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Attention-driven bias for threat-related stimuli in implicit memory. Preliminary results from the Posner cueing paradigm

An implicit memory advantage for angry faces was investigated in this experiment by means of an additional cueing task. Participants were to assess the orientation of a triangle's peak, which side of presentation was cued informatively by angry and neutral face stimuli, after which they immediately completed an unexpected "old-new" task on a set of the previously presented faces and new, distractor-faces. Surprisingly, the RTs were similarly long on the invalid trials for angry and neutral facial cues in the Posner task. However, performance on the "old-new" task was better for angry than neutral faces. A strong correlation between RTs in angry-invalid trials and confidence ratings for these angry faces was observed only in highly reactive participants. These results suggest that presentation of threatening material can induce enhanced incidental encoding which can result in stronger familiarity for such material, and this effect is driven by attentional bias in highly reactive individuals.

Keywords: *attention, emotional expressions, emotional reactivity, cueing, memory, biases*

It is a well grounded finding that the valence of stimuli aids selection of such stimuli over others in a complex social environment (for a review, see Vuilleumier & Driver, 2007). More specifically, a processing bias towards stimuli signalling threat seems to be adaptive, as it increases the chances of human survival by giving priority to processing potentially dangerous stimuli. There is however an ongoing debate on the status of the automaticity of the threat-related stimuli processing. On one hand, Öhman, Lundqvist, and Esteves (2001) showed rapid orienting to negatively valenced stimuli, for which the short non-cortical route through amygdala (LeDoux, 1998) was proposed. On the other hand, some researchers provided evidence against the "absolute" automaticity of processing of such stimuli – processing of such stimuli was shown neither to be involuntary (Pessoa, McKenna, Gutierrez, & Ungerleider 2002), nor load-insensitive (Bishop, Jenkins, & Lawrence, 2007). However, biases in threat-related material processing seems to prevail in cognition, the most often reported being attentional and memory biases (see Fox & Georgiou, 2005). What is more, the vulnerability for negative emotional stimuli is significantly modulated by individual levels of anxiety (Derryberry & Reed, 1998).

Memory biases and anxiety

While the attentional bias towards threat-related stimuli might be adaptive, as it determines quick response to a possible threat, a similar bias in the memory domain serves no clear adaptive function and is often linked with elevated anxiety levels in normal and clinical populations (see Eysenck & Keane, 2005). As such, negative memory bias is probably a product of threat biases at earlier stages of cognitive processing, e.g. an involuntary deployment of attentional resources to threatening material, which results in more in-depth processing. For example, MacLeod and Mathews (1991) aimed to test whether the negative memory bias might be more readily visible in conditions which enable selective processing of different stimuli, related to threat or not. In their study participants were asked to recall pairs of words of differing valence, presented at two different locations, either concurrently or one after another. A cue was indicating which of the two words were to be

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recalled. Importantly, investigators measured the level of participants' trait–anxiety. In the concurrent presentation condition, in which the words were in a direct competition for working memory resources, high-anxiety participants had shorter latencies when recalling threatening words, while low-anxiety participants were recalling the neutral words faster. These results were taken to show that anxious individuals, rather than having an increased access to threatening material, assign higher processing priority to threatening stimuli. While this study showed evidence that memory bias might be also driven by preferential processing at the stage of information encoding, it did not take into account that there are different types of memory which might operate on the basis of different neural circuits and cognitive processes. Recall memory requires a conscious, effortful retrieval of the stimulus representation, and the negative bias here is probably based on the mood congruency mechanisms (see Macleod & Mathews, 1991). On the other hand, implicit memory (and more specifically its familiarity component) is much more effortless and sensitive predominantly to relative differences in activation of stimuli representations in their relevant networks (see Graf & Mandler, 1984). As such, it also operates beside conscious control processes (Mathews, Mogg, May, & Eysenck, 1989), what can probably mitigate any processing of the meaning of such stimuli (i.e. explicit memory).

