Epilepsy & Behavior xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Epilepsy & Behavior

journal homepage: www.elsevier.com/locate/yebeh

Brief Communication

Gaze matters! The effect of gaze direction on emotional enhancement of memory for faces in patients with mesial temporal lobe epilepsy

Łukasz Okruszek [a,*], Aleksandra Bala [b], Marcela Dziekan [b], Marta Szantroch [c], Andrzej Rysz [c], Andrzej Marchel [c], Sylwia Hyniewska [d]

[a] Clinical Neuroscience Lab, Institute of Psychology, Polish Academy of Science, Warsaw, Poland
[b] Faculty of Psychology, University of Warsaw, Warsaw, Poland
[c] Department of Neurosurgery, Medical University of Warsaw, Warsaw, Poland
[d] University of Bath, Bath, United Kingdom

ARTICLE INFO

Article history:
Received 13 October 2016
Revised 21 March 2017
Accepted 8 April 2017
Available online xxxx

Keywords:
Temporal lobe epilepsy
Gaze
Emotion
Amygdala
Emotional memory
Self-relevance
Appraisal
Amygdala lesion

ABSTRACT

Purpose: The aim of the study was to examine if gaze and emotional expression, both highly self-relevant social signals, affect the recollection accuracy of perceived faces in patients with mesial temporal lobe epilepsy (MTLE).
Methods: Forty patients with MTLE (twenty-one without surgery and nineteen after anterior temporal lobectomy) as well as twenty healthy controls (HC) took part in the study. We used a set of 64 facial stimuli: 32 neutral and 32 emotional displays (16 fearful; 16 angry) from well-established affective stimuli databases. Half of the faces in each condition had eyes directed straight and half — away from the observer. Participants performed a gender identification task, and then, after a 45-minute delay were asked to identify the previously seen stimuli, presented among a new set of photos.
Results: Increased automatic learning of angry and fearful compared to neutral expressions was found in HC. There was no emotional enhancement of memory in MTLE but an increased learning for faces with averted than direct gaze.
Conclusion: Our results expand on previous research by demonstrating that emotion expression and gaze direction can affect memory of faces. The study supports the hypothesis that healthy individuals and patients with temporal lobe abnormalities present different patterns of emotional gazes processing. The potential consequences of altered emotional gaze processing and social cognition impairments need to be further investigated to improve the quality of life of patients with MTLE.

1. Introduction

Emotional enhancement of memory is a well-established phenomenon, which may be attributed to the modulation of the medial temporal lobe memory activity by the amygdala [1], a brain structure that may be critical for emotion processing and the closely-linked relevance detection [2,3]. Interestingly, attention cueing [4] and capture [5] by emotional stimuli have been observed to be preserved in patients with amygdala damage. Similarly, it has been observed that despite dysfunctional limbic activity, emotions can enhance memory in patients with temporal lobe resection, although the effect was limited to fearful facial expressions [6].

Researchers have speculated that reactions to faces rely on the inference about inner-states of expressers and the expressers' direction of attention, and both those cues are appraised with respect to the observer's own goals and well-being (self-relevance) [2]. According to the appraisal theories of emotion, the interaction between gaze and expression affects the interpretation and the degree of relevance of perceived faces to the observer. Fearful faces with an averted gaze might signal danger in the environment, while angry faces with a direct gaze might signal aggressive intentions and these self-relevant configurations would elicit stronger amygdala activation [2]. Reduced appraisal of self-relevant emotional gaze has been observed in patients with unilateral amygdala damage after lobectomy [3]. At the same time, most of the studies which examined the interaction between emotional expressions and gaze processing tasks which required participants to provide explicit ratings of emotional stimuli [2,3]. Here we aim at expanding these empirical studies, by examining the extent to which automatic processing of highly self-relevant emotional gazes (anger directed at and fear away from the observer) enhances memory in healthy controls (HC) and patients with mesial temporal lobe epilepsy (MTLE) without surgery (ATL−) or after anterior temporal lobectomy (ATL+). Whereas it is difficult to find participants that meet the required criteria, we believe it is important to conduct a study with a relatively large sample

