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Associative learning in flying phobia

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Background and objectives: Modern learning theories suggest that particularly strong associative learning contributes to the etiology and maintenance of anxiety disorders, thus explaining why some individuals develop an anxiety disorder after a frightening (conditioning) event, whereas others do not. However, associative learning has rarely been investigated experimentally in specific phobias. The current study investigated associative learning in patients with flying phobia and healthy controls using a modified version of Olson and Fazio's associative learning paradigm (Olson & Fazio, 2001).

Methods: Under the guise of an attention task, patients with flying phobia ($n = 33$), and healthy controls ($n = 39$) viewed a series of distracters interspersed with pairings of novel objects (counterbalanced conditioned stimuli, CSs) with frightening and pleasant stimuli (unconditioned stimuli, USs).

Results: After the conditioning procedure patients with flying phobia rated both CSs more frightening and showed stronger discrimination between the CSs for valence compared to healthy controls.

Conclusions: Our findings indicate a particularly stronger conditioning effect in flying phobia. These results contribute to the understanding of the etiology of specific phobia and may help to explain why only some individuals develop a flying phobia after an aversive event associated with flying.

1. Introduction

Traditionally, anxiety disorders have been considered to be a learned fear response to a stimulus after a frightening experience with that stimulus (Pavlov, 1927; Watson & Rayner, 1920). However, retrospective investigation into the learning history of fear showed that not all people experiencing fear or trauma in a given situation go on to develop a phobia, and that patients with anxiety disorders and healthy controls report a similar amount and intensity of frightening experiences with typical phobic stimuli (Lautch, 1971; Liddell & Lyons, 1978; Rachman, 1977). With respect to flying phobia, 3 retrospective studies investigating associative learning experiences before the development of the flying phobia have been conducted so far. In interview studies, Wilhelm and Roth (1997) found that participants with flying phobia and healthy controls did not differ in the number of reported conditioning events associated with flying, and Schindler, Vriends, Michael, and Margraf (submitted for publication) found a similar pattern of results: Patients and healthy controls reported an equal number of comparable frightening events associated with flying. In a study with aircrew participants, Aitken, Lister, and Main (1981) showed that not all people who have had fearful events during flying go on to develop phobias. They found that a higher percentage of healthy controls reported having experienced a significant flying accident compared to participants with a flying phobia. In sum, the findings that healthy controls and patients with flying phobia both report aversive experiences during flying and that only patients developed a specific phobia after these incidents demonstrate, that the assumption that associative learning is an appropriate model for the development of specific phobia is doubted today.

In the past decade conditioning models have experienced a renaissance, as associative learning models have become more sophisticated (Field, 2000) and findings that patients with anxiety disorders (social anxiety disorder, post-traumatic stress disorder and panic disorder) show different associative learning effects in comparison to healthy controls have been published (Blechert, Michael, Vriends, Margraf, & Wilhelm, 2007; Grillon & Morgan, 1999; Hermann, Ziegler, Birbaumer, & Flor, 2002; Michael, Blechert, Vriends, Margraf, & Wilhelm, 2007; Orr et al., 2000; Peri, Ben-Shakhar, Orr, & Shalev, 2000). Compared to healthy controls, patients with these anxiety disorders show either stronger discrimination between a CS paired with an aversive stimulus (e.g., electric shock, CS+) and a CS not paired (CS−) (Orr et al., 2000) or

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stronger CRs to both CSs, indicating stimulus generalization (Mineka & Zinbarg, 1996), or weaker inhibition of the fear response in the presence of safety signals (Davis, Falls, & Gewirtz, 2000). These results indicate that patients may have developed the disorder because of their propensity to form particular strong conditioning responses or they might reflect an epiphenomenon contributing to the maintenance of the disorder. Although specific phobias are the most common anxiety disorders (Kessler et al., 2005), to date associative learning has only been investigated in spider phobia.

Schweckendiek et al. (2011) used a novel picture–picture conditioning paradigm and found that patients with spider phobia showed enhanced brain activation to a CS that was paired with phobia-relevant pictures (US) and not to CSs that were paired with non-phobic aversive USs or neutral pictures in the fear network. Regarding verbal ratings (e.g., fear, valence), patients showed higher discrimination between the CSs that were paired with phobic or non-phobic USs and neutral USs compared to healthy controls. These results show a phobia-relevant conditionabilty effect measured by brain activation and a general conditionability effect (independent from phobia-(ir)relevant USs) measured by verbal ratings. Thus indeed a stronger conditioning effect might play a role in specific phobia at least at subjective levels.

In the present study we experimentally investigated associative learning effects in flying phobia, using a modified version of the associative learning paradigm of Olson and Fazio (2001, 2002)[3] for its lifelike design. As in everyday life, in which many associations will be formed between flying and mildly aversive USs (e.g., hard work life, reports of turbulent flights), this paradigm uses mildly aversive USs, namely words and pictures. Further, similar to the associations of flying in real life with pleasant (e.g., holidays, nice view, smiling crew) and frightening (e.g., strange movements in the plane, reports of flying accidents on TV) stimuli, this paradigm uses several pleasant and frightening USs. Finally, the participants view, under the guise of an attention and surveillance task, a series of random images and words (430 trials) interspersed with CS–US pairings (40 trials), making it closer to real life in the sense that associative learning always takes place within a context of many distracting stimuli. In our paradigm, neutral novel cartoon characters served as CSs. Of the 2 counterbalanced CSs 1 CS was paired with 10 different pleasant USs (CSpleas) and the other CS with 10 different frightening USs (CSfear). In a subsequent evaluation task participants rated how anxious they feel when viewing the CSs and their valence. Stronger associative learning was measured by the differentiation between CSfear and CSpleas (Orr et al., 2000) as well as generalization of the CSfear to the CSpleas (Davis et al., 2000). Recent studies have shown that increased contingency awareness in healthy participants is often correlated with stronger associative learning (Pleyers, Corneille, Luminet, & Yzerbyt, 2007). Thus, we also explored if contingency awareness of the CS–US pairings influences conditionability.