Taking these features of implicit memory into account, it might be a particularly good indicator of memory biases driven by stronger involuntary deployment of attentional resources to threat-related stimuli (Roediger, 1990). In support of this notion are results from a study by Mathews, Mogg, May, and Eysenck (1989). They tested explicit and implicit memory in clinically anxious and healthy controls on lists of threatening and non-threatening words. These lists of words were presented to participants to memorize and were followed by either a cued recall (explicit memory) or a word completion task (implicit memory). While clinically anxious participants showed no stronger recall than normal controls to threatening words in the cued recall task, they scored higher on the word completion task, but only from sets which were recently presented to them. These results show that anxious individuals more readily show a bias for previously presented (i.e. primed) threatening material in a type of memory which is sensitive to enhanced activation of a representation of a stimulus, as opposed to a type of memory based on conscious retrieval of the meaning of such a stimulus. These results seem to be in line with the conclusions of Williams, Watts, MacLeod,and Mathews (1997) who concluded after reviewing the existing literature on memory bias in anxiety, that anxious individuals most often show a stronger implicit memory bias, i.e. better performance for threatening than neutral stimuli in tasks which do not require conscious recollection, while explicit memory bias is found predominantly in depressive participants.

The abovementioned studies suggest jointly that attention bias towards threatening material driven by higher priority assigned to such material at the encoding stage might have the largest effect on the implicit memory. As noted above, this effect is particularly strong in anxious individuals, what in turn could be explained by their tendency to involuntarily process threatening material in more depth than individuals who are not anxious. This possibility is explained in more detail below.

Individual differences in anxiety and orienting towards threat-related stimuli

It has been often reported that individual differences (e.g. anxiety) could modulate the process of attending to threat-related stimuli (see Fox, Lester, Russo, Bowles, Pichler, & Dutton, 2000). As a result, an attentional bias in orienting towards threat-related stimuli have been proposed (e.g. Fox, Russo, & Dutton, 2002). The first hypothesis which has been tested in this area was that threat-related stimuli are going to capture visual attention more effectively than happy or emotionally neutral faces. However, in one of such studies Fox, Russo, Bowles, and Dutton (2001) showed no advantage of the former in orienting of attention. Such a lack of preferential processing for negatively valenced stimuli was shown even for highly-anxious people, who in theory should be more sensitive to processing of threat-related stimuli. Somewhat surprisingly, Fox et al. (2001) found that both threatening faces, as well as threatening words resulted in impaired disengagement of attention from the location of presentation of such stimuli. That is, RTs to a target in a detection task were delayed on trials where their location was invalidly cued by angry, as opposed to happy or neutral face cues, and this effect was especially strong in high-state anxious individuals. These results strongly suggested that, while processing of threat-related stimuli might strongly affect the disengaging component of the spatial attention, processing of such stimuli might not have any advantage in respect to the shifting of attention.

In the previous studies which used the typical Posner cueing task with emotional stimuli as cues (Fox et al., 2001; Fox et al., 2002) also the STAI (State-Trait Anxiety Inventory) was often administered in order to assess the role of individual differences in attention orienting to threat-related stimuli and disengagement from their location. STAI is a self- report method developed by Spielberger, Gorsuch, Lushene, Vagg, and Jacobs (1983) and contains two separate scales: State-Anxiety (temporary component) and Trait-Anxiety (longstanding, relatively stable component). However, the usage of STAI as a measure in attentional research is rather questionable.

Some researchers postulated that Trait-Anxiety Scale assesses both anxiety and depression (Bieling, Antony, & Swinson, 1998). However, Fox and colleagues (2001, 2002), were often reporting scores from the State-Anxiety or Trait-Anxiety Scales interchangeably in different experiments, while not providing sufficient theoretical background for choice of a particular scale for a particular paradigm. While the correlation between these two scales is quite high (Pearson r from .6 to .8; Spielberger, Strelau, Tysarczyk, & Wrześniewski, 2006), they are measuring different theoretical constructs. Moreover, the most theoretically important (even critical) interaction of cue validity (valid vs. invalid) x cue valance (neutral vs. emotional) x anxiety (low vs. high) often did not reach the significance level in many of their studies (Fox et al., 2001, Experiment 1 & Experiment 2; Fox et al., 2002, Experiment 2). These null findings, despite their reoccurrence, were not explicitly discussed from a theoretical point of view. Furthermore, participants responding near the median (from 35 to 40) in the STAI State-Anxiety were not included in these studies, so the comparisons were being conducted on much disparate groups of high- and low-anxiety individuals.

