk, J., & Dearing, R. (2014). Children's proneness to shame and guilt predict risky and illegal behaviors in young adulthood. *Child Psychiatry and Human Development*, *46*(2), 217–227.

Tafoya, M., & Spitzberg, B. (2007). The dark side of infidelity: Its nature, prevalence, and communicative functions. In: B. Spitzberg & W. Cupach (Eds.), *The dark side of interpersonal communication* (2nd ed., pp. 201–242). New Jersey: Lawrence Erlbaum Associates.

Tangney, J., & Dearing, R. (2002). *Shame and Guilt*. New York: Guilford.

Tangney, J., Stuewig, J., Mashek, D., & Hastings, M. (2011). Assessing jail inmates' proneness to shame and guilt: Feeling bad about the behavior or the self? *Criminal Justice and Behavior*, *38*(7), 710–734.

Toplu-Demirtas, E., & Fincham, F. (2017). Dating infidelity in Turkish couple: The role of attitudes and intentions. *The Journal of Sex Research*, *55*(42), 1–11.

Wacker, R., Bolte, S., & Dziobek, I. (2017). Women know better what other women think and feel: Gender effects on mindreading across the adult life span. *Frontiers in Psychology*, *8*, 1–7.

Weeks, G., Fife, S., & Peterson, C. (2016). *Techniques for the couple therapist: Essential interventions from the experts*. New York, NY: Routledge.

Wei, M., Shaffer, P., Young, S., & Zakalik, R. (2005). Adult attachment, shame, depression, and loneliness: The mediation role of basic psychological needs satisfaction. *Journal of Counseling Psychology*, *54*(4), 591–601.

Wheeler, G. (1997). Self and shame: A gestalt approach. *Gestalt Review*, *1*(3), 221–224.

Whitty, M., & Quigley, L. (2008). Emotional and sexual infidelity offline and in cyberspace. *Journal of Marital and Family Therapy*, *34*(4), 461–468.

Widmer, E., & Tras, J. (1998). Attitudes toward nonmarital sex in 24 countries. *The Journal of Sex Research*, *35*(4), 349–358.

Wilson, K., Mattingly, B., Clark, E., Weidler, D., & Bequette, A. (2011). The gray area: Exploring attitudes toward infidelity and the development of the Perceptions of Dating Infidelity Scale. *Journal of Social Psychology*, *151*(1), 63–86.

Wolfinger, N. (2017). Institute for family studies. America's generation gap in extramarital sex. Retrieved from https://ifstudies.org/blog/americas-generation-gap-in-extramarital-sex.

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Interference of Emotional Information in Briefly Presented Scene Arrays

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Research has shown that the presentation of emotional information interferes with the processing of neutral information. The present study examined whether one can suppress this interference when being asked to ignore an emotional scene before attention is engaged with a target or if emotional information always engages attention, resulting in attentional capture. We examined participants' ability to actively inhibit emotional scenes of different valence and arousal when identifying neutral scenes. In three experiments, a 4-scene array was presented for 250 ms while one emotional scene was present in the display. The scene was either to be ignored or freely available in the array. The results show that the interference from emotional scenes is a pervasive phenomenon, suggesting an involuntary attentional capture by emotional scenes. Moreover, despite the vast literature on the evolutionary advantage of preferential processing of negative information, we show a potent attentional bias toward positive information.

Key words: attentional bias, directed inhibition, emotional interference, Sperling paradigm, visual attention

Introduction

There is a preponderance of evidence supporting the notion that emotional information is selected automatically without the need for attention (Anderson, Christoff, Panitz, Rosa, & Gabrieli, 2003; Bradley, Keil, & Lang, 2012; Oca, Villa, Cervantes, & Welbourne, 2012; Pessoa, Padmala, & Morland, 2005; Schupp, Junghöfer, Weike, & Hamm, 2003) and that attention is preferentially allocated to emotional events even when those stimuli are not consciously perceived (Anticevic, Barch, & Repovs, 2010; Calvo, Nummenmaa, & Hyönä, 2008; Dolcos & McCarthy, 2006; Kalanthroff, Cohen, & Henik, 2013; Padmala, Bauer, & Pessoa, 2011). For example, an emotional event is more likely to permeate consciousness as documented through paradigms such as inattentional blindness (Mack & Rock, 1998; New & German, 2014; Wiemer, Gerdes, & Pauli, 2013), attentional blink (Choisdealbha, Piech, Fuller, & Zald, 2017; Most, Chun, Widders, & Zald, 2005; Oca et al., 2012), or continuous flash suppression (Yang, Zald, & Blake, 2007), demonstrating a privileged status of emotional information in visual attention.

The facilitation and preferential processing of emotional information at the expense of neutral information is well documented through interference of emotional information when processing other neutral information (Keil & Ihssen, 2004; New & German, 2015; Yiend et al., 2008; Yiend, 2010). In other words, attention is effectively captured by a distracting, task-irrel-

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evant emotional event, and causes attentional disengagement from the originally attended task (Gupta, Hur, & Lavie, 2016; Nummenmaa, Hyönä, & Calvo, 2006). An emotional event presented prior to, simultaneously with, or even after a neutral event disrupts processing of other neutral events, which has been attributed to an instinctive and involuntary attentional shift toward those emotional events (Becker, 2012; Choisdealbha et al., 2017; Fernández-Martín & Calvo, 2016; Krug & Carter, 2012; Öhman, Flykt, & Esteves, 2001; Oca et al., 2012; Sakaki, Gorlick, & Mather, 2011). Likewise, eye movement studies illustrate that initial fixations are more likely to land on emotional information (Adolphs, Tranel, & Buchanan, 2015; Calvo & Lang, 2005), and that semantic details of emotional information can be picked up even in peripheral vision (Bocanegra & Zeelenberg, 2009; Calvo et al., 2008).

However, not all emotional information presents interference of equal magnitude. Exposure to a transient negative stimulus (regardless of its arousal level) generally impairs performance to a greater extent in attentional and working memory tasks compared to a positively valenced event (Bolte, Goshke, & Kuhl, 2003; Calvo et al., 2008; Kuhbandner, Spitzer, & Pekrun, 2011; Sakaki et al., 2011), even though positive information is rated as equally arousing as negative events (Garcí-a-Pacios, Río, Villalobos, Ruiz-Vargas, & Maestú, 2015). Choisdealbha and colleagues (2017) utilized the attentional blink paradigm and presented neutral landscape images both prior to and after the emotional distractor, where erotic and gory stimuli elicited the greatest blink effect. Supplementing this, when compared with low- and high-arousal positive images, high-arousal negative stimuli tend to narrow one's useful field of view, resulting in poorer performance on the main letter identification task (Masuda, 2015; Nobata, Hakoda, & Ninose, 2010; Sekuler, Bennett, & Mamelak, 2000). Negative high arousal objects also decay slower from iconic memory in comparison to all others emotional stimuli (Kuhbandner et al., 2011).

The emotional interference effect is so powerful that it persists even when explicitly tasked with maintaining visual fixation on a neutral stimulus while emotional stimuli appear in peripheral vision (Calvo et al., 2008), or when given monetary reward for resisting the processing of those stimuli (Most, Smith, Cooter, Levy, & Zald, 2007; Piech, Pastorino, & Zald, 2010). Here, we add to the body of existing literature by examining the interference of emotional information in briefly presented scenes using a novel, pre-cue paradigm. Adopted from the directed forgetting paradigm (Bjork, LaBerge, & LeGrand, 1968), where the participant is typically given items or word lists to either actively remember or forget, we devised a directed ignoring paradigm in which participants were asked to actively ignore one scene from a four scene array. This to-be-ignored scene could be either emotional or neutral, and participants were told to ignore the scene as it will never be reported on it. We hypothesized that emotional stimuli would lead to attentional capture despite the conscious attempt to inhibit the interference of this information. Based on previous studies, we believed that negative high arousal stimuli would be particularly potent in disrupting processing of other information. (Calvo et al., 2008; Choisdealbha et al., 2017; Kuhbandner et al., 2011; Sakaki et al., 2011; Sekuler et al., 2000). In a series of experiments, we examined whether a concurrent presentation of an emotional distractor in an array of otherwise neutral scenes would disrupt a memory representation for those scenes. If the prioritization of emotional visual scenes is automatic one will not be able to suppress this emotional scene even when volitionally attempting to avoid its processing. Second, we were interested in the possible discrepancy in interference that may result from negative and positive scenes. Lastly, we were interested in elucidating the fate of non-emotional visual scenes that are neighboring an emotional visual scene of various valence and arousal.

General Materials and Methods

Participants

32, 35, and 31 college students participated in the experiments 1, 2, and 3, respectively, for course credit. All participants reported that they had normal or corrected-to-normal vision. No participant took part in more than one experiment to avoid any potential practice effects.

Stimuli and Conditions

Stimuli for the experiment were neutral and emotional scenes were selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1999), which has been shown to be internally consistent with cross-cultural validity. Each scene was selected based on its rating of arousal (the level of "arousability" or physiological reactivity ranging from low arousal to high arousal) and its valence (an index of its pleasantness or its hedonistic value varying from negative through neutral to positive) as indicated in the IAPS Manual. We decided to select stimuli for the experiment from IAPS as it provides ratings for valence and arousal on a scale from 1-9. The stimuli in all of the experiments were the same as we needed to control for variables such as the presence or absence of agents in the scene, scene complexity, or chromatic parameters of each scene.

All four experiments had the following within-subject conditions:

In all experiments, *the emotional condition* consisted of only one emotional scene in an array of otherwise neutral scenes, while *the neutral condition* comprised an array of solely neutral scenes. The to-be-cued and the to-be-reported on scenes were matched for presence of agents. There were 20 training trials, and a total of 24 experimental trials (12 in the emotional condition and 12 in the neutral condition). The 12 experimental trials had 3 scenes from the following emotional conditions: negative high arousal, negative low arousal, positive high arousal, and positive low arousal. The number of trials was low because we were committed to selecting scenes with specific arousal and valence parameters so they could be clearly classified as neutral or emotional. We compensated for this through a larger sample size for the within-subject design we used.

At the end of each trial, participants were prompted to write their response identifying the gist of the post-cued scene. More specifically, they were asked to describe the scene in much detail. To measure gist identification, the participant's response was given one of three scores: A score of 0 means they incorrectly identified the scene, a score of 1 implies they did not fully identify the gist of the scene (i.e., if the scene was a snake and they reported "animal" or if the scene was a child crying and they reported "person"), while a score of 2 was given if they properly identified the scene. Ultimately, their cumulative score is what is reported in the subsequent figures and results as the gist identification score. Participants completed one version of the experiment (see the conditions below). The individual emotional scene conditions were as follows [2 (arousal) x 2 (valence)], with the stimuli within each condition being randomized to account for order effects:

Positive valence and high arousal (PHA). The arousal ratings of images presented in this condition ranged from 5.41 to 7.35, while valence ratings varied between 6.82 and 8.34. Examples of images included in this conditions were naked bodies, adventurous sports (a person skiing or skydiving), and images depicting victory (a person winning a competition).

Positive valence and low arousal (PLA). The arousal ratings of images presented in this condition ranged from 2.51 to 3.94, while valence ratings varied between 6.54 and 8.05. Examples in this condition could be affection-evoking images (a smiling girl) or positive nature images (a meadow full of flowers).

Negative valence and high arousal (NHA). The arousal ratings of images presented in this condition ranged from 5.17 to 6.99, while valence ratings varied between 1.67 and 3.95. Some examples are scenes containing injured bodies (a man with blood on his face), scenes containing threatening animals (a biting dog, a snake, a spider) or accident scenes (airplane crash, fire scenes).

Negative valence and low arousal (NLA). The arousal ratings of images presented in this condition ranged from 3.52 to 4.96, while valence ratings varied between 1.95 and 3.92. Scenes selected for this category were for instance images of sad persons (a child hiding in a corner) or funeral or cemetery scene.

Experiment 1

Rationale

Because of the well-documented pervasive nature of emotional interference, we aimed to examine whether one can suppress the interference from emotional scenes when asked to disregard the scene as it would not be reported on. In order to accomplish this, we devised a precueing paradigm (similar to the directed forgetting paradigm), in which we instructed the participants to ignore one of the scenes by presenting a pre-cue at the location of that to-be-ignored scene.

Procedure

At the beginning of the experiment, each participant read and signed an informed consent form. A research assistant explained the nature of the task, that is, to identify the scene gist as accurately and in as much detail as possible of the cued scene, while ignoring a scene that was pre-cued at the beginning of each trial. Subsequently, the participant started a training session comprising 20 trials. None of the scenes presented during the training session were presented in the actual experimental session. The training session was procedurally identical to the experimental part and its objective was to familiarize participants with the experiment and their task.

Partial Report Paradigm

Each trial started with the presentation of a fixation cross at the center of the screen for 1500 ms, followed by a 4-scene array template. This template was presented for 2000ms and included a pre-cue (crossed out location of one of the scenes in the array) that determined which scene is to be ignored. There was an ISI of 2000ms before the presentation of the actual 4-scene array, which was presented for 250ms. Immediately upon the disappearance of the scene array, a post-cue (a red line placed beneath the location of one of the lower two scenes or above the location of one of the upper two scenes) indicating which scene to report was presented (100 ms). The cue was followed by a text box in which participants were required to report the gist of the cued scene. For schematic illustration, see Figure 1.

Each individual scene subtended 6 x 5 degrees of visual angle at a viewing distance of 56 cm. The scene array consisted of 4 scenes centered around the fixation cross. The center of each scene was ~ 5.3 visual degrees away from fixation, while the nearest corner of the scene was ~1.4 degrees from fixation.

Depending on the experimental condition, the 4-scene arrays either contained or did not contain an emotionally charged scene, which al-

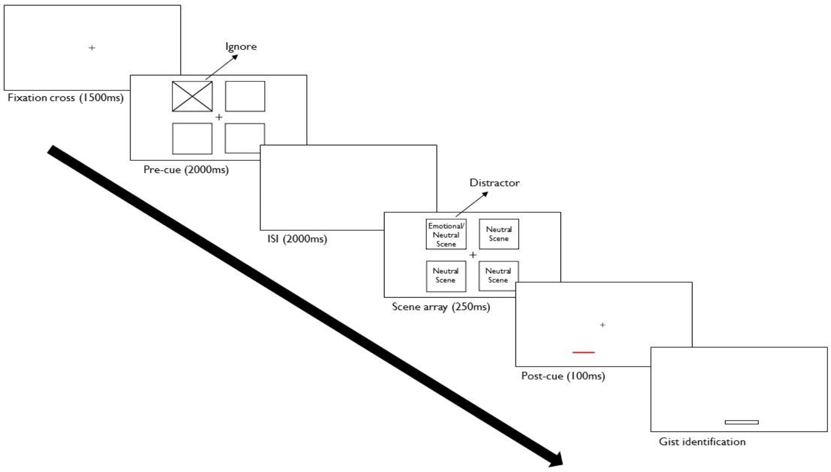

Figure 1 Schematic illustration of the experimental design in Experiment 1.

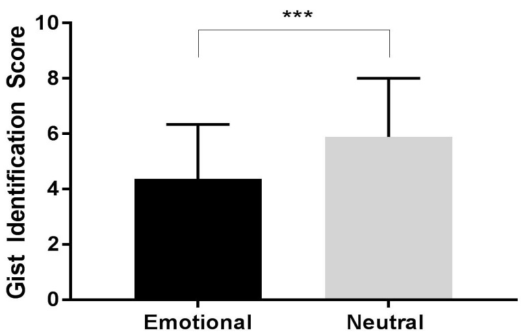

Figure 2 Gist identification of neutral scenes in emotional or neutral interference conditions in Experiment 1.

ways presented the interference. The experiment included 24 trials (12 in the emotional and 12 in the neutral condition) presented in a fully random order.

Experiment 1: Results

We computed a dependent *t*-test in order to examine the differences in reporting the gist of neutral scenes in the emotional versus neutral interference condition. We found that participants identified fewer neutral scene gists in the emotional interference ($M = 4.36$, $SD = 1.98$) condition in comparison with the neutral interference condition ($M = 5.89$, $SD = 2.11$), $t(31) = 5.10$, $p < .001$ ($p = .0001$), 95% confidence interval [CI]:-2.144 to -0.919. The results (displayed in Figure 2) indicate that despite the instruction to suppress the emotional distractor, participants' performance was heavily affected by it.

Discussion

In Experiment 1, the pre-cue presented for 2000ms before the onset of a 4-scene matrix designated which scene was to be ignored as it would never be reported on. The to-be-inhibited scene was either emotional or neutral and participants were supposed to report on another neutral scene in the array. As hypothesized, it was found that fewer scenes were identified in the emotional distractor condition than the neutral distractor condition, suggesting interference from emotional scenes. This is most likely due to both conscious and unconscious attentional capture by emotional scenes (Anderson et al., 2003; Anticevic et al., 2010; Bradley et al., 2012; Calvo et al., 2008; Dolcos & McCarthy, 2006; Kalanthroff et al., 2013; Oca et al., 2012; Padmala et al., 2011) and the inability to filter and control emotional stimulus despite being told to ignore it (Bjork et al., 1968; McKenna & Sharma, 1995; Most et al., 2005; Vuilleumier, Armony, Driver, & Dolan, 2001; Williams, Moss, Bradshaw, & Mattingley, 2005). Positive high-arousal stimuli resulted in the greatest "emotion-induced blindness", which has been observed even when monetary incentives for inhibiting such stimuli are involved (Most et al., 2005; Most et al., 2007). Interestingly, negative high-arousal scenes did not interfere much differently from the neutral scenes. The results of the individual valence-arousal combination scenes are displayed in Figure 5 and Table 1. This data suggests that these negative high arousal stimuli may be more easily processed causing a smaller interference effect (Anderson, 2005; Calvo & Marrero, 2009; Gupta et al., 2016; Mathewson, Arnell, & Mansfield, 2008; Most et al., 2007; Schimmack, 2005).