* Corresponding author at: Institute of Psychology, Polish Academy of Science, Warsaw, Jaracza 1, 00-378 Warsaw, Poland.
E-mail address: lukasz.okruszek@psych.pan.pl (Ł Okruszek).

http://dx.doi.org/10.1016/j.yebeh.2017.04.016
1525-5050/

size that investigates patients' processing of social signals and particularly how higher relevance of such signals could be preserved in those two populations.

Based on previous studies showing partially spared emotional memory modulation in MTLE [5], we hypothesize that HC and MTLE will show emotional memory enhancement for emotional than neutral faces. Given that gaze-related self-relevance detection in MTLE is impaired [3], we expect this emotional effect to be further modulated by the focus of attention (eye gaze direction) of presented faces in HC, but not in patients.

2. Material and methods

2.1. Participants

Twenty-one ATL− and nineteen ATL+ participants were separately recruited from the patients treated at the Department of Neurosurgery of the Medical University of Warsaw. Exclusion criteria included: multifocal epilepsy, history of other neurological or psychiatric disorders, drug or alcohol abuse, uncorrected vision defect and intellectual disability. For HC, twenty participants were recruited among healthy volunteers and matched demographically with patients. Exclusion criteria were the same. For details see Table 1.

2.2. Clinical assessment

Video-EEG and magnetic resonance imaging (MRI) were conducted as a part of a standard procedure of drug-resistant epilepsy diagnosis in order to establish the location of epileptic focus. In all patients who underwent the surgical treatment, the histopathological examination of excised tissue was also performed.

2.3. Procedure

We conducted a hospital-based case–control study. We used facial stimuli from well-established affective stimuli databases [7–9]. The pictures of faces were cropped in order to display only the head and showed no hair. The faces were devoid of specific characteristics and were displayed in shades of gray. The pictures were aligned with each other in terms of size, rotation and brightness. First, participants were asked to make gender decisions on 32 neutral and 32 emotional displays (16 fearful; 16 angry face expressions) presented for 3 s each on a 17″ computer screen. Half of the displays for each category was presented with direct and half with averted gaze. Each face was presented only once. Secondly, after a delay of 45 min, participants were presented with 64 stimuli from the first part of the task and 64 matched displays (different faces) and were asked to decide if a specific face was previously presented. Participants were not overtly informed that the aim of the study was to measure implicit/automatic encoding.

All procedures were in accordance with the Declaration of Helsinki and approved by the Department of Psychology of University of Warsaw Ethics Committee. All participants gave written informed consent.

2.4. Statistical analysis

Statistical analyses were performed using SPSS v.22 for Windows. We ran a 3-Emotion (Fear, Anger, Neutral) × 2-Gaze (direct, averted) Q4 repeated-measures ANOVA on hits with Group (ATL−, ATL+, HC) as between-subject factor. To analyze the impact of the laterality of the epilepsy focus on the results of the study we ran an additional ANOVA with Emotion and Gaze as within-subject factors and Group (ATL−, ATL+) and Laterality (Right, Left) as a between-subject factor. All df's were Greenhouse–Giesser corrected.

Table 1
Sociodemographic and clinical characteristics: patients with epilepsy before (ATL−) or after (ATL+) the anterior temporal lobectomy and healthy controls (HC).