Hence, we argue that in the past research on individual differences in attentional bias the choice of anxiety as a valid measure of enhanced processing of threat-related material was not well theoretically grounded and its unsystematic measurement created a body of research without a clear framework explaining the attentional effects driven by temporary and more long-term effect of anxiety.

Present study

The purpose of this preliminary study was to investigate the interplay of the attentional and memory biases while controlling for possibly important individual differences. Previous studies which focused exclusively on the role of anxiety in attentional bias inclined us towards searching for other individual differences which might provide a clearer picture of mechanisms driving enhanced attentional engagement/disengagement in regard to emotional stimuli. Hence, in the present study individual differences with stronger biological underpinnings were chosen for investigation. More specifically, the Emotional Reactivity and the Perseverence scales from the Formal Characteristics of Behaviour-Temperament Inventory (FCB-TI; Strelau & Zawadzki, 1993, 1995) were also administered in the present study.

According to the Regulative Theory of Temperament (Strelau, 1996), temperamental traits have a strong biological basis and refer to the formal aspects of behaviour – aspects which reveal themselves in behaviour's energetic and temporal characteristics. The FCB-TI questionnaire measures six aspects of behaviour: Briskness (BR), Perseverance (PE), Sensory Sensitivity (SS), Emotional Reactivity (ER), Endurance (EN) and Activity (AC). Basing on their theoretical characteristics, Perseverance and Emotional Reactivity seemed to authors as potentially important factors modulating threat-related information processing.

Strelau and Zawadzki (1993) defined the emotional reactivity as a "tendency to react intensively to emotion-inducing stimuli, expressed in high emotional sensitivity and low emotional endurance". As such, Emotional Reactivity (ER) belongs to the group of energetic characteristics of behaviour and refers to the strength of typical reactions to emotional stimuli. Some recent studies showed that psychophysiological reactions to emotionally salient stimuli are significantly different for high and low ER scorers. For instance, individual level of ER was found to modulate the pattern of heart rate response for unpleasant vs. nonsense words (De Pascalis, Strelau, & Zawadzki, 1999), as well as the cortical responses to emotional faces (Zagórska, Fajkowska, Strelau, & Jaśkowski, 2010). On the other hand, Perseverance (PE) is related to the temporal aspects of behaviour and refers to the duration of one's reaction after disappearance of a stimulus. Strelau and Zawadzki (1993) defined it as a "tendency to continue and to repeat behaviour after cessation of stimuli (situations) evoking this behaviour". Also PE scores are related to specific brain activity in response to emotional material (De Pascalis et al., 1999). Namely, ERP (event-related potentials) responses to emotional and nonsense words in the group of high PE participants had a larger (in comparison to low PE ones) amplitude of the N500 component, which is linked with affective and semantic stimulus processing (Williamson, Harpur, & Hare, 1991). Basing on these findings, the ER and PE scales were chosen for investigation as individual differences constructs which might significantly modulate performance on attentional and memory tasks involving threatening material.

As mentioned previously, attention dwells on threat-related stimuli, i.e. there is a difficulty in re-orienting attention to a different location if the previous location was cued by a threat-related stimulus, and this effect is particularly strong in anxious participants. On the other hand, there is a body of evidence strongly suggesting that such participants show a memory bias for threat-related stimuli if the task requires merely some degree of familiarity with such stimuli. Hence, the aim of this study was to test whether this implicit memory bias can be driven by an involuntary deployment of focal attention to processing of such stimuli, and how this interplay is modulated by biologically-based individual differences. If angry faces can induce attention dwell, this might trigger stronger involuntary in-depth processing which in turn might result in enhanced activation of their representations and enhanced familiarity. This enhanced familiarity can be readily detected by an "old-new" task, in which participants are to assess whether presented stimuli have been just presented or are new.