Experiment 2

Rationale

We aimed to compare the directed inhibition of emotional scenes in Experiment 1 with a pre-cueing paradigm, where the emotional scene is never pre-cued (to be ignored), but instead another neutral scene is pre-cued (to be ignored) while the emotional scene is in the scene array. This was a control condition in order to compare the full "potency" of emotional scenes and see the potential automatic attentional capture from emotional scenes when participants are not asked to ignore them.

Procedure

The procedure was identical to Experiment 1, with the only difference being that the participants were never instructed to ignore the emotional scene. In the emotional condition, participants were instead instructed to ignore another neutral scene in the array.

Experiment 2: Results

We computed a dependent t-test in order to examine the differences in reporting the gist of neutral scenes in the emotional versus neutral interference condition. We found that participants identified fewer neutral scene gists in the emotional interference ($M = 4.47$, $SD = 1.66$) in comparison with the neutral interference condition ($M = 5.70$, $SD = 1.55$), $t(34) = 4.21$, $p < .001$ ($p = .0002$), 95% confidence interval [CI]: -1.821 to -0.636. The results are displayed in Figure 3.

Additionally, we compared individual interference conditions for results in both Experiment 1 and Experiment 2. This was done to examine participants' ability to inhibit interference from emotional scenes (Experiment 1) in comparison to emotional scene being freely avail-

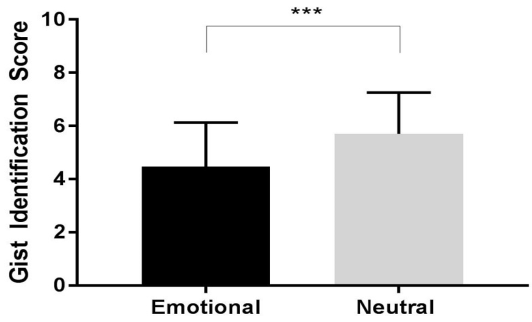

Figure 3 Gist identification of neutral scenes in the emotional or neutral interference conditions in Experiment 2.

able in the scene array (Experiment 2). An unpaired *t*-test showed that participants did not perform differently in those two conditions, $p = 0.80$. Therefore, one can conclude that emotional scenes cause an emotional capture and cannot be easily inhibited as documented by no differences in the identification of neutral scenes in the emotional interference condition between Experiment 1 and Experiment 2.

Discussion

In Experiment 2, which presented a control condition, the pre-cue was used to indicate the ignoring of a scene that would always be neutral, while either one scene in the vicinity was emotional and the other two neutral or all other scenes were neutral. Once again, fewer scene gists were identified in the emotional interference condition than in the neutral interference condition. Similarly, as documented in the previous experiment, the particularly positive scenes (of both arousal levels) interfered to a greater extent than neutral images, however this was not true for negative high arousal scenes (Table 1 and Figure 5). Furthermore, the findings indicate that, similar to Experiment 1 and previous literature, emotional scenes lead to attentional capture and disrupt subsequent processing of neutral information. This was particularly true for positive high arousal scenes (Keil & Ihssen, 2004; Fernández-Martín & Calvo, 2016; New & German, 2015; Oca et al., 2012; Yiend, 2010). Additionally, both Experiments 1 and 2 exemplified the automatic capture by emotional information and the inability to volitionally suppress their interference (Bjork et al., 1968; Kalanthroff et al., 2013; McKenna & Sharma, 1995; Most et al., 2005; Vuilleumier et al., 2001; Williams et al., 2005).

Experiment 3

Rationale

In Experiment 3, we employed the traditional partial report paradigm (Clarke & Mack, 2014; Sperling, 1960[1]) as a supplemental control experiment (in addition to Experiment 2). We aimed

[1] Developed by George Sperling, the partial report paradigm measures iconic memory capacity by having participants recall a random subset of items from a visual display using cued recall. Here, we used it to understand an individual's ability to maintain simultaneously several scenes while reporting on only one of the scenes from the scene array. This was performed in order to understand the interference of one of the scenes with processing of the scene that was cued. The partial report paradigm using scene arrays was designed by Clarke and Mack in 2014.

to examine the potential interference from emotional stimuli while not including any pre-cue indicating inhibition or ignoring of any scene.

Procedure

The procedure was identical to Experiments 1 and 2, with the only exception being the absence of a pre-cue indicating any particular scene to be ignored. In both emotional and neutral conditions, participants were asked to report on a gist of a neutral scene while there could be an emotional scene distractor in the scene array (emotional interference condition) or no emotional scene distractor (neutral interference condition). The performance was more difficult as now participants had to encode and maintain all 4 scenes from the array as no scene was to be ignored as in the Experiments 1 and 2, where only 3 scenes had to be encoded and maintained. The reasoning for this experiment was to ensure that the participants were actively using the pre-cue in both experiments 1 and 2 (but particularly Experiment 1, as it examined the ability to actively inhibit the emotional stimulus). We used the same design (2 x 2 scene matrix) without the presentation of a pre-cue that indicated which scene should be ignored. If participants were properly inhibiting a scene using the pre-cue, we should see that the performance in Experiment 1 should be superior to the performance in Experiment 3. The response set was different because participants had to select one of 4 scenes (instead of 3 in Experiment 1). Therefore, we transformed the mean gist identification scores in both Experiments 1 and 3 so they would be comparable (this transformation is described in the Results section).

Experiment 3: Results

Paired *t*-test revealed that in reporting gist of neutral scenes, participants identified fewer neutral scene gists in the emotional interference (M = 3.13, SD = 1.74) in comparison with the neutral interference condition (M = 4.82, SD = 1.77), $t(30) = 6.03, p < .001$ ($p = .0001$), 95% Confidence Interval [CI]: -2.267 to -1.120. The results are displayed in Figure 4.

In terms of individual emotional scenes categories, once again PHA, PLA, and NLA scenes interfered significantly more than neutral im-

Figure 4 Gist identification of neutral scenes in emotional or neutral interference conditions in Experiment 3.

ages, and performance on neutral scene gist identification was not significantly different in the NHA emotional interference condition than the neutral scene interference condition.

Examining the Effectiveness of the Pre-Cue

As mentioned previously, we tested whether the pre-cue was truly effectively used by participants and we did this by comparing the results of Experiment 1 (where pre-cue was used) with the results of Experiment 3, where no pre-cue was used to ignore a scene.

In Experiment 1, the response set was ultimately 3 scenes, since participants only had to maintain 3 scenes in their iconic memory before reporting on one of them. However, in Experiment 3, the response set was 4 scenes. To compare those results, we needed to transform those scores by finding a common denominator. We did so by computing the score as if reporting for one singular scene. Therefore, performance in Experiment 1 was divided by 3 and performance in Experiment 3 was divided by 4, in order to achieve this level of comparability.

We subsequently computed independent *t*-tests for both the emotional interference and all neutral conditions in Experiments 1 and 3. As such, participants reported on more scenes in the emotional pre-cue condition (Experiment 1) (M = 1.45, SD = .66) than in the emotional no pre-cue condition (Experiment 3) (M = .81, SD = .44), $t(61) = 4.51, p < .0001$ ($p = .000014$). Additionally, in the neutral condition, participants once again identified more scenes in the pre-cue condition (Experiment 1) (M = 1.96, SD = .70) compared to the no pre-cue condition (Experiment 3) (M = 1.21, SD = .44), $t(61) = 5.08, p < .0001$ ($p = .00001$). This demonstrates that participants were, indeed, using the pre-cue effectively in Experiment 1 as their normalized performance was better than their performance in Experiment 3 with no-cue.

Discussion

In Experiment 3, a typical partial-report paradigm was used. In the emotional condition, an emotional scene was in the vicinity of the to-be-reported neutral scene, which was compared to all neutral scenes in the array. Fewer neutral scene gists were identified when there was interference from an emotional scene than a neutral scene. Again, as displayed in Table 1 and Figure 5 positive images interfered most, while negative high-arousal once again resulted in the smallest interference with a magnitude that of neutral scenes. Even with more images to be maintained in the visual sensory memory, emotional images interfered with the neutral scene processing (Clarke & Mack, 2014; Dick, 1974; Kuhbandner et al., 2011).

Additional Analyses: The Interference of Individual Emotional Categories

As an additional goal of the study was to examine the interference from individual emotional categories (PHA, PLA, NHA, NLA), we compared performance on target neutral scene gist identification for those emotional categories compared to neutral scene distractors. Since there were 12 emotional scenes in total (3 for each emotional category), we had to divide the performance for all neutral scene gist performance by 4 to be able to achieve such a comparison.

We consistently found that NHA scenes interfered to the same extent as neutral scenes, as indicated in Figure 5 and Table 1 (p values for NHA and neutral scenes, $p > .05$). However, all other emotional scene categories interfered significantly more than neutral scenes. Namely, PHA inferred to the greatest extent in all experiments ($p < .001$), followed by PLA ($p < .001$), and then NLA scenes ($p < .01$, $p < .01$, and $p < .001$ for Experiments 1, 2, and 3, respectively).

Table 1 *Comparison of gist identification scores between neutral distractor and individual emotional categories distractors in individual experiments*

Experiment/ Emotional Category	Experiment 1 (Ignore Emotional)	Experiment 2 (Ignore neutral only)	Experiment 3 (No inhibition)
NHA	1.719(ns)	1.629(ns)	1.081(ns)
PHA	0.641(***)	0.800(***)	0.758(***)
NLA	0.969(**)	1.000(**)	0.677(***)
PLA	0.938(***)	1.043(***)	0.613(***)
NEUTRAL	1.473	1.425	1.206

Note. The table shows means for the number of neutral scene identifications due to interference from individual emotional scenes (NHA = negative high arousal, PHA = positive high arousal, NLA = negative low arousal, PLA = positive low arousal) or neutral scenes which were the control condition. The performance on all neutral scene conditions was divided by 4, as there were 4 different emotional categories which made up 12 scenes, and 12 neutral scenes in total. In order to be able to compare the individual emotional categories of the presented scenes, we divided the performance on neutral scene condition by 4.
*p < .05. **p < .01, ***p < .001.

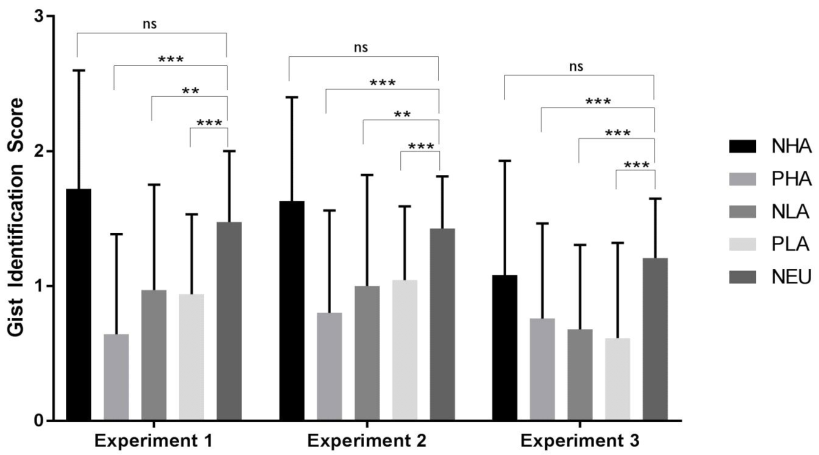

Figure 5 Gist identification of neutral scenes based on individual emotional categories or neutral interference conditions throughout all the experiments.

General Discussion

The current study examined one's ability to inhibit and filter emotional scenes in briefly presented scene arrays. We were also interested in one' ability to identify non-emotional visual scenes that were adjacent to an emotional scene in the array. Previous studies have shown that emotionally arousing scenes modulate visual attention, causing attentional capture and subsequent slower attentional disengagement (Anticevic et al., 2010; Bradley et al., 2012; Brockmole & Boot, 2009; Buodo, Sarlo, & Palomba, 2002; Dennis et al., 2008; Fernández-Martín & Calvo, 2016; Garcí-a-Pacios et al., 2015; Gupta et al., 2016; Jefferies, Smilek, Eich, & Enns, 2008; Lang, Bradley, & Cuthbert, 1997; Mathewson et al., 2008; Oca et al., 2012; Pessoa et al., 2005; Vuilleumier et al., 2001; Yiend et al., 2008; and see Yiend, 2010 for a review). We hypothesized that if an emotional visual scene receives preferential processing, one will not be able to suppress the processing of those emotional scenes even when tasked with directly inhibiting them.

In Experiment 1, the pre-cue was presented before the onset of the stimulus array, which designated which scene was to be ignored as it would never be reported on. Subsequently, participants were directed to report on a neutral scene in the array, while the to-be-inhibited scene was either emotional or neutral. Experiment 2 presented a control condition, where the pre-cue was used to indicate inhibition of a neutral scene, while all other scenes were either neutral (completely neutral condition) or one emotional (emotional interference condition). Finally, in Experiment 3, the typical partial-report paradigm was used; in the emotional condition, an emotional scene was in the vicinity of the to-be-reported neutral scene, which was compared to a neutral condition, where all neutral scenes were presented in the array.

We found an interference effect from emotional scenes regardless of instruction. Even when the participants were instructed to inhibit emotional scenes, these scenes interfered with the processing of neutral scenes. Results of Experiment 1 demonstrated that individuals cannot disengage from an emotional scene even when told to ignore it as it is irrelevant, and its processing is subsequently detrimental to the performance in the primary task. In Experiment 2, we have shown that emotional scenes also cause attentional capture – if an emotional scene is freely present in the scene array, it negatively affects the performance on identifying non-emotional scenes. Regardless of instruction, emotional scenes seem to cause attentional capture and reduce the ability to identify neutral scenes. This attentional capture by emotional scenes seems to be automatic and pervasive regardless of whether the emotional scene was to be ignored or freely available in the scene array. Our study corroborates accounts supporting automatic attentional capture by emotion, specifically by non-threatening, evolutionarily relevant stimuli such as food (Lang et al., 1997; Piech et al., 2010), threatening stimuli (Brailsford, Catherwood, Tyson, & Edgar, 2014; Dennis et al., 2008; Koster, Crombez, Verschuere, & Houwer, 2004; New & German, 2015; Öhman et al., 2001; Wiemer, Gerdes, & Pauli, 2012; Williams et al., 2005; Yang et al., 2007), and erotic images or words (Arnell, Killman, & Fijavz, 2007; Gupta et al., 2016; Most et al., 2007; Schimmack, 2015; Sennwald et al., 2015). Here we exemplify that simultaneous presentation of competing visual scenes results in preferential processing of emotional information. This favored orientation of visual attention towards high-priority stimuli through top-down and bottom-up processes is posited by the arousal-biased competition model (for a review, see Mather & Sutherland, 2011; Wang, Kennedy, & Most, 2012; Zeelenberg, Wagenmakers, & Rotteveel, 2006).

Despite the illustrated attentional capture and interference from emotional scenes, we show that negatively valenced, high arousal (NHA) scenes do not seem to interfere with the processing of neutral scenes to the same extent as other emotional scenes (specifically negatively valenced, low-arousal and positively valenced, low and high-arousal scenes). In fact, negative high arousal scenes exhibited the same level of interference as neutral scenes when identifying the cued neutral scene. The fact that this finding is in direct opposition with studies demonstrating that emotionally negative stimuli create a greater interference in many gist and scene identification tasks (Biederman, 1982; Jefferies et al., 2008; Kuhbandner et al., 2011; Sakaki et al., 2011; Schimmack, 2005) might be explained by several mechanisms. First, NHA scenes might be more easily inhibited and therefore their interference effect is smaller or equivalent to other non-emotional scenes. However, if this were the case, we would find greater interference in Experiment 2 in which the participants were never cued to inhibit emotional scenes, when in fact performance was akin to that of Experiment 1. Therefore, it is more likely that those scenes might be more easily processed, using fewer attentional resources and reflecting automatic, capacity-free bottom-up processing (Carretie, Hinojosa, Martin-Loeches, Mercado, & Tapia, 2004). A few studies have shown that gory distractors lead to a smaller disruption in identifying targets in math solving and RSVP tasks (attentional blink) when compared to erotic images (Anderson, 2005; Mathewson et al., 2008; Most et al., 2007; Schimmack, 2005), and additionally, that negatively valenced scenes and faces are more poorly detected than happy faces in a visual and letter search task (Calvo & Marrero, 2009; Gupta et al., 2016). Those studies similarly show smaller attentional bias toward threatening scenes (NHA), and it seems that there is a smaller interference from negative images when the task's perceptual load is high. Indeed, amygdala activation in response to the presence of irrelevant negatively valenced distractors is eliminated under high perceptual load (Pessoa et al., 2005). Research by Gupta et al. (2016) consistently showed that interference from negative scenes is load-contingent while interference from positive information is not, and positive information interference is pervasive regardless of the task load. This differential interference effect for positive and negative information was shown across different semantic categories (such as erotic and happy for positive scenes, and gory and angry for negative scenes). Furthermore, happy faces are more likely to capture attention in an inattentional blindness task than sad faces (Mack & Rock, 1998), and positive scenes, particularly erotica, were found to impair target detection in an attentional blink paradigm to much greater extent than both disgusting and fear-containing scenes (Ciesielski, Armstrong, Zald, & Olatunji, 2010). However, due to the complex nature of attentional bias, this can also be contingent on other variables, such as personality traits, mental illness, or one's emotional state (Duque & Vázquez, 2015; Sears, Newman, Ference, & Thomas, 2011).

In relation to the current study, one could argue that the pre-cue used to instruct participants to ignore the scene actually drew the participants' attention towards the scene. However, we found that this was not the case. To ensure that participants were actually using the pre-cue effectively and thus ignored the pre-cued scenes, we ran a control experiment (Experiment 3) without a pre-cue which included a 2 x 2 scene array but otherwise emulated the design of Experiment 1. We observed that the pre-cue was in fact used effectively, as participants performed significantly better when the pre-cue was presented when compared to the no pre-cue performance (this was observed for both emotional a neutral conditions).