		ATL−	ATL+	HC
N		21	19	20
Age (M ± SD)		33.09 ± 11.41	35.94 ± 6.85	30.23 ± 11.49
Sex (M/F)		9/12	10/9	11/10
Handedness (R/L)		19/2	18/1	19/1
Years of education (M ± SD)		13.42 ± 2.56	13.50 ± 3.18	16.0 ± 1.51
Work (yes/no)		8/13	12/7	14/6
Epilepsy Focus (R/L/B)		10/9/2	11/8	–
Age at epilepsy onset (M ± SD)		12.86 ± 10.57	11.51 ± 9.36	–
Years of epilepsy (M ± SD)		20.23 ± 11.91	22.84 ± 9.71	–
Dominant hemisphere in Wada Test (L/R/B)		N/A	15/2/2	–
Seizures per month (M ± SD)		12.07 ± 12.46	3.60 ± 4.76	–
Years from surgery (M ± SD)		–	4.34 ± 3.28	–
Extend of ATL resection, cm from temporal pole (M ± SD)	I & II temporal gyri	–	3.03 ± 0.69	–
	III temporal gyrus	–	4.97 ± 1.33	–
Histopathology n	Focal cortical dysplasia & Hippocampal sclerosis	–	17	–
	Focal cortical dysplasia	–	2	–
Pharmacotherapy n	Treatment status (mono−/polytherapy)	3/18	2/17	–
	Levetiracetamum	13	10	–
	Carbamazepinum	6	5	–
	Lacosamidum	8	1	–
	Lamotriginum	8	2	–
	Phenobarbitalum	0	1	–
	Topiramatum	4	3	–
	Clobazamum	4	1	–
	Gabapentinum	3	0	–
	Oxcarbazepinum	2	6	–
	Acidum valproicum	3	3	–
	Vigabatrinum	0	2	–
	Natrii valproas	1	0	–
	Clonazepamum	0	1	–
	Tiagabinum	1	1	–
TMT B (M ± SD)		107 ± 88	155 ± 202	42 ± 22
RMET (M ± SD)		20.4 ± 5.9	20.2 ± 5.6	24.0 ± 4.8

Abbreviations: ATL− = patients with epilepsy before anterior temporal lobectomy; ATL+ = patients with epilepsy after anterior temporal lobectomy; HC = healthy controls; TMT B = Trail Making Test part B; RMET = Reading Mind in the Eyes Test.

Please cite this article as: Okruszek Ł, et al, Gaze matters! The effect of gaze direction on emotional enhancement of memory for faces in patients with mesial temporal lobe epilepsy, Epilepsy Behav (2017), http://dx.doi.org/10.1016/j.yebeh.2017.04.016

3. Results

We found a main effect of Emotion ($F(2114) = 5.2$ $p < 0.01$) and Gaze ($F(1,57) = 5.2$ $p < 0.05$). Both effects were modulated by Group (Emotion × Group: $F(4114) = 4.2$ $p < 0.01$; Gaze × Group $F(1,57) = 8.25$ $p < 0.01$). Analysis of these effects revealed that the Emotion effect was observed only in HC (fear vs. neutral: $t(20) = 3.8$ $p < 0.01$; anger vs. neutral: $t(20) = 5.4$ $p < 0.001$). The gaze effect was observed only in patients: in ATL− ($F(1,20) = 7.2$ $p < 0.05$) and in ATL+ ($F(1,18) = 12.1$ $p < 0.01$) memory enhancement for averted gazes was observed. Results are visualized in Fig. 1. The secondary ANOVA revealed no main effect of the Laterality of the focus, nor higher-order interaction between Laterality of the focus and any of the remaining factors.

4. Discussion

This is the first study to our knowledge to investigate the effect of emotional expressions and gaze on memory processes in patients with MTLE. Our observations were partially consistent with previous findings. We found an effect of emotional memory enhancement in healthy controls, with higher hit rates for angry and fearful compared to neutral expressions. No emotional enhancement was found in patients, even though previous findings suggested that effects of fearful stimuli were preserved in ATL− patients [6].