It was predicted that in the attentional task the emotional stimuli in the form of angry faces are going to be eliciting longer RTs to targets than neutral stimuli on invalidly cued trials (‘attention dwell’), but only in participants high in trait anxiety and emotional reactivity. Furthermore, the performance in the “old-new” memory task should be better for angry than neutral faces, and this relation should be particularly strong for participants scoring high on the Trait-Anxiety, Emotional Reactivity and Perseverance scales.. Crucially, the correlation between the elongated RTs on invalid trials for angry faces and the enhanced familiarity for angry faces should be significant only for these participants.

Method

Participants

Eighteen undergraduate psychology students with mean age of 22.7 years (SD = 3.2 years; 15 women) participated in this study in exchange for credit points. All of them had normal or corrected-to-normal vision and gave informed consent before the experiment.

Materials and design

Cueing task

A typical Posner cueing paradigm was used to investigate the effects of processing of threat-related stimuli on attention. In a 2 (Emotional expression: angry vs. neutral) x 2 (Cue validity: valid vs. invalid) within-subject factorial design participants had to detect the orientation of the target stimulus – a blue triangle’s apex; the triangle was appearing on the left or right side of the fixation point with equal probability. If the triangle was presented up-right, participants were asked to press the up-arrow key. In the case of inverse presentation, they were asked to press down-arrow key. In each trial, the fixation point was followed after 500 ms by a cue stimulus, which appeared either on the left or the right side of the screen with the distance of approximately 6.6° of visual angle from the center of the fixation point. The cues and targets were presented at the same location.

Twenty facial expressions of ten identities (5 males, 5 females) served as the cue stimuli. Each identity, selected from the set provided by Lundqvist, Flykt, and Öhman (1998), was presented in neutral and angry emotional expression. Ovals containing only faces (without hair, background or other personal non-emotional features) were cut from these pictures and used as stimuli. Each greyscale face, subtending 6.8° in vertical and 5.2° in horizontal visual angle, was visible on the screen for 250 ms and followed by target stimulus (with ISI of 150 ms) which in turn stayed on the screen for 2000 ms or until participant’s reaction. On the valid trials target appeared on the same side as the cues, while on the invalid trials it was presented at the opposite lateral location on the other side of the fixation point. Each facial expression appeared exactly 32 times during test trials. In order to maintain participants’ alertness catch trials were introduced, on which a target stimulus was not presented. Next trial always started automatically with an inter-trial interval of 1000 ms after participant’s response or 2000 ms of the target duration.

Each of the eight blocks consisted of 80 randomly selected trials, giving the total number of 640 test trials. Valid, invalid and catch trials appeared with the probability of 60%, 20% and 20%, respectively, what means that the cues were informative, just like in the Experiment 2 from the Fox et al. (2002) study. After each block subjects had an opportunity to have a short break of 2-minute maximum duration. Half of the participants were asked to start the experiment pressing up-arrow key with left-hand finger and down-arrow key with right-hand finger. After four blocks of trials each participant had to invert his key-hand arrangement. This way participants’ responses were counterbalanced both across- and within-subjects. Two ten-trial practice blocks preceded each change.

Questionnaires

Each participant completed the Polish version of Trait-Anxiety Scale from the Spielberger State-Trait Anxiety Inventory (Spielberger et al., 2006) and two scales from the Formal Characteristics of Behaviour-Temperament Inventory (FCB-TI; Zawadzki, & Strelau; 1997) – Emotional Reactivity (ER) and Perseverance (PE).

STAI is often used as a measure differentiating high and low anxious individuals on two dimensions of anxiety – a temporary state of feeling anxious (state - anxiety) and a long-term, stable tendency to respond with state anxiety in the anticipation of threatening situations (trait - anxiety). The Trait-Anxiety Scale consists of 20 statements describing general feelings, experiences or beliefs related to anxiety understood here as a “trait” (e.g. “I’m feeling nervous”). Participant has to assess how often he or she feels this way by using 4-point scale (“1” – not at all; “4” – all the time). Polish adaptation of STAI has been provided, tested and validated by Spielberger et al. (2006).