The difficulty of the task is also important to consider: the perceptual load has been shown to modulate attentional capture of negative, task-irrelevant stimuli and amygdala response (Gupta et al., 2016; Pessoa et al., 2005), suggesting that the allocation of attention and the difficulty or level of engagement in the task also greatly affect the amount of interference that may occur. Our task was attentionally demanding, as participants had to maintain several scenes in their working memory before the cue appeared, and therefore we can conclude that threatening scenes do not captivate attention (evident through the lack of their interference). Going forward, it is important to take into account these variables in future experimental designs and further examine the potential load-contingency of emotional information of different valence and arousal levels. Currently, we are exploring the power of recall by including a post-cue instead of inhibition.

Taken together, the results of the current study suggest a powerful interference effect by emotional scenes, but not negative high arousal stimuli. It makes sense that an individual's attention would be motivated to shift towards the biological desire to reproduce, as seen in the PHA condition. This effect could also be enhanced in part because of societal taboos surrounding sexual scenes (Arnell et al., 2007; Mathewson et al., 2008; Sennwald et al., 2015). However, similar interference effects observed when non-sexual, low arousal positive scenes (PLA) and even non-threatening, low arousal negative scenes (NLA) were presented, which raises some questions. It is still unclear why the negative high-arousal as well as the low-arousal condition would not consistently elicit an effect similar to that seen from the positive high- and low-arousal conditions. Previous literature has suggested that, although the transient, emotion-induced blindness effects between positive and negative high-arousal stimuli are similar, they may not be processed identically and therefore subsequently produce differential effects (Arnell et al., 2007; Bocanegra & Zeelenberg, 2011; Gupta et al., 2016; Most et al., 2007). Perhaps the negative stimuli were simply not biologically threatening enough or were presented too briefly to warrant disengagement from the task, which would result in less interference.

Our study thus corroborates the potent attentional capture by positively valenced scenes, and extends the current understanding of this advantage for briefly presented scenes that are in competition with each other.

References

Adolphs, R., Tranel, D., & Buchanan, T. W. (2015). Amygdala damage impairs emotional memory for gist but not details of complex stimuli. *Nature Neuroscience, 8*(4), 512–518. doi: 10.1038/nn1413

Anderson, A. K., Christoff, K., Panitz, D., Rosa, E. D., & Gabrieli, J. D. (2003). Neural correlates of the automatic processing of threat facial signals. *The Journal of Neuroscience, 23*(13), 5627–5633. doi: 10.1523/jneurosci.23-13-05627.2003

Anderson, A. K. (2005). Affective influences on the attentional dynamics supporting awareness. *Journal of Experimental Psychology: General, 134*(2), 258–281. doi: 10.1037/0096-3445.134.2.258

Anticevic, A., Barch, D. M., & Repovs, G. (2010). Resisting emotional interference: Brain regions facilitating working memory performance during negative distraction. *Cognitive, Affective, & Behavioral Neuroscience, 10*(2), 159–173. doi: 10.3758/cabn.10.2.159

Arnell, K. M., Killman, K. V., & Fijavz, D. (2007). Blinded by emotion: Target misses follow attention capture by arousing distractors in RSVP. *Emotion, 7*(3), 465–477. doi: 10.1037/1528-3542.7.3.465

Becker, M. W. (2012). Negative emotional photographs are identified more slowly than positive photographs. *Attention, Perception, & Psychophysics, 74*(6), 1241–1251. doi: 10.3758/s13414-012-0308-x

Biederman, I., Kubovy, M., & Pomerantz, J. R. (1982). On the semantics of a glance at a scene. *Perceptual organization* (pp. 213–254). Hillsdale, NJ: Erlbaum.

Bjork, R. A., Laberge, D., & Legrand, R. (1968). The modification of short-term memory through instructions to forget. *Psychonomic Science, 10*(2), 55–56. doi: 10.3758/bf03331404

Bocanegra, B. R., & Zeelenberg, R. (2009). Emotion improves and impairs early vision. *Psychological Science, 20*(6), 707–713. doi: 10.1111/j.1467-9280.2009.02354.x

Bocanegra, B. R., & Zeelenberg, R. (2011). Emotion-induced trade-offs in spatiotemporal vision. *Journal of Experimental Psychology: General, 140*(2), 272–282. doi: 10.1037/a0023188

Bolte, A., Goschke, T., & Kuhl, J. (2003). Emotion and intuition. *Psychological Science, 14*(5), 416–421. doi: 10.1111/1467-9280.01456

Bradley, M. M., Keil, A., & Lang, P. J. (2012). Orienting and emotional perception: Facilitation, attenuation, and interference. *Frontiers in Psychology*, *3*. doi: 10.3389/fpsyg.2012.00493

Brailsford, R., Catherwood, D., Tyson, P. J., & Edgar, G. (2013). Noticing spiders on the left: Evidence on attentional bias and spider fear in the inattentional blindness paradigm. *Laterality: Asymmetries of Body, Brain and Cognition, 19*(2), 201–218. doi: 10.1080/1357650x.2013.791306

Brockmole, J. R., & Boot, W. R. (2009). Should I stay or should I go? Attentional disengagement from visually unique and unexpected items at fixation. *Journal of Experimental Psychology: Human Perception and Performance, 35*(3), 808–815. doi: 10.1037/a0013707

Buodo, G., Sarlo, M., & Palomba, D. (2002). Attentional resources measured by reaction times highlight differences within pleasant and unpleasant, high arousing stimuli. *Motivation & Emotion, 26*(2), 123–138. Retrieved from https://hs1.farmingdale.edu:2443/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=11307550&site=ehost-live

Calvo, M. G., & Lang, P. J. (2005). Parafoveal semantic processing of emotional visual scenes. *Journal of Experimental Psychology: Human Perception and Performance, 31*, 502–519. http://dx.doi.org/10.1037/0096-1523.31.3.502

Calvo, M. G., & Marrero, H. (2009). Visual search of emotional faces: The role of affective content and featural distinctiveness. *Cognition & Emotion, 23*(4), 782–806. doi: 10.1080/02699930802151654

Calvo, M. G., Nummenmaa, L., & Hyönä, J. (2008). Emotional scenes in peripheral vision: Selective orienting and gist processing, but not content identification. *Emotion, 8*(1), 68–80. doi: 10.1037/1528-3542.8.1.68

Carretié, L., Hinojosa, J. A., Martín-Loeches, M., Mercado, F., & Tapia, M. (2004). Automatic attention to emotional stimuli: Neural correlates. *Human Brain Mapping, 22*(4), 290–299. doi: 10.1002/hbm.20037

Choisdealbha, Á. N., Piech, R. M., Fuller, J. K., & Zald, D. H. (2017). Reaching back: The relative strength of the retroactive emotional attentional blink. *Scientific Reports, 7*(1). doi: 10.1038/srep43645

Ciesielski, B. G., Armstrong, T., Zald, D. H., & Olatunji, B. O. (2010). Emotion modulation of visual attention: Categorical and temporal characteristics. *PLoS ONE, 5*(11). doi: 10.1371/journal.pone.0013860

Clarke, J., & Mack, A. (2014). Iconic memory for the gist of natural scenes. *Consciousness and Cognition, 30*, 256–265. doi: 10.1016/j.concog.2014.09.015

Dennis, T. A., Chen, C., & McCandliss, B. D. (2008). Threat-related attentional biases: An analysis of three attention systems. *Depression and Anxiety, 25*(6). doi: 10.1002/da.20308

Dick, A. O. (1974). Iconic memory and its relation to perceptual processing and other memory mechanisms. *Perception & Psychophysics, 16*(3), 575–596. doi: 10.3758/bf03198590

Dolcos, F., Kragel, P., Wang, L., & McCarthy, G. (2006). Role of the inferior frontal cortex in coping with distracting emotions. *Neuroreport, 17*, 1591–1594. doi: 10.1097/01.wnr.0000236860.24081.be

Dolcos, F., McCarthy, G. (2006). Brain systems mediating cognitive interference by emotional distraction. *Journal of Neuroscience, 26*(7), 2072–2079. doi: 10.1523/jneurosci.5042-05.2006

Fernández-Martín, A., & Calvo, M. G. (2016). Selective orienting to pleasant versus unpleasant visual scenes. *Cognition, 155*, 108–112. doi: 10.1016/j.cognition.2016.06.010

Garcí-a-Pacios, J., Rã-o, D. D., Villalobos, D., Ruiz-Vargas, J. M., & Maestãş, F. (2015). Emotional interference-based forgetting in short-term memory. Cognitive inhibition of pleasant but not unpleasant biologically relevant distractors. *Frontiers in Psychology, 6*. doi: 10.3389/fpsyg.2015.00582

Gupta, R., Hur, Y., & Lavie, N. (2016). Distracted by pleasure: Effects of positive versus negative valence on emotional capture under load. *Emotion, 16*(3), 328–337. doi: 10.1037/emo0000112

Jefferies, L. N., Smilek, D., Eich, E., & Enns, J. T. (2008). Emotional valence and arousal interact in attentional control. *Psychological Science, 19*, 290–295. http://dx.doi.org/10.1111/j.1467-9280.2008.02082.x

Kalanthroff, E., Cohen, N., & Henik, A. (2013). Stop feeling: Inhibition of emotional interference following stop-signal trials. *Frontiers in Human Neuroscience, 7*. doi: 10.3389/fnhum.2013.00078

Keil, A., & Ihssen, N. (2004). Identification facilitation for emotionally arousing verbs during the attentional blink. *Emotion, 4*(1), 23–35. doi: 10.1037/1528-3542.4.1.23

Koster, E. H., Crombez, G., Verschuere, B., & Houwer, J. D. (2004). Selective attention to threat in the dot probe paradigm: Differentiating vigilance and difficulty to disengage. *Behaviour Research and Therapy, 42*(10), 1183–1192. doi: 10.1016/j.brat.2003.08.001

Krug, M. K., & Carter, C. S. (2012). Proactive and reactive control during emotional interference and its relationship to trait anxiety. *Brain Research, 1481*, 13–36. doi: 10.1016/j.brainres.2012.08.045

Kuhbandner, C., Spitzer, B., & Pekrun, R. (2011). Read-out of emotional information from iconic memory. *Psychological Science, 22*(5), 695–700. doi: 10.1177/0956797611406445

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). Motivated attention: Affect, activation, and action. In P. J. Lang, R. F. Simons, & M. T. Balaban (Eds.), *Attention and orienting: Sensory and motivational processes* (pp. 97–135). Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.

Lang, P. J., Bradley, M., & Cuthbert, B. N. (1999). International affective picture system (IAPS). University of Florida: NIMH Centre for the Study of Emotion and Attention.

Mack, A., & Rock, I. (1998). *Inattentional blindness*. Cambridge, MA: MIT Press.

Masuda, N. (2015). Effects of emotional valence (positive or negative visual images) and arousal levels (high or low arousal levels) on the useful field of view. *Psychology, 06*(04), 478–483. doi: 10.4236/psych.2015.64045

Mather, M., & Sutherland, M. R. (2011). Arousal-biased competition in perception and memory. *Perspectives on Psychological Science, 6*(2), 114–133. doi: 10.1177/1745691611400234

Mathewson, K. J., Arnell, K. M., & Mansfield, C. A. (2008). Capturing and holding attention: The impact of emotional words in rapid serial visual presentation. *Memory & Cognition, 36*(1), 182–200.

McKenna, F. P., & Sharma, D. (1995). Intrusive cognitions: An investigation of the emotional Stroop task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*(6), 1595–1607. doi: 10.1037/0278-7393.21.6.1595

Most, S. B., Chun, M. M., Widders, D. M., & Zald, D. H. (2005). Attentional rubbernecking: Cognitive control and personality in emotion-induced blindness. *Psychonomic Bulletin & Review, 12*(4), 654–661. doi: 10.3758/bf03196754

Most, S. B., Smith, S. D., Cooter, A. B., Levy, B. N., & Zald, D. H. (2007). The naked truth: Positive, arousing distractors impair rapid target perception. *Cognition & Emotion, 21*(5), 964–981. doi: 10.1080/02699930600959340

New, J. J., & German, T. C. (2015). Spiders at the cocktail party: An ancestral threat that surmounts inattentional blindness. *Evolution and Human Behavior, 36*(3), 165–173. doi: 10.1016/j.evolhumbehav.2014.08.004

Nobata, T., Hakoda, Y., & Ninose, Y. (2010). The functional field of view becomes narrower while viewing negative emotional stimuli. *Cognition & Emotion, 24*(5), 886–891. doi: 10.1080/02699930902955954

Nummenmaa, L., Hyönä, J., & Calvo, M. G. (2006). Eye movement assessment of selective attentional capture by emotional pictures. *Emotion, 6*(2), 257–268. doi: 10.1037/1528-3542.6.2.257

Oca, B. M., Villa, M., Cervantes, M., & Welbourne, T. (2012). Emotional modulation of the attentional blink by pleasant and unpleasant pictures. *The Journal of General Psychology, 139*(4), 289–314. doi: 10.1080/00221309.2012.708681

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General, 130*(3), 466–478. doi:10.1037//0096-3445.130.3.466

Padmala, S., Bauer, A., & Pessoa, L. (2011). Negative emotion impairs conflict-driven executive control. *Frontiers in Psychology, 2*. doi: 10.3389/fpsyg.2011.00192

Pessoa, L., Padmala, S., & Morland, T. (2005). Fate of unattended fearful faces in the amygdala is determined by both attentional resources and cognitive modulation. *NeuroImage, 28*(1), 249–255. doi: 10.1016/j.neuroimage.2005.05.048

Piech, R. M., Pastorino, M. T., & Zald, D. H. (2010). All I saw was the cake. Hunger effects on attentional capture by visual food cues. *Appetite, 54*(3), 579–582. doi: 10.1016/j.appet.2009.11.003

Sakaki, M., Gorlick, M. A., & Mather, M. (2011). Differential interference effects of negative emotional states on subsequent semantic and perceptual processing. *PsycEXTRA Dataset, 11*(6), 1263–1278. doi: 10.1037/e520602012-543

Schimmack, U. (2005). Attentional interference effects of emotional pictures: Threat, negativity, or arousal? *Emotion, 5*(1), 55–66. doi: 10.1037/1528-3542.5.1.55

Schupp, H. T., Junghöfer, M., Weike, A. I., & Hamm, A. O. (2003). Attention and emotion: An ERP analysis of facilitated emotional stimulus processing. *NeuroReport, 14*(8), 1107–1110. doi: 10.1097/00001756-200306110-00002

Sekuler, A. B., Bennett, P. J., & Mamelak, M. (2000). Effects of aging on the useful field of view. *Experi-*

mental Aging Research, 26(2), 103–120. doi: 10.1080/036107300243588

Sennwald, V., Pool, E., Brosch, T., Delplanque, S., Bianchi-Demicheli, F., & Sander, D. (2015). Emotional attention for erotic stimuli: Cognitive and brain mechanisms. *Journal of Comparative Neurology, 524*(8), 1668–1675. doi: 10.1002/cne.23859

Sperling, G. (1960). The information available in brief visual presentations. *Psychological Monographs, 74*(11).

Vuilleumier, P., Armony, J. L., Driver, J., & Dolan, R. J. (2001). Article: Effects of attention and emotion on face processing in the human brain. An event-related fMRI study. *Neuron, 30*, 829–841. https://doi.org/10.1016/S0896-6273(01)00328-2

Wang, L., Kennedy, B. L., & Most, S. B. (2012). When emotion blinds: A spatiotemporal competition account of emotion-induced blindness. *Frontiers in Psychology, 3*. doi: 10.3389/fpsyg.2012.00438

Wiemer, J., Gerdes, A. B., & Pauli, P. (2012). The effects of an unexpected spider stimulus on skin conductance responses and eye movements: An inattentional blindness study. *Psychological Research, 77*(2), 155–166. doi: 10.1007/s00426-011-0407-7

Williams, M., Moss, S., Bradshaw, J., & Mattingley, J. (2005). Look at me, I'm smiling: Visual search for threatening and nonthreatening facial expressions. *Visual Cognition, 12*(1), 29–50. doi: 10.1080/13506280444000193

Yang, E., Zald, D. H., & Blake, R. (2007). Fearful expressions gain preferential access to awareness during continuous flash suppression. *Emotion, 7*(4), 882–886. doi: 10.1037/1528-3542.7.4.882

Yiend, J., Mathews, A., Weston, B., Dunn, B. D., Cusack, R., & Mackintosh, B. (2008). An investigation of the implicit control of the processing of negative pictures. *Emotion, 8*(6), 828–837. doi: 10.1037/a0014146

Yiend, J. (2010). The effects of emotion on attention: A review of attentional processing of emotional information. In J. D. Houwer & D. Hermans (Eds.), *Cognition and emotion reviews of current research and theories* (pp.211–275). New York, NY: Psychology Press

Zeelenberg, R., Wagenmakers, E., & Rotteveel, M. (2006). The impact of emotion on perception. *Psychological Science, 17*(4), 287–291. doi: 10.1111/j.1467-9280.2006.01700.x

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Predictors of Reading Fluency in Second and Third Grade Students: Results from Bosnia and Herzegovina

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Learning to read is one of the most important academic accomplishments in the early grades of elementary school. Knowing what factors contribute to reading ability would improve instructional practices. The goal of the present study was to examine the effects of semantic fluency, phonological fluency, rapid naming, inhibitory control, selective attention, and visual motor integration on reading fluency in 140 second and third grade students. The results of this study indicated that significant predictors of reading fluency were: selective attention, semantic fluency, inhibitory control, and rapid naming. However, the association between predictor variables and reading fluency was moderated by the students' grade. The article concludes with some suggestions on how to improve reading fluency in elementary school children, given that all predictors are susceptible to instruction.