Increased learning of averted compared to direct gaze faces was observed in patients. A previous study reported that, while amygdala activity is modulated by both emotional displays and gaze direction, increased hippocampal activity which can be linked to self-relevant memory processes is selectively activated by direct gaze perception in healthy individuals [11]. At the same time, we found no effect of the gaze direction on the automatic learning in healthy controls in the current study. However, unlike the previous studies on self-relevance processing [2,3] we used static pictures of direct or averted gazes, instead of dynamic displays presenting gaze-shifts. It has been suggested that when it comes to the social realm, the shift of the gaze may be a more meaningful information than the direction of the other agent's gaze [12]. The observation of the gaze aversion has been found to elicit a range of negative effects on the viewer [12], thus a dynamic gaze-shift may be of greater importance in signaling a negative value in social interaction, than a static gaze expression. Therefore, finding a memory bias to averted gaze inpatients with temporal lobe dysfunction, may be linked to the fact that structures which respond to gaze aversion (particularly posterior superior temporal regions; [13]) are not damaged in patients with MTLE. At the same time, MTLE patients present large deficits in recognition of affective facial displays, which may be linked to the disruption of the facial processing network [14,15]. Thus, the unbalance between the activity of the networks which subserve facial affect processing and gaze-shift coding may lead to lack of emotional enhancement of the memory and memory bias for averted gazes, which both have been observed in MTLE patients in the current study.

The present study explores further the atypical self-relevance processing observed in patients with amygdala lesions [3–7] and suggests