FCB-TI is a questionnaire used for diagnosing biologically-determined tendencies in behaviour as defined by the Regulative Theory of Temperament (Strelau, 1996). In the present study only two out of six of the FCB-TI scales were included: Perseverance (PE) and Emotional Reactivity (ER), what was motivated by an assumption of a common biological basis of both the attentional bias towards threat-related material and the temperamental traits investigated in this study. The FCB-TI scales contain 20 statements (with answers ’yes’/’no’) each, e.g. in the ER scale “I often have

Table 1
Descriptive statistics for response latencies (ms) in the cueing task.

Trial type	Mean	SD
Angry-invalid	428.19	65.81
Angry-valid	406.18	57.28
Neutral-invalid	429.73	64.85
Neutral-valid	402.37	55.69

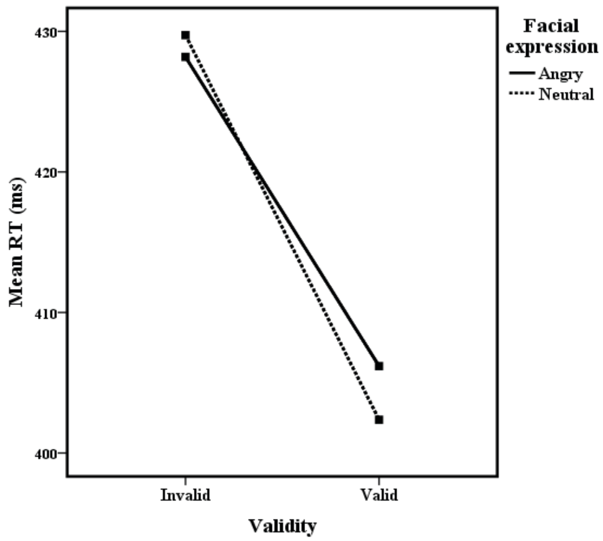

Figure 1. Mean reaction times to targets as a function of cue emotional expression and cue validity.

a breakdown in difficult moments", "I have a stage-fright if I am to speak in public"; in the PE scale: "After a failure it takes a long time for me to pull myself together"; "I often become preoccupied with one thought".

Procedure

Participants were seated in a dimly lit room 50 cm from the screen of the Iiyama Vision Master 22" monitor with a refresh rate of 100Hz. The responses were gathered by an ergonomic response pad located on the desk. Cueing task was followed by the unexpected by participants "old-new" task. Twenty facial expressions that appeared in the cuing task and 20 other new facial stimuli from the same KDEF set (10 angry and 10 neutral) were presented sequentially for 2000 ms in random order. After each picture disappeared, participants had to assess the degree of their confidence of seeing each facial expression in the previous task. Participants indicated the level of their confidence on a 12-point scale with anchors: "-6" – certainly not presented and "6" – certainly presented. In the last stage of the study participants filled out a battery of questionnaires containing Emotional Reactivity (ER) and Perseverance (PE) scales from FCB-TI (Zawadzki & Strelau, 1997) and Trait-Anxiety from STAI (Spielberger et al., 2006). The administration order of questionnaires was counterbalanced.

Results

Data transformation

Trials with response latencies shorter than 250 ms were excluded from further analysis. RT data were z-score transformed for each participant separately. Individual RT deviations defined as latencies longer than 2.5 SD were also removed. Mean RTs only for correct responses were computed for each participant giving a total of 97.7% of all trials on which the subsequent analyses were performed. Catch trials, in which target was not presented after cue exposition, were not included in any analysis (the accuracy in these trials was approximately 99.5%).

Cueing task

Data were analysed with 2 (Face expression: angry vs. neutral) x 2 (Cue validity: invalid vs. valid) repeated-measures ANOVA (see Table 1 for descriptive statistics). There was a main effect of cue validity, $F(1,17) = 18.468$, $p < .001$, $\eta^2 = .52$, showing shorter RT to targets on valid trials. There was no main effect of face expression ($F < 1$). The interaction of these two factors was marginally significant, $F(1,17) = 4.405$, $p = .051$, $\eta^2 = .21$, resulting in longer latencies for angry vs. neutral faces on validly cued trials (Figure 1).