Key words: reading fluency, elementary school children, academic achievement

Introduction

Reading ability is one of the most important academic skills, next to writing and basic mathematical skills. The preschool period and the early grades of elementary school are particularly important for developing reading skills. One of the main goals of elementary school education is teaching children to read (Guo, Sun, Breit-Smith, Morrison, & Connor, 2015). Early reading abilities are strong predictors of reading comprehension and general knowledge at later age (Cunningham & Stanovich, 1997) and they represent the foundation of children's later academic success (Lonigan, Burgess, & Anthony, 2000).

Reading is a complex process consisting of reading fluency and linguistic comprehension (Hoover & Gough, 1990) and these two constructs are moderately correlated with each other (Levy, 2001). Each of these processes is complex in its own right. This is best illustrated by the fact that neuro-anatomy of reading encompasses neural systems that support every aspect of language, visual and orthographic

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processes, working memory, attention, motor movements, and higher level comprehension and cognition (Norton & Wolf, 2012).

Reading fluency has become a topic of major importance in the field of reading and the number of studies investigating it has increased in comparison to all other reading topics (Landerl & Wimmer, 2008; Teale, Whittingham, & Hoffman, 2018). Fluency definitions comprise the following skills in oral reading: 1) accuracy for reading words, 2) appropriate pace for reading text, and 3) prosody or expression (Antonacci, O'Callaghan, & Berkowitz, 2014). Often viewed as a bridge between word identification and comprehension, fluency needs to be considered in any reading process framework, used to assess and intervene in case of children with reading difficulties (Bashir & Hook, 2009). Reading fluency is a very good indicator of early reading development and overall reading competence (Cohen-Mimran, 2009; Fuchs et al., 2001; Hasbrouck & Tindal, 2006; Morris & Perney, 2018).

Skills leading to successful reading are developed in preschool period and these skills become coordinated into fluent reading in grades 1-5 (Paris, 2005). Many factors and skills may contribute to reading fluency, such as accuracy in recognition of visual stimuli and efficiency in identifying single sight words (Torgesen & Hudson, 2006). Other factors related to reading development are phonological awareness and naming speed (David et al., 2007; Kirby, Parrila, & Pfeifer, 2003). To date, a plethora of research has demonstrated the effects of phonological awareness on reading development (Carrillo, 1994; Chiappe & Siegel, 1999; Lonigan et al., 2000; Stahl & Murray, 1994). However, although very important, phonological awareness is not a sufficient condition for early reading (Bus & Van Ijzendoorn, 1999). Another set of predictors, examined in relation to reading skills, are the executive functions skills. Executive functions are related to reading development, as they govern the integration of visual and linguistic information, as well as retrieval of linguistic information from the memory while learning to read (Altemeier, Abbott, & Berninger, 2008). Executive functions are related to reading achievement (Monette, Bigras, & Guay, 2011) and studies have shown that children with reading difficulties have also deficits in executive functions (Reiter, Tucha, & Lange, 2005). Several executive functions have been implicated to play a role in reading development, including working memory (Chiappe, Hasher, & Siegel, 2000), inhibitory control (Allan et al., 2014), and cognitive flexibility (Cole, Duncan, & Blaye, 2014).

Besides cognitive factors contributing to reading literacy, there are many personality factors such as motivation and self-confidence, which are related to reading skills (Netten, Droop, & Verhoeven, 2011). Demographic factors such as gender have also been studied in relation to reading but the results seem to be inconclusive. Most of the conducted studies point to females' advantage in the language domain (Clinton et al., 2014; Voyer & Voyer, 2014). However, there are also reports of no gender effects on reading measures between boys and girls (Berninger et al., 2008).

Reading is a foundation stone of learning and fundamental educational goal across the world (Wagner, 2017). Many children at early primary grades have problems in acquiring adequate reading skills. A report by US Department of Education indicated that 36% of fourth grade children were reading below the basic level (Katzir et al., 2006). Identification of children at risk of reading problems is particularly important, as research indicates that poor readers at an early age tend to be poor readers in later grades as well (Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996). Given its importance, it comes as no surprise that so much scientific attention has been given to improving reading. Still, many school-aged children struggle with reading and there are several distinct types of reading difficulties. Some of these difficulties are related to naming speed and phonological processes (Wolf & Katzir-Cohen, 2001), and some are related to other factors such as visual attention.

Knowing which factors contribute to efficient reading might help educators in identifying and creating intervention programs even before children are formally taught to read. In addition to this, knowledge about the predictors of reading can inform practitioners and help them improve their professional practices. The goal of the present study is to examine the extent to which certain factors (verbal fluency, selective attention, inhibitory control, rapid naming, and visual-motor integration) are related to reading fluency in a sample of second and third grade students whose native language is Bosnian, and to examine whether there are differences in reading fluency in relation to children's gender.

This Study

Schoolchildren in Bosnia and Herzegovina start their formal education at the age of 6 years by enrolling into the first grade of elementary school, which is compulsory. Prior to enrolling in elementary schools, all children are required to attend obligatory preschool preparation program at the age of 5 years (one year prior to their enrollment in elementary school). However, in that preparation program children are not required to learn any academic content such as numbers and/or letters. As for the reading outcomes, children are expected to learn to read in the second grade of elementary school. The curriculum goals for the first grade of elementary school are related to learning letters, reading short words and learning to write. Thus, we did not assess first grade students on the task of reading fluency, although some children learn to read in the first grade. The sample for this study consisted of children in second and third grades, as these children are expected to know how to read. The first objective in this study was to examine whether there are differences between girls and boys in reading fluency, as the research in this domain is inconclusive. The second objective was to examine the predictors of reading fluency at early school age and their relative effect on reading fluency. Some predictors of reading fluency, such as phonologic awareness, have already been established in the literature for both, languages with transparent orthography (Öney & Durgunoğlu, 1997) and languages with less transparent orthography (Anthony & Francis, 2005). It is important to note that, at least in the Anglo-Saxon linguistic field, there are children who do not respond well to phonological-based treatments in learning to read (Wolf & Katzir-Cohen, 2001). Also, in an orthographically regular language, such as Finnish, there seems to be a minor link between early phonological skills and reading fluency in second grade students (Puolakanaho et al., 2008) and thus, there is a need to find additional avenues of treatment of reading difficulties besides phonological skills. As for the predictors in this study, we examined the effects of verbal fluency, rapid object naming, inhibitory control, selective attention and visual-motor skills on reading fluency. The reasons for selecting these predictors are two-fold. First, they are theoretically founded in earlier studies (Norton & Wolf, 2012), where the authors implied wider neural networks involved in reading fluency. However, the joint/confounding effect of these variables on reading fluency remains unclear. These predictors, apart from rapid naming, have not received much attention in scientific literature. Thus we wanted to enhance our understanding of how these predictors affect the reading skills. The second reason we were interested in these particular predictors is that they might be receptive to academic interventions both at school age and, more importantly, at preschool age. If proven significant, these predictors can systematically be targeted by preschool educators, which in turn would result in better reading fluency at school age and better academic outcomes. This is the first study examining predictors of reading fluency in early grade students, whose native language is Bosnian. This study is innovative in the way that it examines the relationship between some components of executive functions and reading fluency: 1) in transparent orthography (as most of the studies were conducted in English language), 2) in normative population of students (most of the studies were examining this link in students with reading/learning disabilities), and 3) the outcome measure in this study is reading fluency (most existing studies examined the link between executive functions and reading comprehension).

The specific research questions in this study are:

1) Are there gender differences in reading fluency in children attending second and third grade of elementary school?

2) What are the best predictors of reading fluency?

3) Does the strength of the association between predictors and reading fluency vary in relation to the children's grade?

Method

Participants

The sample for this study was convenient and it consisted of 140 (73 boys, 67 girls) children attending second and third grade of two elementary schools in the Sarajevo city. There were 70 students attending second grade (36 boys, 34 girls; mean age = 92.1 months, SD = 3.6 months) and 70 (37 boys, 33 girls; mean age = 103.1 months, SD = 5.6 months) students attending third grade. According to the teachers' reports, children were free of any developmental disability or other neurological condition.

Measures

Outcome Measure

Reading Fluency

The outcome measure in this study was a test of reading ability. The students were required to read a text and the number of words read in one minute served as an outcome measure. We created the reading text for the purpose of this study and it was the same for both second and third grade students. The reading text was developed with consultation with children's teachers as to reflect the language curriculum. The methodology, originally developed by Deno (1985), involves students reading short passages of text to assess their reading fluency. This way of assessing reading fluency has many advantages, it is simple to perform, can differentiate between students of different reading ability and can easily serve as a measure of intervention efficacy (Fuchs et al., 2001).

Predictors

In this study we used the following predictors for reading fluency: 1) Verbal fluency measured through Semantic fluency and Phonological fluency task; 2) Rapid object naming test; 3) Inhibitory control test; 4) Selective attention test; and 5) Visual-motor integration skills. Although verbal fluency tests and rapid naming test are frequently used in studies, no normative data that are standardized in Bosnia and Herzegovina are available. Thus, we provided descriptive data for these tests that can serve as preliminary normative data for these age/grade groups.

1) Semantic Fluency

Numerous studies examining language and relationship between language and executive functions have used semantic fluency as an independent variable. In this study we used a semantic category of animals. We used a standard procedure for conducting this test (Troyer, Moskovitch, & Winocur, 1997). Children were asked to name as many animals as possible in 60 seconds. Total number of named, non-repeated, animals was used as a predictor variable.

2) Phonological Fluency

Another test of verbal fluency we used in this study was phonological fluency. The procedure is the same as for the semantic fluency task (Troyer et al., 1997). Children were asked to name as many words as possible in 60s starting with a letter M. Number of named, non-repeated, words was used as a predictor variable.

3) Rapid Object Naming test

In this test children are required to quickly name aloud all the objects on an A4 format sheet. We adopted an object naming test because object names are the least automatized category, regardless of being acquired earlier than colors, numbers, and letters (Denckla & Rudel, 1974). In this test we had a total of 36 pictures (12 familiar objects, each repeated 3 times) on the sheet. The time to name all the pictures was used as an outcome variable.

4) Inhibitory Control - Commission Errors

The task used for the assessment of Inhibitory Control was a computerized Multiple-Choice Reaction Time Test (Di Nuovo, 2000). In this test, children are required to press the space key on a computer every time they see a star appearing on the screen and to inhibit the response when they see any other object appearing on the screen (go-no/go paradigm). The total number of stimuli presented was 45, out of which 9 were targets. The stimuli were presented randomly. The computer program used for this assessment was *Attenzione e conzentrazione* (Di Nuovo, 2000), which was used previously for measuring inhibitory control in preschool children (Memisevic & Biscevic, 2018). There are four outcome measures on this test: number of correct answers, mean reaction time, errors of omission and errors of commission. For the purposes of this study we only present the number of commission errors committed as they are a measure of inhibitory control. The other three measures are regarded as the measures of attentional control and were not used in this study.

5) Selective Attention - Cancellation Test

Selective attention was measured through a cancellation test. Cancellation tests are widely used to assess selective attention and visual search abilities. They are commonly used to asses a person's ability to simultaneously target stimuli while ignoring distracters and these tests are tapping a wide array of executive function skills such as planning, organizing information, and ignoring irrelevant information (Wu et al., 2017). We used a computerized Cancellation task from the program *Attenzione e conzentrazione* (Di Nuovo, 2000). In this task children were asked to cancel out all the stars that appear on the screen. Success on the task is measured through several indices: number of omissions, number of correct answers, and completion time. However, as a predictor variable for this task we used a so-called Performance Quotient (PQ) (Huang & Wang, 2009). PQ is a more precise indicator in cancellation tasks since the number of correct answers is usually not a sensitive measure due to the ceiling effect and completion time may have a wide range of scores. PQ accounts for both speed and accuracy of the performance and was calculated through this math expression:

$$PQ = \frac{\text{correct responses}}{\text{total target}} \times \frac{\text{correct responses}}{\text{completion time}}$$

6) Visual Motor Integration

Visual motor integration, defined as the coordination of fine motor skills and perceptual abilities, is a very good indicator of a child's level of functioning and academic performance (Memisevic & Djordjevic, 2018). In this study we used a Grooved Pegboard Test, the test that is frequently used in neuropsychological assessment batteries (Bryden & Roy, 2005). In this test children are required to insert 25 keys into holes. Time to finish the task was used as a predictor variable.

Procedure

In this study we employed a transversal research approach. We selected two elementary schools in Canton Sarajevo and provided teachers with the consent forms for the children's parents. After the consent forms were returned, we tested the children using the tests described above. We tested a total of 210 children (70 children were attending first grades, 70 children were attending second grades and 70 children were attending third grades). However, for this study we only reported results for children attending second and third grades because the first graders were not administered the reading fluency test. All children were tested individually, in the morning hours, in the classrooms that were available for the testing. The order of testing was the same for all children. The approval for this study was obtained from the Canton Sarajevo Ministry of Education and the Ethical Committee Board at the Faculty of Educational Sciences at the University of Sarajevo. Only children with written parental consent were tested.

Statistical Analysis

Descriptive results (means and standard deviations) are presented for second and third grade students of both boys and girls. To answer the first research question we performed a *t*-test and two-way ANOVA. For the second and third research questions, we performed a stepwise multiple regression. An alpha level of .05 was used for all statistical tests.

Results

We first present descriptive data (means and standard deviations) for the predictor variables of reading fluency (Table 1). As there are no normative data available for Bosnian speaking children, these data can serve as normative for future studies on this topic.

The first research aim in this study was to examine whether there are differences in reading skills in relation to gender and grade of the students. We performed a two-way analysis of variance to examine if these differences were statistically significant in relation to the gender and grade of the students, and if there exists an interaction effect of gender and grade on reading skills. Summary of these results is presented in Table 2.

Table 1 *Descriptive data for the predictors of reading fluency*

Predictor variables	Second grade		Third grade	
	M	*SD*	*M*	*SD*
Semantic fluency	12.1	4.2	13.1	4.5
Phonological fluency	6.0	2.4	6.7	2.9
Rapid naming	54.7	16.1	51.9	19.4
Inhibitory control	1.1	1.3	1.0	1.2
Visual motor integration	97.2	23.9	86.0	25.9
Selective attention	23.3	7.3	27.1	6.8

Table 2 *Means, standard deviations, and analysis of variance (ANOVA) results for reading skills for gender and grade*

	Second grade		Third grade		ANOVA		
	M	*SD*	*M*	*SD*	Gender (Ge)	Grade (Gr)	Ge x Gr
Gender					6.7[a]	40.2[b]	0.65[c]
Boys	59.3	31.2	90.4	35.0			
Girls	69.3	34.3	109.5	32.1			

Note. [a]p = .011, η^2 = .05 ; [b]p = .001, η^2 = .23; [c]p = .42, η^2 = .005.

As can be seen from Table 2, girls outperformed boys on the task of reading fluency in both, second grade and third grade. However, according to the results of an independent *t*-test, these differences were statistically significant for the third grade students, but not for the second grade students (third grade: $t(68) = 2.4$; $p = .021$; second grade: $t(68) = 1.3$; $p = .21$). As can be seen from the table, there was an increase for both, boys and girls in reading fluency from second grade to third grade. For the boys the overall improvement in reading fluency from second grade to the third grade was 52.4%, and for the girls the improvement from second to third grade was 58%. However, as this is a cross-sectional study, this improvement in percentage (%) should serve only as an indicator, as there are no national norms for reading fluency.

Results of ANOVA clearly show that there are statistically significant gender and grade effects, and there is a lack of their interaction effect on reading skills. Girls read more fluently than boys in both, second and third grade, and as expected, reading fluency improved significantly from second grade to third grade.

We next performed a correlation between all the measures in the study. These results are shown in Table 3.

As can be seen from Table 3, reading skills are significantly correlated with all the predictors. Also, as can be seen from Table 3, the issue of multicollinearity was not problematic, since the predictors were not highly correlated among each other. Thus, we next performed a stepwise multiple regression with all the predictors. The results have shown that the significant predictors of reading skills were semantic fluency, rapid naming, inhibitory control, and selective attention. Visual-motor integration ($t = 0.6$; $p = .58$) along with phonological fluency ($t = 1.86$; $p = .064$) were not significant

Table 3 *Correlation between reading skills and the predictors*

	READ	SF	PF	RN	INH_CON	VMI	SA
READ	1.00	.31**	.31**	-.29**	-.18*	-.17*	.31**
SF	-	1.00	.47**	-.30**	-.04	-.17*	.10
PF	-	-	1.00	-.22**	-.02	-.26**	.14
RN	-	-	-	1.00	.03*	.19*	-.17*
INH_CON	-	-	-	-	1.00	.25**	.06
VMI	-	-	-	-	-	1.00	-.34**
SA	-	-	-	-	-	-	1.00

Note. READ – reading skills; SF – semantic fluency; PF – phonological fluency; RN – rapid naming; INH_CON – inhibitory control; VMI – visual motor integration skills; SA – selective attention.

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

predictors of reading fluency. In Table 4 are the results of a stepwise multiple regression, with all statistically significant predictors.

The model presented in Table 4 was statistically significant $F(4) = 10.5$; $p < .001$, although it only explained around 24% of the scores in reading fluency. The strongest predictor of reading ability was Selective Attention, followed by Semantic Fluency, Inhibitory Control and Rapid Naming. In order to obtain better insight into these results we also wanted to check whether these predictors are the same and have the same strength for both second grade students and third grade students. The results of multiple regression are shown in Table 5.

As can be seen from Table 5, the prediction model changes if the sample is split between second grade and third grade students. For second grade students, the model changed drastically and the only significant predictor of reading fluency was rapid naming, which explained around 15% of variance in scores on reading fluency. For the third grade students, the model did not change significantly. The only difference from the original model was that the variable rapid naming did not reach statistical significance. However, for third graders the model explained almost 1/3 of the variance on the scores in reading fluency. It is evident that the initial model was more applicable to third grade students and better predicted their scores.