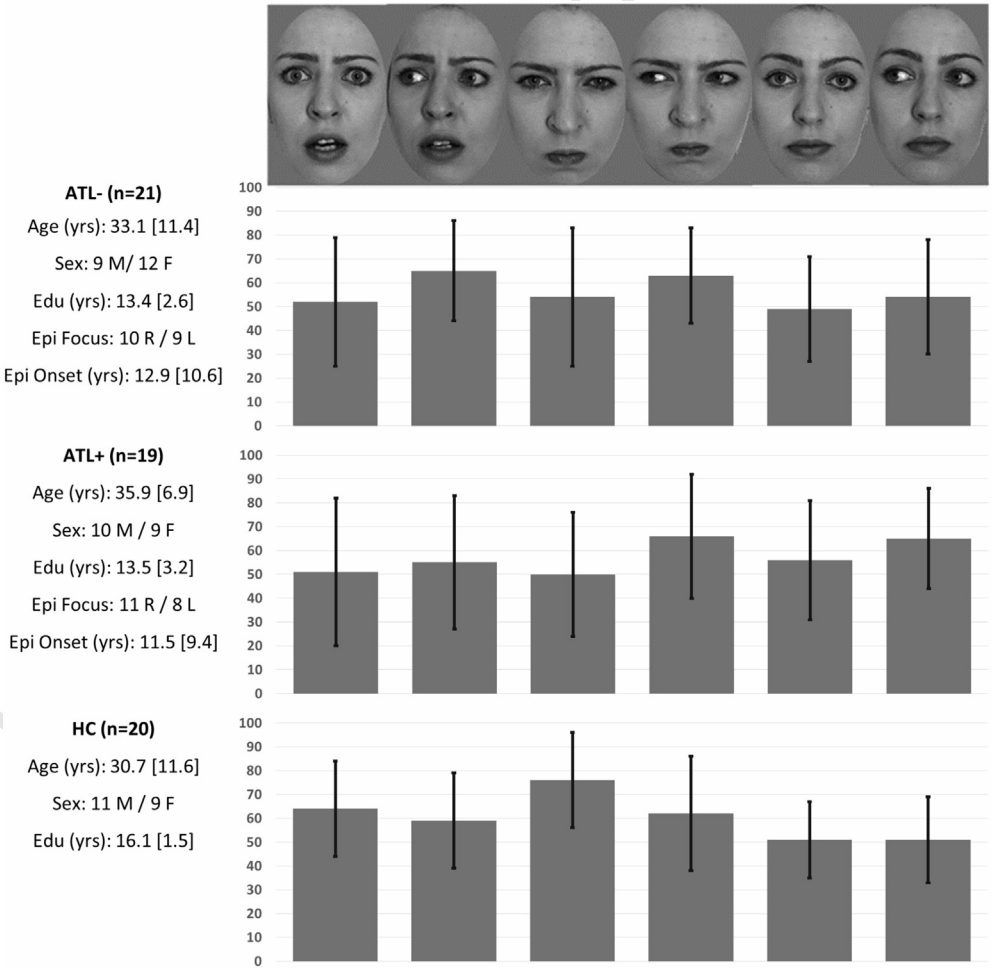

Fig. 1. Recognition rates in percentages for each type of stimuli (Emotions: fear/anger/neutral × Gaze: direct/averted). ATL− = patients with mesial temporal lobe epilepsy before anterior temporal lobectomy; ATL+ = patients with mesial temporal lobe epilepsy after anterior temporal lobectomy; HC = healthy controls. Error bars are for standard deviations. Pictures presented in the figure have been created for presentation purposes given the copyrights of original stimuli (original set of stimuli available on request). Each face identity was used exclusively for one of the three possible facial expressions.

Please cite this article as: Okruszek Ł, et al, Gaze matters! The effect of gaze direction on emotional enhancement of memory for faces in patients with mesial temporal lobe epilepsy, Epilepsy Behav (2017), http://dx.doi.org/10.1016/j.yebeh.2017.04.016

that gaze and emotion processing should be both taken into account while examining the nature of social impairments in MTLE. We must however mention the limitations of the research. First, given the very restrictive criteria for participant inclusion in our study, an even larger number of participants are needed to validate our results and further investigate social cognition and self-relevance impairments in MTLE. Second, emotional enhancement was only partially confirmed in the control group, suggesting that explicit threat related with hostile intentions was the most salient category for the healthy participants of this study. Third, despite surgical procedures not all ATL+ patients were seizure-free. And finally, the study was not longitudinal, the ATL− and the ATL+ groups were not the same patients, which — given the diversity and extent of affected brain regions in MTLE — makes it difficult to specifically evaluate the influence of the surgery. A fully longitudinal research would require a longer period of study, encompassing a time before surgery and more than one postsurgical time point after surgery in order to enable researchers to observe the dynamics of functional changes, which are now partially speculative.

Further research could clarify whether: i) there are differences in emotional memory enhancement in MTLE and extra-MTLE; ii) seizure-free post-lobectomy patients' performance is closer to HC than to those with seizures; iii) inclusion of the same patients pre- and post-surgically would show stronger differences than comparing two populations.

5. Conclusions

Our study suggests that patients with epilepsy remember social–emotional messages differently than healthy individuals. MTLE patients seem to exhibit impairments in the processing of stimuli that are relevant to them, as observed in the lack of memory enhancement for emotional stimuli and memory enhancement for faces gazing away from the patients. This impairment in self-relevance processing was observed in patients with MTLE irrespectively of whether they have undergone an anterior temporal lobectomy or no surgery. Our study is in line with the rare studies that compared both groups of patients, failing to detect significant differences in terms of social inference abilities [14,15]. However, given how significantly social and self-relevance processing impairments can affect the quality of life of patients with epilepsy, further systematic studies are required on large longitudinal samples with an in-depth investigation of the consequences of surgery and surgery laterality.

We believe that better understanding of the changes in social processing, encoding and decoding of emotional information as well as perception of self-relevance information in epilepsy is essential. Further research is required to evaluate patients' socio-emotional functioning and particularly how the surgery for the treatment of intractable epilepsy may affect patients' everyday life and well-being.

Study funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contributions

Łukasz Okruszek contributed to study design, data analysis, data visualization and manuscript preparation. Aleksandra Bala contributed to data collection, data analysis and manuscript preparation. Marcela Dziekan contributed to preparation of research paradigm and data collection. Marta Szantroch contributed to manuscript revision. Andrzej Rysz contributed to manuscript revision. Andrzej Marchel contributed to manuscript revision. Sylwia Hyniewska contributed to study design, data analysis and manuscript preparation.