Three follow-up analyses carried out with the STAI, ER and PE scales (dichotomized by median value) showed no interaction effects in repeated-measures ANOVA with face expression (2) and cue validity (2) as within-subjects factor and individual differences variables as between-subjects factors (all $Fs < 1$). Due to the lack of significant effects no other analyses were conducted on these data.

Implicit memory task

In order to test for the threat-related stimuli implicit memory bias a two-way repeated-measures ANOVA with 2 (Face expression: angry vs. neutral) x 2 (Old-new task: new vs. old faces) as within-subjects factors was performed. As Figure 2 shows, there was a main effect of face expression, $F(1,17) = 35.692$, $p < .001$, $\eta^2 = .68$, as well as a main effect of prior face presentation in the old-new task, $F(1,17) = 32.114$, $p < .001$, $\eta^2 = .65$. In other words, in general participants declared stronger confidence in the implicit task for threat-related faces, as well as for "old" faces previously presented in the cueing task. Critically, the interaction of these two factors was also highly significant, $F(1,17) = 39.530$, $p < .001$, $\eta^2 = .70$. Simple effects analysis indicated that "old" angry faces were significantly better recognized (higher confidence level) than "new" angry faces, $F(1,17) = 59.693$, $p < .001$, $\eta^2 = .78$. The analogical difference in neutral faces was not observed ($F < 1$).

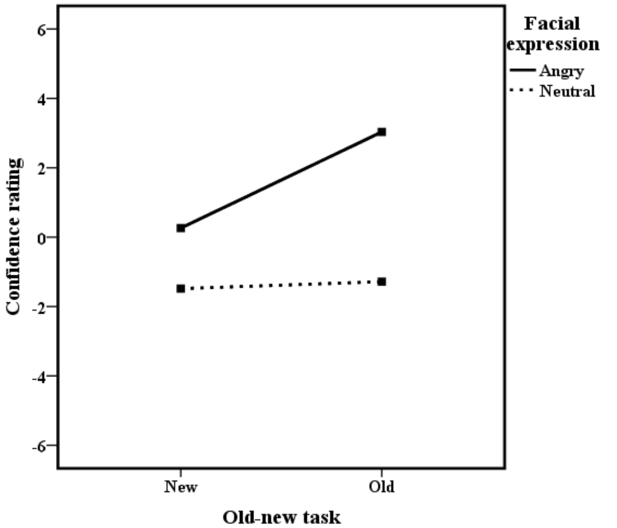

Figure 2. Mean confidence rating in the ”old-new” implicit memory task (-6 – certainly not presented; 6 – certainly presented).

Correlations

To test the relation between effects of attention disengagement from threat-related faces (defined by longer RT in angry-invalid condition; Fox et al., 2002) and the confidence ratings in the subsequent “old-new” task a correlation analysis was conducted. The correlation between these two variables was not significant, $r(16) = .237$, $p > .05$. Further analyses were performed on two groups (high and low in: anxiety, emotional reactivity and perseverance; divided by the median value) separately in order to show independent relations between variables in those groups. The correlation between attention disengagement and performance in the implicit memory task was shown not to be significant, even when STAI and PE were taken into account. A significant correlation between the two variables was observed only in the group of participants highly reactive, $r(7) = .619$, $p < .05$. The longer latencies evoked by angry faces on the invalid trials (when the attentional dwell was present), the higher were the confidence ratings for “old” angry faces reported in the “old-new” task (Figure 3).