Discussion

The goal of this study was to examine the gender effects on reading and factors contributing to reading fluency in children attending second and third grades of elementary school. Our first research question dealt with gender differences in reading fluency. The results of this study showed that girls outperformed boys in both second and third grades, but statisti-

Table 4 *A stepwise multiple regression for predicting reading fluency*

Predictors	*B*	*SEB*	*β*	*t*	*p*
SA	1.42	.40	.27	3.55	.001
SF	1.96	.68	.23	2.86	.005
INH_CON	-5.32	2.20	-.18	-2.42	.017
RN	-0.37	0.17	-.17	-2.16	.032

Note. R^2 = .24 (unadjusted), R^2 = .22 (adjusted). SA – selective attention; SF – semantic fluency; INH_CON – inhibitory control; RN – rapid naming.

Table 5 *A stepwise multiple regression for predicting reading fluency for second and third grade students*

Predictors		*B*	*SEB*	*β*	*t*	*p*
2nd Grade[a]						
	Rapid naming	-.81	.23	-.40	-3.60	<.01
3rd Grade[b]						
	SA	1.22	.53	.24	2.31	.024
	SF	2.87	.80	.37	3.58	<.01
	INH_CON	-6.96	2.90	-.25	-2.41	.019

Note. [a] R^2 = .16 (unadjusted); R^2 = .14 (adjusted); [b] R^2 = .30 (unadjusted); R^2 = .27 (adjusted). SA – selective attention; SF – semantic fluency; INH_CON – inhibitory control.

cally significant differences were only found for third graders. The results of previous studies on gender differences in reading have found mixed results. A large meta-analysis conducted by Hyde and Linn (1988) showed that gender differences for most types of verbal abilities are negligible across development, except for speech production which favors females. A study by Klein and Jimerson (2005) examined gender differences in reading fluency in children grades 1-3 and found no differences between boys and girls. However, it seems that some differences in reading ability appear later in development. For example, Berninger et al. (2008) found that men had more difficulties than women in reading abilities, but no such differences were found between boys and girls.

One possible explanation for gender differences in this study might lie in motivational and attitudinal factors in reading. It has been shown that girls have more positive attitudes towards reading than boys (Logan & Johnston, 2009) and perhaps the difference stemmed from higher interest of girls towards reading materials. Thus, motivational factors such as attitudes and interests should be controlled in future studies.

As for the predictors of reading fluency, the results of this study have indicated that rapid object naming, selective attention, inhibitory control and semantic fluency are significantly associated with reading fluency. However, the significant predictors were not the same for students in second and third grades. For the second grade students the only significant predictor of reading fluency was rapid naming, while for the third graders the significant predictors were semantic fluency, inhibitory control, and selective attention.

Rapid naming is a very good predictor of reading skills in early school grades (Manis, Seidenberg, & Doi, 2009). It is also one of the most widely studied predictors of reading fluency. In this study, rapid naming had a larger effect on reading fluency in second than in third grade students. There are several potential explanations for this result. Rapid naming is a test of processing information. It might be the case that these results are dependent on the naming category. In the present study, we used pictures of familiar objects and animals to be named. We might have achieved different results if we had used alphanumeric naming tasks, which are known to better differentiate impaired readers (Wolf, 1991). It might be the case that naming of familiar objects becomes more automatic with age, so the differences among children and their effect on reading is reduced. This explanation is in line with a hypothesis that naming speed is a lower level process, which is a major factor in initial stages of reading and disappears in later grades (Walsh, Price, & Gillingham, 1988).

In this study, selective attention had the largest effect on reading fluency. Previous studies have shown that deficits in selective attention have negative effects on reading efficiency (Casco, Tressoldi, & Dellantonio, 1998). But the question remains on why was selective attention the most significant predictor of reading fluency for third grade students but not for second grade students? The answer to this question might be related to earlier theories of reading, where selective attention played a central role (Willows, 1974). In line with that theory, the probable explanation is that older children attend more successfully to the more important words, ignore those that are redundant and can connect the text logically. Selective attention is a complex ability, which incorporates the competency of focusing on target stimuli as well as the inhibition of unimportant stimuli. It is important to note that we used a Performance Quotient on the cancellation task as a measure of selective attention. This measure takes into account both speed and accuracy of the performance and this measure can probably better predict reading success and should thus be used more widely as a predictor of reading fluency. Also of note is that PQ is not a pure measure of selective attention as it taps other skills as well, such as visuospatial function. Future studies should examine the other measures of selective attention as well.

The second strongest predictor of reading fluency for third graders was semantic fluency. Interestingly, there is a lack of research examining the link between semantic fluency and reading fluency. There are, however, many studies in which semantic fluency was correlated with other constructs important for reading such as working memory and executive functions (Biscevic, Pasalic, & Memisevic, 2018; Daneman, 1991). One possible explanation of why semantic fluency was a significant predictor might be the fact that semantic fluency has a linear trajectory line until the age of 10, and as the children age, there is higher variance in the scores. Thus, the fluency scores of third graders might have been influenced more by semantic fluency than the scores of second graders.

The last significant predictor in our model was inhibitory control. It is a well-established fact that older children have better inhibitory control than younger children. However, the exact nature of the relationship between inhibitory control and reading is not clear. It is well established that reading involves both automatic and control processes. Inhibitory control can be viewed as a control process involving allocation of attention and working memory to reading (Walczik, 2000). Thus, the older childen, were able to better use these resources in decoding unfamiliar words and resolving any inconsistencies in the text because the process of decoding is more automatized. Studies to date have shown that poor readers have difficulties in inhibitory control (Chiappe et al., 2000).

Children differ widely in their prerequisite skills when entering primary schools. The role of educators, both preschool and elementary school teachers, is to reduce these gaps in skills. Much has been written about the so-called Matthew effects in reading, defined as a widening achievement gap between good and poor readers, and although the topic is inconclusive (Pfost, Hattie, Dorfler, & Artelt, 2014), the teachers need to be aware of this phenomena and start using reading interventions as soon as possible. Reading difficulties tend to be stable across school age. Around 70% of children who were poor readers at Grade 1, continue to be poor readers at Grade 8 (Landerl & Wimmer, 2008). Teacher education programs should thus incorporate discussions on different teaching methods proven to improve reading (Kikas et al., 2017). This study is important as it can point the researchers and practitioners to the strategies that can be used to enhance academic achievements in reading. According to developmental theories, reading development is cumulative in the sense that later skills are built on foundational skills (Kieffer, 2011). Therefore, it is important to identify the skills that constitute the foundation of reading. The results of this study can offer some useful guidelines. In particular, this study points to the importance of selective attention in reading fluency. Instructions aimed at practicing selective attention can probably have a positive impact on reading. In addition to improving selective attention, practice in verbal fluency and inhibitory control can also serve the function of improving reading fluency in children (Kolić-Vehovec, 2002). Educators can use a number of strategies to improve these skills in children. Short, high-intensity physical activities have been shown to improve selective attention in school children (Ma, Le Mare, & Gurd, 2014). Some preschool programs such as Tools of Mind can help to improve inhibitory control in preschool children (Diamond, Barnett, Thomas, & Munro, 2007). Educators need to share information with parents on effective strategies for increasing reading skills. This is because within family factors, such as home literacy environment, have a large effect on child's literacy (Puglisi et al., 2017).

Our study is the first one examining the predictors of reading fluency in Bosnian language. As there might be different effects of various predictors on reading fluency, depending on the orthographic complexities, this study is warranted. Most of the studies on predictors of reading have been conducted in English speaking countries, thus it is important to determine these predictors for languages with transparent orthographies. Bosnian language has a so-called shallow or transparent orthography, meaning that the connections between the letters and speech sounds are consistent. It is a well-established fact that learning to read is easier in languages that have consistent grapheme-phoneme correspondence (transparent orthographies) than in languages that have inconsistencies (Solheim, Frijters, Lundetrae, & Uppstad, 2018). We believe that the results of this study could be transferable to similar languages as well, especially to the Serbian and Croatian language, as they are very similar to Bosnian and also have transparent orthography.

There are a couple of limitations of this study that need to be mentioned. First, the design of this study was cross-sectional, so we need to be cautious in concluding that there is a real change in the predictors of reading fluency. The difference in the predictors might have been sample specific. This calls for future longitudinal studies which will provide us with more precise answer to this question. Second, although the sample size was sufficient for the overall research question, the sample for subgroups analysis (grades) was barely enough – thus future studies need to include more participants. Finally, we did not include some other predictors that proved significant in earlier studies such as IQ, phonological awareness and working memory, which might share the same variance in explaining reading fluency. Future studies would benefit from including all these significant predictors and testing them together in order to create even better models for prediction of reading fluency.

Conclusion

Knowing the predictors of reading fluency will help educators create better programs for enhancing reading skills of all learners. This study has pointed to four predictors of reading fluency: selective attention, semantic fluency, inhibitory control, and rapid naming. All these skills are susceptible to training and should thus be the focus of early intervention in preschool years.

References

Allan, N. P., Hume, L. E., Allan, D. M., Farrington, A. L., & Lonigan, C. J. (2014). Relations between inhibitory control and the development of academic skills in preschool and kindergarten: A meta-analysis. *Developmental Psychology*, *50*(10), 2368–2379. doi: 10.1037/a0037493

Altemeier, L. E., Abbott, R. D., & Berninger, V. W. (2008). Executive functions for reading and writing in typical literacy development and dyslexia. *Journal of Clinical and Experimental Neuropsychology*, *30*(5), 588–606. doi: 10.1080/13803390701562818

Anthony, J. L., & Francis, D. J. (2005). Development of phonological awareness. *Current Directions in Psychological Science*, *14*(5), 255–259. doi: 10.1111/j.0963-7214.2005.00376.x

Antonacci, P. A., O'Callaghan, C. M., & Berkowitz, E. (2014). *Developing content area literacy: 40 strategies for middle and secondary classrooms*. Sage Publications.

Bashir, A. S., & Hook, P. E. (2009). Fluency: A key link between word identification and comprehension. *Language, Speech, and Hearing Services in Schools*, *40*(2), 196–200. doi: 10.1044/0161-1461(2008/08-0074)

Berninger, V. W., Nielsen, K. H., Abbott, R. D., Wijsman, E., & Raskind, W. (2008). Gender differences in severity of writing and reading disabilities. *Journal of School Psychology*, *46*(2), 151–172. doi: 10.1016/j.jsp.2007.02.007

Biscevic, I., Pasalic, A., & Memisevic, H. (2018). The effects of executive functions and theory of mind on semantic fluency in preschool children. *Problems of Education in the 21st Century*, *76*(1), 21–28.

Bryden, P. J., & Roy, E. A. (2005). A new method of administering the Grooved Pegboard Test: Performance as a function of handedness and sex. *Brain and Cognition*, *58*(3), 258–268. doi: 10.1016/j.bandc.2004.12.004

Bus, A. G., & Van IJzendoorn, M. H. (1999). Phonological awareness and early reading: A meta-analysis of experimental training studies. *Journal of Educational Psychology*, *91*(3), 403. doi: 10.1037/0022-0663.91.3.403

Carrillo, M. (1994). Development of phonological awareness and reading acquisition. *Reading and Writing*, *6*(3), 279–298. doi: 10.1007/BF01027086

Casco, C., Tressoldi, P. E., & Dellantonio, A. (1998). Visual selective attention and reading efficiency are related in children. *Cortex*, *34*(4), 531–546. doi: 10.1016/S0010-9452(08)70512-4

Chiappe, P., & Siegel, L. S. (1999). Phonological awareness and reading acquisition in English- and Punjabi-speaking Canadian children. *Journal of Educational Psychology*, *91*(1), 20–28. doi: 10.1037/0022-0663.91.1.20

Chiappe, P., Siegel, L. S., & Hasher, L. (2000). Working memory, inhibitory control, and reading disability. *Memory & Cognition*, *28*(1), 8–17. doi: 10.3758/BF03211570

Clinton, V., Seipel, B., van den Broek, P., McMaster, K. L., Kendeou, P., Carlson, S. E., & Rapp, D. N. (2014). Gender differences in inference generation by fourth-grade students. *Journal of Research in Reading*, *37*(4), 356–374. doi: 10.1111/j.1467-9817.2012.01531.x

Cohen-Mimran, R. (2009). The contribution of language skills to reading fluency: A comparison of two orthographies for Hebrew. *Journal of Child Language*, *36*(3), 657–672. doi: 10.1017/S0305000908009148

Colé, P., Duncan, L. G., & Blaye, A. (2014). Cognitive flexibility predicts early reading skills. *Frontiers in Psychology*, *5(*565), 1–8. doi: 10.3389/fpsyg.2014.00565

Cunningham, A. E., & Stanovich, K. E. (1997). Early reading acquisition and its relation to reading experience and ability 10 years later. *Developmental Psychology*, *33*(6), 934–945. doi: 10.1037/0012-1649.33.6.934

Daneman, M. (1991). Working memory as a predictor of verbal fluency. *Journal of Psycholinguistic Research*, *20*(6), 445–464. doi: 10.1007/BF01067637

David, D., Wade-Woolley, L., Kirby, J. R., & Smithrim, K. (2007). Rhythm and reading development in school-age children: A longitudinal study. *Journal of Research in Reading*, *30*(2), 169–183. doi:10.1111/j.1467-9817.2006.00323.x

Denckla, M. B., & Rudel, R. (1974). Rapid "automatized" naming of pictured objects, colors, letters and numbers by normal children. *Cortex*, *10*(2), 186–202. doi: 10.1016/S0010-9452(74)80009-2

Deno, S. L. (1985). Curriculum-based measurement:The emerging alternative. *Exceptional Children*, *52*(3), 219–232. doi: 10.1177/001440298505200303

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science (New York, NY)*, *318*(5855), 1387–1388. doi: 10.1126/science.1151148

Di Nuovo, S. (2000). *Attenzione e concentrazione*. Trento, Italy: Edizioni Centro Studi Erickson.

Francis, D. J., Shaywitz, S. E., Stuebing, K. K., Shaywitz, B. A., & Fletcher, J. M. (1996). Developmental lag versus deficit models of reading disability: A longitudinal, individual growth curves analysis. *Journal of Educational Psychology*, *88*(1), 3–17. doi: 10.1037/0022-0663.88.1.3

Fuchs, L. S., Fuchs, D., Hosp, M. K., & Jenkins, J. R. (2001). Oral reading fluency as an indicator of reading competence: A theoretical, empirical, and historical analysis. *Scientific Studies of Reading*, *5*(3), 239–256. doi: 10.1207/S1532799XSSR0503_3

Guo, Y., Sun, S., Breit-Smith, A., Morrison, F. J., & Connor, C. M. (2015). Behavioral engagement and reading achievement in elementary-school-age children: A longitudinal cross-lagged analysis. *Journal of Educational Psychology*, *107*(2), 332–347. doi:10.1037/a0037638

Hasbrouck, J., & Tindal, G. A. (2006). Oral reading fluency norms: A valuable assessment tool for reading teachers. *The Reading Teacher*, *59*(7), 636–644. doi: 10.1598/RT.59.7.3

Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing*, *2*(2), 127–160. doi: 10.1007/BF00401799

Huang, H. C., & Wang, T. Y. (2009). Stimulus effects on cancellation task performance in children with and without dyslexia. *Behavior Research Methods*, *41*(2), 539–545. doi: 10.3758/BRM.41.2.539

Hyde, J. S., & Linn, M. C. (1988). Gender differences in verbal ability: A meta-analysis. *Psychological Bulletin*, *104*(1), 53–69. doi:10.1037/0033-2909.104.1.53

Katzir, T., Kim, Y., Wolf, M., O'Brien, B., Kennedy, B., Lovett, M., & Morris, R. (2006). Reading fluency: The whole is more than the parts. *Annals of Dyslexia*, *56*(1), 51–82. doi: 10.1007/s11881-006-0003-5

Kikas, E., Pakarinen, E., Soodla, P., Peets, K., & Lerkkanen, M. K. (2017). Associations between reading skills, interest in reading, and teaching practices in first grade. *Scandinavian Journal of Educational*

Research, *62*(6), 1–18. doi: 10.1080/00313831.2017.1307272

Kirby, J. R., Parrila, R. K., & Pfeiffer, S. L. (2003). Naming speed and phonological awareness as predictors of reading development. *Journal of Educational Psychology*, *95*(3), 453–464. doi: 10.1037/0022-0663.95.3.453

Kieffer, M. J. (2011). Converging trajectories: Reading growth in language minority learners and their classmates, kindergarten to grade 8. *American Educational Research Journal*, *48*(5), 1187–1225.doi: 10.3102/0002831211419490

Klein, J. R., & Jimerson, S. R. (2005). Examining ethnic, gender, language, and socioeconomic bias in oral reading fluency scores among Caucasian and Hispanic students. *School Psychology Quarterly*, *20*(1), 23–50.doi: 10.1521/scpq.20.1.23.64196

Kolić-Vehovec, S. (2002). Effects of self-monitoring training on reading accuracy and fluency of poor readers. *European Journal of Psychology of Education*, *17*(2), 129–138. doi: 10.1007/BF03173254

Landerl, K., &Wimmer, H. (2008). Development of word reading fluency and spelling in a consistent orthography: An 8-year follow-up. *Journal of Educational Psychology*, *100*(1), 150–161. doi: 10.1037/0022-0663.100.1.150

Levy, B. (2001). Moving the bottom: Improving reading fluency. In M. Wolf (Ed.), *Dyslexia, fluency, and the brain* (pp. 357–379). Timonium, MD: York Press.