Conflict of interest statement

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Uncited reference

[10]

Acknowledgments

The authors thank the patients for their contributions to this research. We also thank Małgorzata Jurek who allowed us to use her pictures as an example of the stimuli. We would also like to thank the anonymous reviewers, who helped to improve the current manuscript.

References

[1] Dolcos F, Denkova E. Current emotion research in cognitive neuroscience: linking enhancing and impairing effects of emotion on cognition. Emot Rev 2014;6:362–75.
[2] N'Diaye K, Sander D, Vuilleumier P. Self-relevance processing in the human amygdala: gaze direction, facial expression, and emotion intensity. Emotion 2009;9:798–806.
[3] Cristinzio C, N'diaye K, Seeck M, Vuilleumier P, Sander D. Integration of gaze direction and facial expression in patients with unilateral amygdala damage. Brain 2010;133:248–61.
[4] Pishnamazi M, Tafakhori A, Loloee S, Modabbernia A, Aghamollaii V, Bahrami B, et al. Attentional bias towards and away from fearful faces is modulated by developmental amygdala damage. Cortex 2016;81:24–34.
[5] Piech RM, McHugo M, Smith SD, et al. Attentional capture by emotional stimuli is preserved in patients with amygdala lesions. Neuropsychologia 2011;49:3314–9.
[6] Pinabiaux C, Bulteau C, Fohlen M, et al. Impaired emotional memory recognition after early temporal lobe epilepsy surgery: the fearful face exception? Cortex 2013;49:1386–93.
[7] Langner O, Dotsch R, Bijlstra G, Wigboldus DH, Hawk ST, van Knippenberg A. Presentation and validation of the Radboud faces database. Cognit Emot 2010;24(8):1377–88.
[8] Olszanowski M, Pochwatko G, Kuklinski K, Scibor-Rylski M, Lewinski P, Ohme RK. Warsaw set of emotional facial expression pictures: a validation study of facial display photographs. Front Psychol 2015;5:1516.
[9] Tottenham N, Tanaka JW, Leon AC, McCarry T, Nurse M, Hare TA, et al. The NimStim set of facial expressions: judgments from untrained research participants. Psychiatry Res 2009;168(3):242–9.
[10] Stussi Y, Brosch T, Sander D. Learning to fear depends on emotion and gaze interaction: the role of self-relevance in fear learning. Biol Psychol 2015;109:232–8.
[11] Conty L, Grèzes J. Look at me, I'll remember you. Hum Brain Mapp 2012;33:2428–40.
[12] Wirth JH, Sacco DF, Hugenberg K, Williams KD. Eye gaze as relational evaluation: averted eye gaze leads to feelings of ostracism and relational devaluation. Pers Soc Psychol Bull 2010;36:869–82.
[13] Caruana F, Cantalupo G, Russo GL, Mai R, Sartori I, Avanzini P. Human cortical activity evoked by gaze shift observation: an intracranial EEG study. Hum Brain Mapp 2014;35:1515–28.
[14] Amlerova J, Cavanna AE, Bradac O, Javurkova A, Raudenska J, Marusic P. Emotion recognition and social cognition in temporal lobe epilepsy and the effect of epilepsy surgery. Epilepsy Behav 2014;36:86–9.
[15] Meletti S, Benuzzi F, Cantalupo G, Rubboli G, Tassinari CA, Nichelli P. Facial emotion recognition impairment in chronic temporal lobe epilepsy. Epilepsia 2009;50:1547–59.

Please cite this article as: Okruszek Ł, et al, Gaze matters! The effect of gaze direction on emotional enhancement of memory for faces in patients with mesial temporal lobe epilepsy, Epilepsy Behav (2017), http://dx.doi.org/10.1016/j.yebeh.2017.04.016