Discussion

Results of this study support the notion that presentation of emotional expressions (here: angry faces) can influence the subsequent implicit type of memory for these faces, what can be shown by an unexpected immediate familiarity task. This effect was specific for threat-related stimuli only and was not shown for neutral faces. What is crucial, only in the group of participants scoring high on the Emotional Reactivity scale the enhanced memory performance for angry faces was significantly related to the degree of difficulty with disengaging the attention on trials

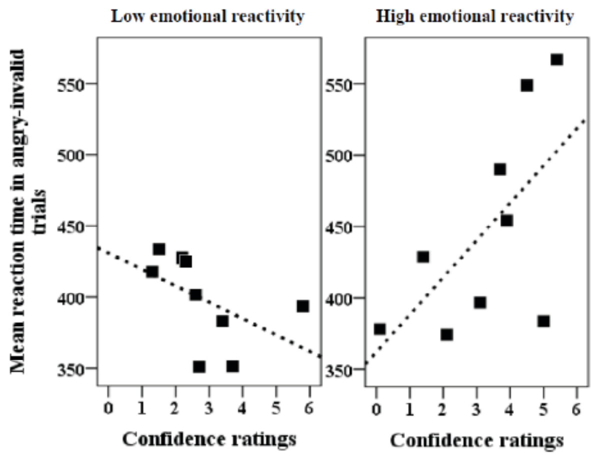

Figure 3. Scatter plots illustrating the correlation between mean reaction times (ms) for angry-invalid trials and confidence ratings for angry-old faces in group of participants low and high in emotional reactivity. Dotted line represents a linear fit.

invalidly cued by angry faces. An analogical pattern of relations was not observed in subjects highly persevering or anxious. On one hand, the emotional reactivity appears to be a more sensitive measure of cognitive bias towards threat-related material, showing it even in circumstances where trait-anxiety fails to do so. On the other hand, the fact that reactiveness reflects the strength of a response to emotional stimuli seems to be the crucial factor determining the strength of the relation between the attentional and implicit memory bias; perseverance, with its temporal profile, seems not to be important in this interplay. Hence, the obtained results are in favour of a strong modulatory role of biologically driven strength-oriented factors (as opposed to more psychologically profiled differences) in attentional bias for threat-related stimuli. Moreover, there was no benefit for participants to gain by paying more attention to cues when these were angry faces, as opposed to neutral faces (face with both expressions appeared with the same frequency etc.), what suggests that any results found in this study indicative of cognitive biases were driven by individual differences in sensitivity to processing of threatening material. We argue that the attention-driven implicit memory bias reflects involuntary preferential processing of such material.

However, the inability to show an interaction between emotional expression and cue validity while controlling the level of anxiety (or ER and PE) stands against the results provided by other investigators (e.g. Fox et al., 2001). In the present experiment both emotional expressions (angry and neutral) were attracting attention with similar effectiveness on the invalid trials. Such discrepant results may be explained by differences in task difficulty[1]. In the studies of Fox et al. (2001, 2002) participants had to perform a simple target categorization task, e.g. assess whether a circle or

1 Additional analysis showed that there was a marginally significant effect of emotional expression on accuracy in the “old-new” task , $F(1,17) = 4.388$, $p = .051$, $\eta^2 = .21$, supporting the notion that angry faces led to a decrease in performance level in the cueing task.

square was presented (mean error rate < 3.5% trials) or to report whether a target appeared on the left or right side of screen (mean error rate < 1% of trials). The task we used in this study turned out to be more difficult, what was evidenced by an elevated level of incorrect responses in trials (mean error rate of approximately 5.4%). In the task used participants had to answer if the apex of the triangle was up or down-oriented and overcome the motor priming tendency (it is easier to react right-hand on the target that appears on the right side of the screen in contrary to opposite side). On invalid trials, a correct answer required a shift of attention from the cue location to the other side of the screen where the discrimination task could be finally performed. As some recent studies showed (see Milders, Sahraie, Logan, & Donnellon, 2006; Stein, Peelen, Funk, & Seidl, 2010), emotionally salient (i.e. threat-related) stimuli can influence the subsequent processing of non-emotional content by depleting the limited-capacity attentional resources. These findings suggest that the lack of effect of cue valence in the cueing task may have been caused by a higher demand for attentional resources, required to perform well on the target discrimination task. However, this hypothesis requires further investigation. More specifically, it would be informative to investigate whether lower task difficulty would enable the attentional bias to be visible in this kind of experiment.