Logan, S., & Johnston, R. (2009). Gender differences in reading ability and attitudes: Examining where these differences lie. *Journal of Research in Reading*, *32*(2), 199–214. doi:10.1111/j.1467-9817.2008.01389.x

Lonigan, C. J., Burgess, S. R., & Anthony, J. L. (2000). Development of emergent literacy and early reading skills in preschool children: Evidence from a latent-variable longitudinal study. *Developmental Psychology*, *36*(5), 596–613. doi: 10.1037/0012-1649.36.5.596

Ma, J. K., Le Mare, L., & Gurd, B. J. (2014). Four minutes of in-class high-intensity interval activity improves selective attention in 9- to 11-year olds. *Applied Physiology, Nutrition, and Metabolism*, *40*(3), 238–244. doi: 10.1139/apnm-2014-0309

Manis, F. R., Seidenberg, M. S., & Doi, L. M. (1999). See Dick RAN: Rapid naming and the longitudinal prediction of reading subskills in first and second graders. *Scientific Studies of Reading*, *3*(2), 129–157. doi: 10.1207/s1532799xssr0302_3

Memisevic, H., & Biscevic, I. (2018). Exploring the link between inhibitory control and cognitive flexibility in preschool children. *Cognition, Brain, Behavior*, *22*(1), 1–11. doi: 10.24193/cbb.2018.22.01

Memisevic, H., & Djordjevic, M. (2018). Visual-motor integration in children with mild intellectual disability: A meta-analysis. *Perceptual and Motor Skills*, *125*(4), 696–717. doi: 10.1177/0031512518774137

Monette, S., Bigras, M., & Guay, M. C. (2011). The role of the executive functions in school achievement at the end of Grade 1. *Journal of Experimental Child Psychology*, *109*(2), 158–173. doi: 10.1016/j.jecp.2011.01.008

Morris, D., & Perney, J. (2018). Using a sight word measure to predict reading fluency problems in grades 1 to 3. *Reading & Writing Quarterly*, *34*(4), 338–348. doi: 10.1080/10573569.2018.1446857

Netten, A., Droop, M., & Verhoeven, L. (2011). Predictors of reading literacy for first and second language learners. *Reading and Writing*, *24*(4), 413–425. doi: 10.1007/s11145-010-9234-2

Norton, E. S., & Wolf, M. (2012). Rapid automatized naming (RAN) and reading fluency: Implications for understanding and treatment of reading disabilities. *Annual Review of Psychology*, *63*, 427–452. doi: 10.1146/annurev-psych-120710-100431

Öney, B., & Durgunoğlu, A. Y. (1997). Beginning to read in Turkish: A phonologically transparent orthography. *Applied Psycholinguistics*, *18*(1), 1–15. doi: 10.1017/S014271640000984X

Paris, S. G. (2005). Reinterpreting the development of reading skills. *Reading Research Quarterly*, *40*(2), 184–202. doi: 10.1598/RRQ.40.2.3

Pfost, M., Hattie, J., Dörfler, T., & Artelt, C. (2014). Individual differences in reading development: A review of 25 years of empirical research on Matthew effects in reading. *Review of Educational Research*, *84*(2), 203–244. doi: 10.3102/0034654313509492

Puglisi, M. L., Hulme, C., Hamilton, L. G., & Snowling, M. J. (2017). The home literacy environment is a correlate, but perhaps not a cause, of variations in children's language and literacy development. *Scientific Studies of Reading*, *21*(6), 498–514. doi: 10.1080/10888438.2017.1346660

Puolakanaho, A., Ahonen, T., Aro, M., Eklund, K., Leppänen, P. H., Poikkeus, A. M., ... & Lyytinen, H. (2008). Developmental links of very early phonological and language skills to second grade reading outcomes: Strong to accuracy but only minor to fluency. *Journal of Learning Disabilities*, *41*(4), 353–370. doi: 10.1177/0022219407311747

Reiter, A., Tucha, O., & Lange, K. W. (2005). Executive functions in children with dyslexia. *Dyslexia*, *11*(2), 116–131. doi: 10.1002/dys.289

Solheim, O. J., Frijters, J. C., Lundetræ, K., & Uppstad, P. H. (2018). Effectiveness of an early reading intervention in a semi-transparent orthography: A group randomised controlled trial. *Learning and Instruction*, *58*, 65–79. doi: 10.1016/j.learninstruc.2018.05.004

Stahl, S. A., & Murray, B. A. (1994). Defining phonological awareness and its relationship to early reading. *Journal of Educational Psychology*, *86*(2), 221–234. doi: 10.1037/0022-0663.86.2.221

Teale, W. H., Whittingham, C. E., & Hoffman, E. B. (2018). Early literacy research, 2006–2015: A decade of measured progress. *Journal of Early Childhood Literacy*, *0*(0), 1–54. doi: 10.1177/1468798418754939

Torgesen, J. K., & Hudson, R. F. (2006). Reading fluency: Critical issues for struggling readers. In S. J. Samuels & A. Farstrup (Eds.).*What research has to say about fluency instruction* (pp. 130–158). Newark, DE: International Reading Association.

Troyer, A. K., Moscovitch, M., & Winocur, G. (1997). Clustering and switching as two components of verbal fluency: Evidence from younger and older healthy adults. *Neuropsychology*, *11*(1), 138–146. doi: 10.1037/0894-4105.11.1.138

Voyer, D., & Voyer, S. D. (2014). Gender differences in scholastic achievement: A meta-analysis. *Psychological Bulletin*, *140*(4), 1–31. doi: 10.1037/a0036620

Wagner, D. A. (2017). Children's reading in low-income countries. *The Reading Teacher*, *71*(2), 127–133. doi: 10.1002/trtr.1621

Walczyk, J. J. (2000). The interplay between automatic and control processes in reading. *Reading Research Quarterly*, *35*(4), 554–566. doi: 10.1598/RRQ.35.4.7

Walsh, D. J., Price, G. G., & Gillingham, M. G. (1988). The critical but transitory importance of letter naming. *Reading Research Quarterly*, *23*(1), 108–122. doi: 10.2307/747907

Willows, D. M. (1974). Reading between the lines: Selective attention in good and poor readers. *Child Development*, *45*(2), 408–415. doi: 10.2307/1127962

Wolf, M. (1991). Naming speed and reading: The contribution of the cognitive neurosciences. *Reading Research Quarterly*, *26*(2), 123–141. doi: 10.2307/747978

Wolf, M., & Katzir-Cohen, T. (2001). Reading fluency and its intervention. *Scientific Studies of Reading, 5*(3), 211–239. doi: 10.1207/S1532799XSSR0503_2

Wu, Y. H., Vidal, J. S., de Rotrou, J., Sikkes, S. A., Rigaud, A. S., & Plichart, M. (2017). Can a tablet-based cancellation test identify cognitive impairment in older adults?. *PloS one*, *12*(7), 1–14. doi: 10.1371/journal.pone.0181809

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Self-reassurance, Self-criticism, and Eye-tracking of Happy Faces

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This study explores the relationship between self-criticism, self-reassurance, and the face scanning patterns participants use to recognize photos of happiness. Forty-two participants were being recorded by eye-trackers while watching photos of happy and neutral facial expressions. Participants also completed the Forms of Self-Criticising/Attacking and Self-Reassuring Scale. The Hated Self score was negatively related to the total fixation duration on the eyes and around the eyes. The Inadequate Self score tended to correlate positively with the total fixation duration time on all examined areas of the face and Reassured Self score tended to correlate positively with the total fixation duration time on the area around the eyes, although none of these correlations appeared to be statistically significant. Being able to distinguish between the more pathological Hated Self form of self-criticism and the less pathological Inadequate Self could improve psychological assessment and intervention evaluations.

Key words: emotion, eye-tracking, face, happiness, self-criticism, self-reassurance

Introduction

Emotion Recognition

There has long been a debate on the universality (e.g., Ekman, 1972; Izard, 1971; Matsumoto, 2001) and cultural specificities of recognizing emotions (e.g., Gendron, Roberson, Vyver, & Barrett, 2014; Jack et al., 2012; Lindquist & Barrett, 2012; 1971; Russell, 1994). The highest recognition levels are obtained with the expression of happiness (Calvo & Lundqvist, 2008; Ekman & Friesen, 1976; Hess, Blairy, & Kleck, 1997; Russell, 1994). Previous studies have shown that a joyful expression is recognized with greater accuracy and/or speed than are other primary emotions (e.g., Gablíková & Strnádelová, 2016; Goren & Wilson, 2006; Leppänen & Hietanen, 2004; Palermo & Coltheart, 2004). However, participants who have depression or who are shy, shameful, anxious or have feelings of inadequacy had more difficulty recognizing precisely joyful expressions (e.g., Gotlib, Krasnoperova, Yue, & Joormann, 2004; Gilbert et al., 2006) than participants who experienced none of these. Wang, Hu, Short, and Fu (2012) assumed that the first category of participants tends to avoid direct eye contact during emotion recognition as the

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participants' shyness scores were negatively correlated with fixation on the eyes. Self-criticism is significantly associated with shyness and shame (Gilbert & Miles, 2000). According to McEwan et al. (2014), self-critical people generally perceive happy facial expressions as threatening. Previous research (Schultheiss & Hale, 2007) showed that happy expressions can be problematic because they may be viewed with aversion and as threatening rather than as expressing sympathy or closeness. Self-critical people do not perceive smiles and facial expressions of happiness and compassion as supportive but as unpleasant and even mocking. Similarly, studies based on the concepts of anxiety and social anxiety (see Daly, 1978; Farabee, Holcom, Ramsey, & Cole, 1993) showed that in social interactions anxious individuals spent less time gazing toward a disagreeing fellow than did socially secure individuals.

In Daly's research (1978) scores by high-school students on a paper-and-pencil test of social anxiety were correlated with eye contact during a videotaped interview. Participants with high levels of anxiety held their gaze for less time overall and for bouts of shorter duration when they were talking. Research findings have supported the idea that self-criticism and a low level of self-reassurance are related to anxiety, shame, feelings of inferiority, or inadequacy (Blatt et al., 1992) and are possible markers of gaze avoidance (e.g., Daly, 1978; Wang, Hu, Short, & Fu, 2012). Despite confirmation of a relationship between self-criticism on the one hand and depression, anxiety, social anxiety on the other (Blatt et al., 1992; Gilbert, 2011), there is a lack of research on the relationship between gaze (avoidance) and self-criticism/self-reassurance in facial expression recognition.

Eye-Tracking of Happiness Recognition

There is confusion in the eye-tracking research as to the role the lip and eye regions play in the facial recognition of primary emotions (see e.g., Blais et al., 2012; Pérez-Moreno, Romero-Ferreiro, & García-Gutiérrez; 2016, Schurgin et al., 2014). Milders, Hietanen, and Leppänen (2011) claimed that happy faces are more frequently detected by healthy individuals using a direct gaze. However, Blais et al. (2012) disagreed and found that the lip area was the most important cue for recognition of both the static and dynamic facial expressions. When happy faces were scanned, there tended to be more fixations on the lip region.

However, Williams et al. (2001) conducted a study examining eye-fixation patterns in order to better understand perceptions of the "true" Duchenne smile. The results indicated that participants' eyes fixated more and for longer on the Duchenne region (e.g., on the crow's feet) of a face with a happy expression than on faces with sad and neutral expressions. This is indicative of a tendency to focus on that specific marker when exposed to a happy expression. Manera et al. (2011) also revealed that participants spent significantly more time on the eye region than on the mouth region, especially when the Duchenne marker and the Lid tightener were activated, than they did in relation to smiles with neutral eyes. This research suggests that healthy individuals are sensitive to the appearance changes created by muscular activation in the eye region when recognizing happiness.

It is assumed that the tendency to be submissive is related to an individual feeling inferior to another in some way and the belief that other people are more competent and valid than the submissive individual (Gilbert & Allan, 1994). Studies have also demonstrated that people who see themselves as inferior to others tend to adopt submissive behavior (Allan & Gilbert, 1997; Gilbert & Allan, 1994) and that submissive behavior is negatively correlated with a fear of negative evaluation, part of self-criticism (Gilbert, 2000). Gilbert et al. (2004)

pointed out that self-criticism has two components: "being self-critical", that is overestimating errors and feeling inadequate; and feeling the need to hurt oneself and feeling contempt and self-hate.

We suppose that highly self-critical people with feelings of inadequacy are less dominant and more submissive than less self-critical people or highly self-reassured people. Investigations into the link between self-criticism and submissiveness have shown that submissive individuals avert their gaze from social threats and do not look into the eyes of an individual seen as a social threat (Terburg & van Honk, 2012). It is believed that highly self-critical people tend to have low self-reassurance and that people with high self-reassurance tend to be less self-critical (Gilbert, 2010). Given previous findings related to concepts associated with self-criticism, such as anxiety, shame, and non-dominance (Daly, 1978; Terburg & van Honk, 2012; Wang, Hu, Short, & Fu, 2012), we were interested in the mechanisms underpinning specific patterns in the identification of the emotion of happiness in relation to level of self-criticism and self-reassurance.

We decided to explore the eye-tracking of happy faces, because the emotion of happiness is perceived with obvious barriers or inaccuracies (McEwan et al.; 2014; Schultheiss & Hale, 2007). We suppose that exactly the smiling expression could evoke the biases and be the significant expression from the list of primary emotions in distinguishing the levels of self-criticism/self-reassurance.

Aim of the Study

Our goal was to identify the facial points people focus on when observing the facial expression of happiness in relation to their level of self-criticism and self-reassurance.

Hypotheses of the Study

Based on the previous studies (mainly Daly, 1978; Farabee, Holcom, Ramsey, & Cole, 1993; Wang, Short, Hu, & Fu, 2012; Milders, Hietanen, & Leppänen, 2011; Williams et al., 2011), we expect that:

1) Higher Self-criticism (Inadequate Self and/or Hated Self score) will predict a lower total fixation time on the eyes when observing the facial expression of happiness.

2) Higher Self-reassurance will predict a higher total fixation time on the eyes when observing the facial expression of happiness.

Method

Participants

The research sample consisted of 42 adult participants from Slovakia, (23 women and 19 men; $M = 27.48$ years, $SD = 13.66$). The participants were recruited by convenience sampling from the general community through social media. Respondents could sign up for a session in the eye-tracking lab and one of them received a financial prize for participation through the draw at the end of the data collection. The data were collected in accordance with the ethical standards of the institutional research committee and the 1964 Helsinki declaration and its later amendments as well as comparable ethical standards.

Procedure

After completing the written online consent form and providing socio-demographic data, participants were shown photos representing happiness on the screen. Each happy expression (6 original color version photos) appeared in the middle of a black screen for 5 seconds in random order. The respondents were then asked to enter their free answer (to the question: "What emotion have you seen?") on the computer without any time limit. We did not analyze the emotion identification further as our goal was to detect scanning patterns for happy faces in relation to self-criticism and self-reassurance and, therefore, the question was only used to help participants to concentrate on the pictures more. They were also instructed that once they had pressed the confirm button, the next photo would automatically appear on the screen. After this identification procedure, participants were asked to complete an online version of The Forms of Self-Criticising/Attacking and Self-Reassuring Scale (FSCRS; Gilbert, Clarke, Hempel, Miles, & Irons, 2004, translated into Slovak by Halamová, Kanovský, & Pacúchová, 2017).

Apparatus

Tobii X2 60 eye-trackers with an I-VT Fixation Filter (Olsen & Matos, 2012) were used to track the participant's gaze. The Velocity-Threshold Identification (I-VT) fixation classification algorithm measures the participant's immediate emotional response. The minimum fixation duration was set to 70 ms; shorter fixations were discarded. The monitor measured 52.5 x 32.5 cm, and the respondent's chair was situated 60 cm away from it. The visual angle of the monitor screen was 46.86°. According to previous studies with the same conditions, the visual angle of the facial emotions should be approximately 8° (see Henderson, Williams, & Falk, 2005) so it simulates the real situation of identifying emotions on human faces. All the photos used in our research measured 5.8 cm × 8.7 cm (width × height), with a resolution of 211 × 317 pixels. The calibration was performed before each data collection and Tobii Studio software was used to present the stimuli and collect the eye-tracking data. Three areas of interest (AOI) were identified for each emotional picture: Area of the Eyes, the Area around the Eyes and the Area of the Lips.

Materials

Umeå University Database of Facial Expressions. The criteria for selecting the set of static images (photographs) of human faces expressing happiness were a good proportional representation of gender and age (the database contains younger and older respondents) and validity (a high percentage of people recognize the emotions in the database). After a thorough selection process, the Umeå University Database of Facial Expressions (Samuelsson, Jarnvik, Henningsson, Andersson, & Carlbring, 2012) was selected for use in our study. We selected six photos of happiness that featured both men and women in three age groups (aged about 25 years old, 45 years old, and 65 years old). The models in the database had been instructed to wear no make-up but no further instructions were given regarding face-editing, so the images closely resembled the facial expressions seen in real life. No additional editing was performed other than resizing the photographs to the simulation reflecting the real-life recognition process (see Henderson, Williams, & Falk, 2005). The mean hit rate (in %) for the happy expressions in the database is 98%, which indicates high prototypicality.

Measure

The Forms of Self-Criticising/Attacking & Self-Reassuring Scale (FSCRS; Gilbert, Clarke, Hempel, Miles, & Irons, 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 ranging from "Not at all like me." to "Extremely like me." Items include "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 different countries (e.g., Castilho, Pinto-Gouveia, & Duarte, 2015; Kupeli, Chilcot, Schmidt, Campbell, & Troop, 2013) including Slovakia (Halamová, Kanovský, & Pacúchová, 2017) show that the FSCRS has good reliability and validity properties. The scale has been validated cross-culturally using 13 different nonclinical samples (Halamová et al., 2018), and the original three-factored solution (distinguishing between Inadequate Self and Hated Self) had an acceptable fit.