Furthermore, the attentional dwell effect was shown not to be significant when individual levels of trait anxiety (STAI) or temperamental differences were taken into account. This seems to be in opposition to the findings of Fox and colleagues (for a review, see Fox & Georgiou, 2005). In these previous studies (e. g. Fox et al., 2001) high- and low-anxiety participants were selected prior to the experiment, choosing the individuals who had highly disparate score and excluding those with average scores. In the present study participants' scores were divided by the median score and no participants were excluded from the analyses. Dividing the whole sample on those scoring above and below the median could have made the differences between the "high" and "low" subgroups of participants too subtle to show any results indicative of attentional bias. As a consequence, the level of statistical power in our study could have been too weak for significant cue validity x face expression x individual level of trait variable interactions to be visible. Such null results, with different types of anxiety taken into account, were also shown in the past studies (Fox et al., 2001, 2002). However, one of the aims of this study was to compare the commonly used measure of trait anxiety with more biologically grounded temperamental characteristics (as measured by the FCB-TI), so exclusion of participants scoring average on each scale was not possible in such a preliminary study.

The main aim of this study was to investigate the role of attentional bias in memory for threat-related material that is mediated by involuntary encoding of such material. Results of the implicit memory task revealed a strong memory bias toward angry faces. In respect to these stimuli participants were more confident while assessing if the presented face was old (i.e. appeared in the previous cueing task) or new (presented for the first time), relative to neutral faces. The latter facial expressions were recognized at the level of other neutral faces which were not previously presented, i.e. activation of their representations in the implicit memory was not enhanced. Moreover, a strong correlation was found between reaction times on invalid trials (cueing task) and the judgement confidence in the implicit memory task for angry faces in high ER participants. For such participants the magnitude of attentional dwell may be directly related to the strength of encoding and remembering of the representations of faces when presented with angry expressions. A recent study of Russo, Fox, Bellinger, and Nguyen-Van-Tam (2001) supports the notion that individual differences in threat-related stimuli processing may be crucial for attentional and memory bias for such stimuli. In their two experiments participants had to make a free recall of target words incidentally encoded in the previous stage of the experiment. Authors did not observe any differences between high- and low-anxiety groups when deep semantic processing was activated or non-threatening words were encoded. These results seem to support the hypothesis that memory bias towards threat-related words is likely to occur only in the high anxious group in case of shallow and incidental processing of these target words. Concluding, our results showing a relation between attentional and implicit memory biases for angry faces in the highly reactive group are in line with the hypothesis provided by Fox and Georgiou (2005, p. 270). That is, the direct link between attentional dwell and enhanced memory encoding of threat-related stimuli may appear in the group of high anxious (or rather emotionally-reactive in general) people, who tend to respond to these stimuli (here: emotional facial expressions) with more in-depth processing commencing in an incidental and involuntary manner.

Although further investigation is required to provide a full picture of the mechanisms linking the attentional bias for threat-related material and incidental encoding of such material, we argue that this effect is moderated predominantly by the individual level of emotional reactivity. According to the definition provided by Strelau and Zawadzki (1993), highly ER people are very susceptible to threat-related stimuli and have a tendency to react intensively even in response to weak stimuli. As such, they might be more prone than weakly reactive participants to involuntarily process threat-related stimuli in more depth, what can result in enhanced encoding of such stimuli and subsequent better implicit memory for them. No similar significant modulation by PE or state-anxiety on responses to emotional stimuli in the attention-driven effect in the implicit memory for threatening stimuli was observed.

To summarize, the results of this preliminary experiment provided evidence for the notion that more attentional resources are involuntarily allocated to threat-related stimuli what in turn can result in their stronger incidental encoding and enhanced implicit memory for such stimuli. However, this pattern of results was observed only in participants highly reactive, so the findings are limited to this specific population. Nevertheless, our results are in line with the hypothesis that, while representations of threat are not in general more easily retrievable, they are still more accessible in memory, which may be the cause behind higher frequency of experiencing threat-oriented thoughts in individuals with high levels of emotional reactivity.

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