The outcome variable is *Total Fixation Duration (TFD*, also known as total dwell time, total viewing time, cumulative dwell time, gaze duration, etc.) and is measured in relation to the predefined Areas of Interest (AOI). TFD should be sensitive to slow and long-term cognitive processes (Holmqvist et al., 2011). According to Henderson and Hollingworth (1999, p. 252) there is "a clear effect of the meaning of a scene region on gaze duration in that region, but a less clear effect on first fixation duration". The relationship between attentional allocation and gaze duration is discussed in Eisenbarth and Alpers (2011). If proportion of gaze duration is used instead of TFD, linear-model statistical analyses can be misleading. Beta regression models are more appropriate for proportions, (Ferrari & Cribari-Neto, 2004), although repeated measures ANOVA (RMANOVA) have been used for proportions in some studies (e.g., Farzin, Rivera, & Hessl, 2009).

Data Analyses

We performed our analysis using the R environment for statistical computing version 3.4.0 (R Core Team, 2017), primarily the *lme4* package (Bates, Maechler, Bolker, & Walker, 2015). We first tested for potential multicollinearity by using the Variance Inflation Factor (VIF), and afterwards we used the Generalized Linear Mixed-effect Model (GLMM). The dependent variable Total Fixation Duration (TFD) in seconds or milliseconds was measured for three Areas of Interest (AOI) using the set of stimuli (photos of human faces expressing happiness presented to all participants). The AOIs were defined as the Area of the Eyes, the Area around the Eyes, and the Area of the Lips. The stimuli represented three age categories (young, middle, and old) and the two sexes (male and female). This meant there were two levels of independent variables to be analyzed. For the first level, repeated measurements were taken for each participant. We took into account three mutually crossed within-subject factors: age and sex of the stimulus; and the Areas of Interest (AOI) for each stimulus. The covariates at the second level described the between-subject variation. The participant variable (ID) was a random factor, whereas the between-subject covariates (the questionnaire scores) were treated as fixed factors.

The first step was to detect any potential multicollinearity among the questionnaire scores. The VIF (Variance Inflation Factor) was calculated using the *usdm* package (Babak, 2015) in an attempt to detect multicollinearity. No multicollinearities were found among the FSCRS subscales (VIF for IS = 1.671, HS = 1.836, RS = 1.130) so they could be included in the model as between-subject covariates.

In the second step, we applied the Generalized Linear Mixed-effect Model (GLMM, see for example Lo & Andrews, 2015). The response variable (Total Fixation Duration) had a highly skewed distribution and did not allow negative values, so models based on normal distribution were statistically inappropriate. There are ways to address these problems. One is to use a natural logarithm transformation of TFD (see for example Häikiö & Vainio, 2018; Indrarathne, Ratajczak, & Kormos, 2018). However, log-transformed TFDs are very difficult to interpret and it is hard to compare the results with those based on raw fixation times. This problem can be solved by using GLMM as it specifies the distribution of the dependent variable describing the plausible processes underlying the observed data (Lo & Andrews, 2015). For variables such as duration, waiting time, and time between some events, gamma regression with the inverse link function is often used (for details, see Hogg & Craig, 1978). For Total Fixation Duration (TFD), we modeled the average time between arriving at a particular AOI and skipping to another place. The average "skipping pace" varies with the individual.

As stated above, the dependent variable was Total Fixation Duration (TFD) measured in seconds. Because each participant viewed the same set of stimuli (i.e., pictures of human faces of varying age and sex) and because we defined the same three AOIs on each face, our data revealed the following structure: the sex and age of the stimuli, and the AOI were considered to be within-subject factors entered into the model as fixed effects. The participant identifier (ID) was included as a random effect in the model. Covariates, that is scores on dimensions of the FSCRS questionnaire (Inadequate Self, Hated Self, Reassured Self), were also kept as fixed effects. Our hypotheses (given in the Hypotheses section) concern the interaction between the self-reassurance and self-criticism measures and the AOI. Because we did not consider the sex and age of the stimuli to be relevant factors, we did not include them in the models.

To perform the GLMM analyses we used *lme4* (Bates, Maechler, Bolker, & Walker, 2015) and to display the effects we used the *effects* package (Fox, 2003), both in the statistical environment R (R Core Team, 2018). As fixed effects, we entered the FSCRS subscale scores in an interaction with the Areas of Interest (AOI). As random effects, we used intercepts for participants. The R code syntax for the model was:

```
fm4 <- glmer(TFD ~ (FSCRS_IS + FSCRS_HS + FSCRS_RS)*AOI + (1 | id), data = x, family = Gamma(link="inverse"), control=glmerControl(optimizer="bobyqa", optCtrl = list(maxfun = 100000)))
```

R^2 ('variance explained') statistics were used to measure the effect size of the model. However, with GLMMs, estimating the R^2 is far from trivial and there is no consensus as to the most appropriate definition of R^2 statistics in relation to mixed-effect models (Edwards et al., 2008; Nakagawa & Schielzeth, 2013; LaHuis, Hartman, Hakoyama, & Clark, 2014; Jaeger, Edwards, Das, & Sen, 2016). Although several methods for estimating the coefficient of determination (R^2) for mixed-effect models are available in the *r2glmm* package (Jaeger, 2017), only the Standardized Generalized Variance approach (SGV) can be used with GLMMs (Jaeger, Edwards, Das, & Sen 2016). This package first estimates the model parameters using the penalized quasi-likelihood, and then estimates the R^2 statistics for the model as well as the semi-partial R^2 for the fixed effects. Graphs were obtained by plotting the marginal effects using R package *jsPlot* (Lüdecke, 2018).

Results

The descriptive statistics for the FSCRS subscale scores and Total Fixation Duration (TFD), mutual correlations among the covariates (i.e., FSCRS subscale scores) as well as the Pearson product-moment correlations between the covariates and the mean TFDs for particular areas of interest (AOIs) are shown in Tables 1.1, 1.2, and 1.3. The TFD plots are given for various combinations of level of fixed effect in relation to level of Inadequate Self, Hated Self, and Reassured Self for the three AOIs: the eyes, lips, and area around the eyes (Figure 1, Figure 2, and Figure 3).

Table 1.1 *Descriptive statistics for FSCRS subscale scores and for the Total Fixation Duration (TFD) in milliseconds*

	n	Mean	SD	Median	Trimmed Mean (tr = .2)	MAD	Min	Max	Skewness	Kurtosis	SE
FSCRS subscale IS	42	15.9	6.99	15	15.42	7.41	2	31	.22	-.76	1.08
FSCRS subscale HS	42	3.45	2.88	3	3	2.97	0	12	1.03	.69	.44
FSCRS subscale RS	42	22.67	4.84	22.5	23	3.71	12	31	-.33	-.62	.75
AOI Lips: Mean TFD (ms)	42	284.37	357.94	122.5	182.31	181.62	0	1533.33	1.53	1.94	55.23
AOI Around Eyes: Mean TFD (ms)	42	369.68	262.34	282.5	341.35	255.75	0	990	.53	-.73	4.48
AOI Eyes: Mean TFD (ms)	42	628.73	486.79	522.5	557.05	509.03	0	2008.33	.78	-.09	75.11

Note. FSCRS – The Forms of Self-Criticising/Attacking & Self-Reassuring Scale, IS – Inadequate Self, HS – Hated Self, RS – Reassured Self, TFD – Total Fixation Duration, AOI – Areas of Interest.

Table 1.2 *Pearson product-moment correlations between the FSCRS subscale scores*

	FSCRS subscale IS	FSCRS subscale HS	FSCRS subscale RS
FSCRS subscale IS	1	.568**	-.129
FSCRS subscale HS	.568**	1	-.278
FSCRS subscale RS	-.129	-.278	1

Note. ** – Correlation is significant at the .01 level (2-tailed). FSCRS – The Forms of Self-Criticising/Attacking & Self-Reassuring Scale, IS – Inadequate Self, HS – Hated Self, RS – Reassured Self, TFD – Total Fixation Duration, AOI – Areas of Interest.

Table 1.3 *Pearson product-moment correlations between the FSCRS subscale scores and the mean Total Fixation Duration (TFD) for particular AOI*

	AOI Lips: Mean TFD	AOI Around Eyes: Mean TFD	AOI Eyes: Mean TFD
FSCRS subscale IS	.264	.341*	-.011
FSCRS subscale HS	.022	.051	-.155
FSCRS subscale RS	-.084	.148	-.132

Note. * – Correlation is significant at the .05 level (2-tailed). FSCRS – The Forms of Self-Criticising/Attacking & Self-Reassuring Scale, IS – Inadequate Self, HS – Hated Self, RS – Reassured Self, TFD – Total Fixation Duration, AOI – Areas of Interest.

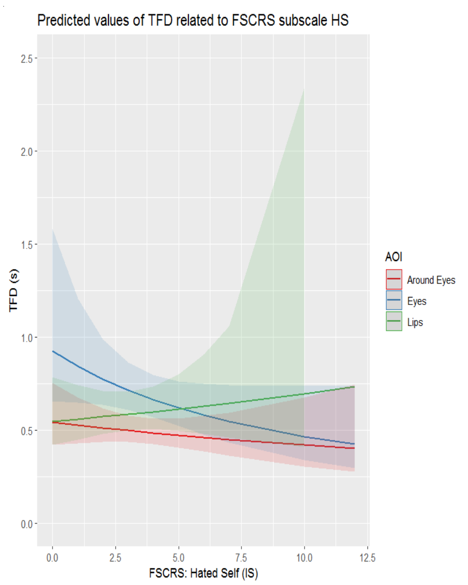

Figure 1 The plots of TFD for Hated Self of FSCRS

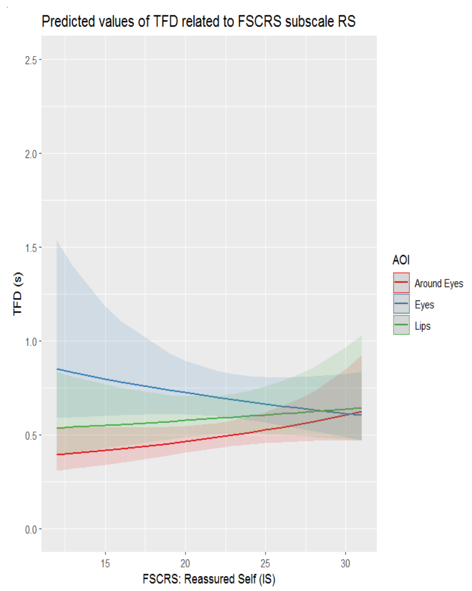

Figure 3 The plots of TFD for Reassured self of FSCRS

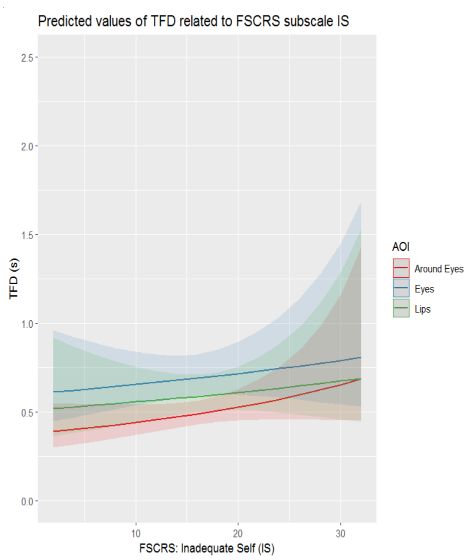

Figure 2 The plots of TFD for Inadequate self of FSCRS

As explained above, the Gamma distribution is a much more appropriate model for the TFD distribution. After the Generalized Linear Mixed-effect Model based on Gamma distribution was fitted, the residuals followed the normal distribution sufficiently for practical needs. The overall fit of the model was low (estimated $R^2 = .126$ with 95% CI [.09, .212]).

The information criteria for the multilevel model were as follows: AIC = 483; BIC = 54.4; the intraclass correlation ICC = .264. The estimated *t*-values in the mixed-effect regression analysis (Table 2) show that the "Eyes" AOI was a significant predictor of Total Fixation Duration (the negative estimate of the Beta value indicates the fixation duration was longer than for the "Lips" AOI). Also, the estimate of the semipartial $R^2 = .015$ (95% CI [.001, .049]) revealed the strongest partial effect. As far as our hypotheses are concerned, the most interesting results relate to the interaction between the various FSCRS dimensions and AOIs.

A rising score on the Hated Self (HS) subscale was generally negatively correlated to Total Fixation Duration on the eye region (β = .146, p = .018; semi-partial R^2 = .009). A similar but weaker effect was observed for the relation between Hated Self score and Total Fixation Duration for the area around the eyes. However, there was no relationship between Total Fixation Duration for the lips and Hated Self score. This finding supports the first hypothesis, but only for the Hated Self dimension. Participants scoring higher on Inadequate Self generally fixated more on all the areas of the face. But this effect was very weak and statistically insignificant (β = -.016, p = .544; semi-partial R^2 = .001). This part of the first hypothesis was therefore not supported by the empirical findings.

Participants scoring higher on Reassured Self tended to spend less time fixating on the eyes than on the area of the lips (β = .042, p = .082;

Table 2 *Mixed effect regression analysis*

Generalized Linear Mixed-effect Model fit by maximum likelihood (Laplace Approximation) ['glmerMod']. Family: Gamma (inverse)

Formula: TFD ~ (FSCRS_IS + FSCRS_HS + FSCRS_RS) * AOI + (1 | id)

Control: glmerControl(optimizer = "bobyqa". optCtrl = list(maxfun = 1e+05))

AIC	BIC	LogLik	Deviance	Df.resid
483	54.4	-227.5	455	433

Scaled residuals

Min	1Q	Median	3Q	Max
-1.335	-.757	-.230	.587	3.854

Random effects:

Groups	Name	Variance	*SD*
id	(Intercept)	.168	.410
Residual		.468	.684
ICC		.264	

Number of obs: 447. groups: id. 40

Fixed effects:

	Estimate (Beta)	SE	*t*	*p*	R^2	lower CL	upper CL
(Intercept)	2.456	.765	3.212	.001**			
FSCRS subscale IS	-.016	.026	-.606	.544	.001	0	.019
FSCRS subscale HS	-.039	.073	-.529	.597	.001	0	.019
FSCRS subscale RS	-.016	.030	-.549	.583	.001	0	.019
AOI Around Eyes	1.136	.823	1.380	.168	.007	0	.033
AOI Eyes	-1.726	.587	-2.942	.003**	.015	.001	.049
FSCRS subscale IS × AOI Around Eyes	-.021	.026	-.813	.416	.002	0	.021
FSCRS subscale IS × AOI Eyes	.003	.021	.121	.904	0	0	.014

Table 2 continues

Table 2 continued

Table 2 *Mixed effect regression analysis*

	Estimate (Beta)	SE	*t*	*p*	R^2	lower CL	upper CL
FSCRS subscale HS × AOI Around Eyes	.092	.072	1.267	.205	.004	0	.026
FSCRS subscale HS × AOI Eyes	.146	.062	2.358	.018*	.009	0	.039
FSCRS subscale RS × AOI Around Eyes	-.034	.030	-1.119	.263	.004	0	.026
FSCRS subscale RS × AOI Eyes	.042	.024	1.739	.082	.005	0	.03
R^2 for model					.126	.09	.212

Note. 1Q – first quartile of the residuals, 3Q – third quartile of the residuals, AIC – Akaike's Information Criterion, AOI – Areas of Interest, BIC – Bayesian Information Criterion, CL – Limit of the 95 % confidence interval, Df.resid – residual degrees of freedom, FSCRS – The Forms of Self-Criticising/Attacking and Reassuring Scale, HS – Hated Self, ICC – Intraclass correlation coefficient, IS – Inadequate Self, LogLik – Logarithm of likelihood, Min – Minimum of the residuals, Max – Maximum of the residuals, *p* – p-value for the null hypothesis that the estimated regression model parameter is equal 0, R^2 – squared semi-partial correlation coefficient used as an effect size, RS – Reassured Self, SE – Standard Error of the regression model parameter estimate, *t* – Student's test statistics.

semi-partial R^2 = .005). They spent more time fixating on the area around the eyes, but this effect was not statistically significant β = -.003, p = .263; semi-partial R^2 = .004. Consequently, the data did not support our second hypothesis.

Discussion

The results of our eye-tracking study indicate that scanning patterns differ in people recognizing the facial expression of happiness according to level of self-criticism and level of self-reassurance. Our findings allow us to partially accept our first hypothesis that self-criticism is related to avoidance of direct eye contact. But it is so only for people who have the more pathological form of self-criticism, Hated Self, and not for people with Inadequate Self. Hated Self is an indicator of the need to hurt oneself through self-contempt and self-hate (Gilbert et al., 2004). Thus, the results are in line with the assumption that a more aggressive or disgust form of self-criticism is related to eye avoidance when recognizing the emotion of happiness in another person.

The results are consistent with previous research findings obtained using constructs such as shyness (Wang, Short, & Fu, 2012), neuroticism (Perlman et al., 2009), anxiety (Wang & Yue, 2011), social anxiety (Daly, 1978; Farabee, Holcom, Ramsey, & Cole, 1993), and empathy (Cowan, 2015) and emphasize the avoidance of fixating on some areas of the face, in some cases directly on the eye area (Cowan, 2015; Wang, Short, Hu & Fu, 2012). In contrast to these findings, higher Inadequate Self score tended to be related to fixating more on all the areas of the faces analyzed (the eyes, outside the eyes as well as the lips) but not to a statistically significant degree. Thus, the Hated Self seems to be a significant form of self-criticism in exploring the biases in happy faces scanning.

We were unable to confirm the second hypothesis that self-reassurance would be related to concentration more on the eye area than the lip area when recognizing happy expressions. Although, not a statistically significant finding it is interesting that people with a higher level of self-reassurance tended to spend more time fixating on the area around the eyes where the happiness wrinkles known as crow's feet are located. A happy face may naturally attract more attention towards the lip area because the lips may be crucial to recognizing the emotion of joy (Schurgin et al., 2014; Blais et al., 2012). Nevertheless, while self-reassured people recognize the expression using an evident cue in the lower parts of the face, it seems they specifically check the region around the eyes that may hide information as to whether the person is truly happy (Manera et al., 2011; Williams et al., 2011), as conveyed by the Duchenne smile (Williams et al., 2001). Definitely, this tendency should be further tested in future research as it might be used for future diagnostic purposes.

We are aware of several limitations of our study. The research was conducted in an artificial laboratory setting, and this may have created specific conditions, as the participants did not have to simulate real interaction with emotional faces in the usual social environment. Another limitation is the convenience sample of 42 participants, mainly consisting of young respondents recruited from a community of the nonclinical population. As the Hated Self seems to be significant predictor of scanning patterns in self-critical sample, further research should focus on selection of participants with particularly high level of Hated Self or Reassured Self or even participants with severe clinical diagnoses. Then, the results might be demonstrated even more clearly and that would be very meaningful for further diagnostic purposes. Even though the size stimuli of 6 happy expressions in our study was as it is recommended by previous research (Henderson, Williams, & Falk, 2005), we might extend their size in future research to test the effect of their size on the results. Facial-expression databases are a standard instrument for measuring facial-emotion recognition (e.g., Steele et al., 2008) because in general, photos of emotional faces elicit a higher subjective response than videos due to their projective nature (see e.g., Poláčková Šolcová, & Lačev, 2017). However, further research may compare the biases comparing static and dynamic stimuli among self-critical individuals to explore the differences in various conditions of viewing. In addition, while the happy faces' scanning was our first interest to explore, other primary emotions can also be relevant for self-criticism and self-reassurance (e.g., angry or sad stimuli). This should be addressed in future research.

Nonetheless, the results are promising in terms of assessing people who score high on Hated Self and in distinguishing them from people with a less pathological form of self-criticism, represented by their Inadequate Self score on the FSCRS. Finally, the study consists of a single experiment using happy faces only, and it is a simple preliminary study that needs to be extended in an additional study to test all the primary emotions.

Conclusion

Our study on scanning patterns and recognition of the facial emotion of happiness has shown that these differed between people according to level and form of self-criticism and self-reassurance. Participants with a higher Hated Self score focused significantly less on the eyes and the areas around the eyes, while participants with a higher Inadequate Self score tended to fixate more on all the areas of the person's face. Self-reassured participants tended to concentrate more on the area around the eyes when recognizing happy facial expressions. These findings deserve further research and the intention is to investigate all the primary emotions. They could potentially be exploited for potential diagnostic purposes in the future. As this study has suggested, eye-tracking is a more objective method than self-report questionnaires and as such is a promising method for research on self-criticism and self-reassurance.

References

Adams, R., & Kleck, R. (2003). Perceived gaze direction and the processing of facial displays of emotion. *Psychological Science*, *14,* 644–647. doi: 10.1046/j.0956-7976.2003.psci_1479.x

Allan, S., & Gilbert, P. (1997). Submissive behavior and psychopathology. *British Journal of Psychopathology,* 36, 467–488. doi: 10.1111/j.2044-8260.1997.tb01255.x

Babak, N. (2015). *usdm: Uncertainty analysis for species distribution models. R package version 1.1-15*. Retrieved from https://CRAN.R-project.org/package=usdm

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models using lme4. *Journal of Statistical Software, 67*(1), 1–48. doi:10.18637/jss.v067.i01

Blais, C., Roy, C., Fiset, D., Arguin, M., & Gosselin, F. (2012). The eyes are not the window to basic emotions. *Neuropsychologia, 50*, 2830–2838. doi: 10.1016/j.*neuropsychologia*.2012.08.010

Blatt, S. J., Quinlan, D. M., Chevron, E. S., McDonald, C., & Zuroff, D. (1982). Dependency and self-criticism: Psychological dimensions of depression. *Journal of Consulting and Clinical Psychology, 50*(1), 113–124. doi: http://dx.doi.org/10.1037/0022-006X.50.1.113

Calvo, M. G, & Lundqvist, D. (2008). Facial expressions of emotion (KDEF): Identification under different display-duration conditions. *Behavior Research Methods*, *40*(1), 109-15. doi: 10.3758/BRM.40.1.109

Castilho, P., Pinto-Gouveia, J., & Duarte J. (2015). Exploring self-criticism: Confirmatory factor analysis of the FSCRS in clinical and nonclinical samples. *Clinical Psychology & Psychotherapy*, *22*(2), 153–164. doi: 10.1002/cpp.1881.

Cowan, D. G. (2015). *The empathic gaze and how to find it: Eye-gaze behaviour to expressions of emotion* (Bachelor thesis). The University of Queensland, Australia.

Daly, S. (1978). Behavioural correlates of social anxiety. *British Journal of Clinical Psychology*, *17*, 117–120. doi: 10.1111/j.2044-8260.1978.tb00252.x

Ekman, P. (1972). Universal and cultural differences in facial expression of emotion. In J. R. Cole (Ed.), *Nebraska Symposium on Motivation, 1971* (Vol. 19, pp. 207–283). Lincoln, NE: Nebraska University Press.

Edwards, L. J., Muller, K. E., Wolfinger, R. D., Qaqish, B. F., & Schabenberger, O. (2008). An R2 statistic for fixed effects in the linear mixed model. *Statistics in Medicine, 27*(29), 6137–6157. doi: 10.1080/02664763.2016.1193725

Eisenbarth, H., & Alpers, G. W. (2011). Happy mouth and sad eyes: Scanning emotional facial expressions. *Emotion, 11*(4), 860–865. doi: 10.1037/a0022758

Ekman, P. (1993). Facial expression and emotion. *American Psychologist*, *48*(4), 384–392. doi: 0003-066X/93/52:00

Ekman, P., & Friesen, W. V. (1971). Constants across cultures in the face and emotion. *Journal of Personality and Social Psychology, 17*(2), 124–129.

Farabee, D. J., Holcom, M. L., Ramsey, S. L, *&* Cole, S. G. (1993). Social anxiety and speaker gaze in a persuasive atmosphere. *Journal of Research in Personality, 27*, 365–376. doi: 10.1006/jrpe.1993.1025

Farzin, F., Rivera, S. M., & Hessl, D. (2009). Brief report: Visual processing of faces in individuals with fragile X syndrome: An eye tracking study. *Journal of Autism and Developmental Disorders, 39*(6), 946–952. doi: 10.1007/s10803-009-0744-1

Ferrari, S., & Cribari-Neto, F. (2004). Beta regression for modelling rates and proportions. *Journal of Applied Statistics, 31*(7), 799–815. doi: 10.1080/0266476042000214501

Fox, J. (2003). Effect displays in R for Generalised Linear Models. *Journal of Statistical Software, 8*(15), 1–27. URL http://www.jstatsoft.org/v08/i15/

Gablíková, M., & Strnádelová, B. (2016). Teachers' ability to detect student's facial expressions of emotion. In J. Halamová (Ed.), *Komunitná psychológia na Slovensku 2016* (pp. 100–108). Bratislava: Univerzita Komenského v Bratislave vo Vydavateľstve UK pre Ústav aplikovanej psychológie.

Gendron, M., Roberson, D., van der Vyver, J. M., & Barrett, L. F. (2014). Perceptions of emotion from facial expressions are not culturally universal: Evidence from a remote culture. *Emotion*, *14*(2), 251–62. doi: 10.1037/a0036052

Gilbert, P. (2010). *Training our minds in, with and for compassion. An introduction to concepts and compassion-focused exercises*. Retrieved on 21.8.2016 from: http://wtm.thebreathproject.org/wp-content/uploads/2016/03/COMPASSION-HANDOUT.pdf

Gilbert, P., & Allan, S. (1994). Assertiveness, submissive behavior, and social comparison. *British Journal of Clinical Psychology*, 33, 295–306.

Gilbert, P., Baldwin, M. W., Irons, Ch., Bacus, J. R., *&* Palmer, M. (2006). Self-criticism and Self-warmth: An imagery study exploring their relation do depression. *Journal of Cognitive Psychotherapy, 20*(2), 183–200. doi: 10.1891/088983906780639817

Gilbert, P., Clark, M., Hempel, S., Miles, J. N. V., & Irons, C. (2004). Criticising and reassuring oneself: An exploration of forms, styles and reasons in female students. *British Journal of Clinical*

Psychology, *43*, 31–50. doi: 10.1348/014466504772812959

Goren, D., & Wilson, H. R. (2006). Quantifying facial expression recognition across viewing conditions. *Vision Research, 46,* 1253–1262. doi: 10.1016/j.visres.2005.10.028

Gotlib, I. H., Krasnoperova, E., Yue, D. N., & Joormann, J. (2004). Attentional biases for negative interpersonal stimuli in clinical depression. *Journal of Abnormal Psycholology*, *113,* 127–135. doi: 10.1037/0021-843X.113.1.121

Häikiö, T., & Vainio, S. (2018). Syllables and inflectional morphemes in early Finnish readers: Evidence from eye-movements. *Journal of Child Language*, 1–19. doi: 10.1017/S0305000918000132

Halamová, J., Kanovský, M., Gilbert, P., Kupeli, N., Troop, N., Zuroff, D., Hermanto, N., Petrocchi, N., Sommers-Spijkerman, M., Kirby, J., Shahar, B., Krieger, T., Matos, M., Asano, K., Yu, F., & Basran, J. (2018). The factor structure of the Forms of Self-Criticising/Attacking & Self-Reassuring Scale in thirteen populations. *Journal of Psychopathology and Behavioral Assessment, 40*(4), 736–751. doi: 10.1007/s10862-018-9686-2

Halamová, J., Kanovský, M., & Pacúchová M. (2017). Robust psychometric analysis and factor structure of the Forms of Self–criticizing/Attacking and Self–reassuring Scale. *Československá Psychologie, 4*, 456–471.

Henderson, J. M., & Hollingworth, A. (1999). High-level scene perception. *Annual Review of Psychology, 50*(1), 243–271.

Henderson, J. M., Williams, C. C., *&* Falk, R. J. (2005). Eye movements are functional during face learning. *Memory & Cognition*, *33*, 98–106. doi: 10.3758/BF03195300

Hess, U., Blairy, S., & Kleck, R. E. (1997). The intensity of emotional facial expressions and decoding accuracy. *Journal of Nonverbal Behavior, 21*, 241–257.

Hessels, R. S., Kemner, C., van den Boomen, C., et al. (2016). The area-of-interest problem in eyetracking research: A noise-robust solution for face and sparse stimuli. *Behavior Research Methods, 48*(4), 1694–1712. doi: 10.3758/s13428-015-0676-y

Hogg, R. V., & Craig, A. T. (1978). *Introduction to mathematical statistics, 4th edition* (Section 3.3). New York: Macmillan.

Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H., & Van de Weijer, J. (2011). *Eye tracking: A comprehensive guide to methods and measures*. Oxford: Oxford University Press.

Indrarathne, B., Ratajczak, M., & Kormos, J. (2018). Modelling changes in the cognitive processing of grammar in implicit and explicit learning conditions: Insights from an eye-tracking study. *Language Learning 8*(3), 669–708. doi: 10.1111/lang.12290

Izard, C. E. (1971). *The face of emotion*. East Norwalk, CT: Appleton-Century-Crofts.

Jaeger, B. C., Edwards, L. J., Das, K., & Sen, P. K. (2016). An R2 statistic for fixed effects in the generalized linear mixed model. *Journal of Applied Statistics, 44*(6), 1086–1105. doi: 10.1080/02664763.2016.1193725

Jaeger, B. (2017). *r2glmm: Computes R Squared for Mixed (Multilevel) Models. R package version 0.1.2*. Retrieved from https://CRAN.R-project.org/package=r2glmm

Jack, R. E., Garrod, O. G. B., Yu, H., Caldara, R., *&* Schyns, P. G. (2012). Facial expressions of emotion are not culturally universal. *Proceedings of the National Academy of Sciences of the United States of America*. *109*(19), 7241–7244. doi: 10.1073/pnas.1200155109

Kupeli, N., Chilcot, J., Schmidt, U. H., Campbell, I. C., & Troop, N. A. (2013). A confirmatory factor analysis and validation of the forms of Self-Criticism/Reassurance Scale. *British Journal of Clinical Psychology*, *52*(1), 12–25. doi: 10.1111/j.2044-8260.2012.02042

LaHuis, D. M., Hartman, M. J., Hakoyama, S., & Clark, P. C. (2014). Explained variance measures for multilevel models. *Organizational Research Methods, 17*(4), 433–451. doi: 10.1177/1094428114541701

Leppänen, J. M., & Hietanen, J. K. (2004). Positive facial expressions are recognized faster than negative facial expressions, but why? *Psychological Research, 69*, 22–29. doi: 10.1007/s00426-003-0157-2

Lindquist, K. A., & Barrett, L. F. (2012). A functional architecture of the human brain: Insights from emotion. *Trends in Cognitive Sciences, 16*(11), 533–540. doi: 10.1016/j.tics.2012.09.005

Lo, S., & Andrews, S. (2015). To transform or not to transform: Using generalized linear mixed models to analyse reaction time data. *Frontiers in Psychology*, *6*, 1171. doi: 10.3389/fpsyg.2015.01171

Lüdecke, D. (2018). *sjPlot: Data visualization for statistics in social science*. (R package version 2.6.1). Retrieved from https://CRAN.R-project.org/package=sjPlot

Manera, V., Del Giudice, M., Grandi, E., & Colle, L. (2011). Individual differences in the recognition of enjoyment smiles: No role for perceptual-attentional factors and autistic-like traits. *Frontiers in Psycholology, 2,* 143. doi: 10.3389/fpsyg.2011.00143

Matsumoto, D. (2001). Culture and emotion. In D. Matsumoto (Ed.), *The handbook of culture and psychology* (pp. 171–194). New York: Oxford University Press.

McEwan, K., Gilbert, P., Dandeneau, S., Lipka, S., Maratos, F., Paterson, K. B., & Baldwin, M. (2014). The processing of compassionate and critical facial expressions. *PLos One, 9*(2), 1–8. doi: 10.1371/journal.pone.0088783.

Milders, M., Hietanen, J. K., Leppänen, J. M., & Braun, M. (2011). Detection of emotional faces is modulated by the direction of eye gaze. *Emotion, 11*(6), 1456–1461. doi: 10.1037/a0022901

Nakagawa, S., & Schielzeth, H. (2013). A general and simple method for obtaining R2 from generalized linear mixed-effects models. *Methods in Ecology and Evolution, 4*(2), 133-142. doi: 10.1111/J.2041-210x.2012.00261.X

Olsen, A., & Matos, R. (2012). Identifying parameter values for an I-VT fixation filter suitable for handling data sampled with various sampling frequencies. In C. H. Morimoto, H. O. Istance, S. N. Spencer, J. B. Mulligan, & P. Qvarfordt (Eds.), *Proceedings of the 2012 symposium on eye tracking research and applications*, ETRA 2012 (pp. 317–320). New York: ACM.

Palermo, R., & Coltheart, M. (2004). Photographs of facial expression: Accuracy, response times, and ratings of intensity. *Behavior Research Methods, Instruments, & Computers, 36*, 634–638. doi: 10.3758/BF03206544

Perlman, S. B., Morris, J. P., Vander Wyk, B. C., Green, S. R., Doyle, J. L., et al. (2009). Individual differences in personality predict how people look at faces. *PLos One, 4*(6): e5952. doi: 10.1371/journal.pone.0005952

Pinheiro, J., Bates, D., DebRoy, S., Sarkar, D., & R Core Team (2017). *nlme: Linear and Nonlinear Mixed Effects Models. R package version 3.1-131*. Retrieved from https://CRAN.R-project.org/package=nlme

Poláčková Šolcová, I., & Lačev, A. (2017). Differences in male and female subjective experience and physiological reactions to emotional stimuli. *International Journal of Psychophysiology, 117*, 75–82. doi: 10.1016/j.ijpsycho.2017.04.009.

R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Retrieved from http://www.R-project.org/.

Russell, J. A. (1994). Is there universal recognition of emotion from facial expression? A review of cross-cultural studies. *Psychological Bulletin*, *115*, 102–141.

Samuelsson, H., Jarnvik, K., Henningsson, H., Andersson, J., & Carlbring, P. (2012). The Umeĺ University database of facial expressions: A validation study. *Journal of Medical Internet Research, 14*(5), 136. doi: 10.2196/jmir.2196

Schurgin, M. W., Nelson J., Iida S., Ohira, H., Chiao, J. Y., & Franconeri S. L. (2014). Eye movements during emotion recognition in faces. *Journal of Vision 14*(13), 1–16. doi: 10.1167/14.13.14

Schultheiss, O. C., & Hale, J. A. (2007). Implicit motives modulate attentional orienting to facial expressions of emotion. *Motiv Emotion 31,* 3–24. doi: 10.1007/s11031-006-9042-9 .

Terburg, D., Aarts, H., & van Honk, J. (2012). Memory and attention for social threat: Anxious hypercoding-avoidance and submissive gaze aversion. *Emotion, 12*(4), 666–672. doi: 10.1037/a0027201

Wang, Q., Hu, C., Short. L. A., & Fu, G. (2012). The influence of shyness on the scanning of own- and other-race faces in adults. *PLoS ONE, 7*(12). doi: 10.1371/journal.pone.0052203

Wang, L., & Yue, X. (2011). *Attention bias during processing of facial expressions in trait anxiety: An eye-tracking study.* 2011 International Conference on Electronics and Optoelectronics (ICEOE 2011). doi: 10.1109/ICEOE.2011.6013117

Williams, L. M., Senior, C., David, A. S., Loughland, C. M., & Gordon, E. (2001). In search of the "Duchenne smile": Evidence from eye movements. *Journal of Psychophysiology*, *15*, 122–127. doi: 10.1027//0269-8803.15.2.122