2. Method

2.1. Participants

The present sample consisted of 33 patients with flying phobia according to the *Diagnostic and Statistical Manual of Mental Disorders–4th edition* (APA, 1994) and 39 healthy controls. The clinical sample comprised patients who decided to join a fear-of-flying weekend seminar run by one of the authors (B.S.).[4] This seminar included cognitive behavior treatment (including a flight in Europe) and technical information about airplanes and flying.

Table 1
Sociodemographics and DSM-IV diagnoses of the flying phobia group and healthy control group.

Variable	Flying phobia patients $N = 33$	Healthy controls $N = 39$
Sex (men) *N* (%)	13 (39.4)	20 (51.3)
Age in years, *M* (SD)	36.4 (9.3)	36.1 (11.1)
Education, N (%)		
Apprenticeship	17 (51.5)	15 (38.5)
Secondary school	2 (6.1)	7 (17.9)
Comprehensive and technical college	8 (24.2)	8 (20.5)
University	6 (18.2)	9 (23.1)
Current diagnoses, N (%)		
Primary diagnosis		
Flying phobia	33 (100)	0
Secondary diagnosis		
Agoraphobia	7 (21.2)	0
Other specific phobia	2 (6.1)	0
Social phobia	1 (3.0)	0
Generalized anxiety disorder	1 (3.0)	0
Total	11 (33.3)	0
Third diagnosis		
Agoraphobia	1 (3.0)	0
Other specific phobia	1 (3.0)	0
Eating disorder	1 (3.0)	0
Generalized anxiety disorder	1 (3.0)	0
Total	4 (12.1)	0
Past diagnoses, *N* (%)		
Major depression	9 (27.3)	8 (5.1)
Panic disorder with agoraphobia	3 (9.0)	0
Post-traumatic stress disorder	2 (6.0)	0
Panic disorder	1 (3.0)	0
Eating disorder	2 (6.0)	1 (2.6)

All participants of the clinical sample fulfilled the *DSM–IV* criteria of specific phobia (flying). Table 1 presents current primary, co-morbid, and past psychological disorders for all participants. 11 patients with flying phobia had a secondary diagnosis, which was mainly another anxiety disorder ($N = 10$, 30.3%). 4 patients (12%) had a third co-morbid disorder that was also mainly (9% of all, 75% of 4) an anxiety disorder. The author B.S. diagnosed patients and healthy controls using the Mini-DIPS (Margraf, 1994). The DIPS is the German version of the Anxiety Disorders Interview Schedule (DiNardo & Barlow, 1988). The Mini-DIPS is the short form of this structured interview following *DSM–IV* criteria for current (6 months) and life-time prevalence of the following disorders: Anxiety, affective, somatization, obsessive–compulsive, and eating. Furthermore, it allows the exclusion of patients with schizophrenic psychoses.

The healthy control group consisted of 39 participants who were recruited through announcements at the University of Basel. Exclusion criteria for the healthy control group were fulfilling the *DSM–IV* criteria of any lifetime anxiety disorder, fulfilling the *DSM–IV* criteria of a current psychiatric disorder according to the Mini-DIPS (see Table 1), or being an airline employee. All participants of the clinical and the control sample had flown before. The clinical sample and the control sample were matched with respect to age, sex, and education (see Table 1).

2.2. Procedures and stimuli

On a website about a fear-of-flying weekend seminar in Zürich (Switzerland), interested people filled out a contact form. An email

[3] Olson and Fazio (2001, 2002) call their paradigm evaluative conditioning, because they used negative and positive unconditioned stimuli (USs) to be associated with the conditioned stimuli. As we use mildly aversive frightening USs we prefer to call our paradigm an associative learning paradigm.

[4] B.S. is a trained cognitive behavior psychotherapist registered at the Federation of Swiss Psychologists (FSP).

reply informed them about the details of the next seminar and invited them to participate in the present study. They were told that they could join the seminar independently from participating in the study and that participation in the study was voluntary. If they were interested in joining the seminar (with or without participating in the study) they should telephone the therapist/experimenter (hereafter referred to as experimenter) to make an appointment. On arrival, participants gave written consent and completed the Mini-DIPS. Directly after the interview the experimenter informed the patients about the result of the interview including information about the diagnosis and if a cognitive behavioral psychotherapy in the form of a weekend treatment was indicated (depending on inter alia the diagnosis, severity and comorbid disorders). This was the case for all 33 patients. They went on to participate in the conditioning task, which was followed by the ratings and an affective priming task.[5] After the conditioning and priming task the experimenter interviewed the participants about their CS–US contingency awareness. Patients were orally debriefed and then either enrolled in therapy with author B.S. or - if they preferred - received counseling about their flying phobia. After being orally debriefed, controls received gifts (e.g., t-shirts and key fobs of a Swiss airline company) as a reward for participation.

2.3. Conditioning task

The conditioning procedure was a modified version of Olson and Fazio's (2001, 2002) attitudinal conditioning task. The current version was developed and successfully evaluated by Michael and Vriends (submitted for publication). The task commenced with the instruction that the participants had to watch for target items and to press a response button if a target item appeared in a stream of distracter stimuli on a 19″ PC monitor. The participants viewed 430 trials that were organized in 5 blocks of 86 trials. Each block contained 10 target items, 52 distracters (pictures and descriptions of objects, e.g., clock, umbrella, landscapes, and cartoons characters), 16 blank screens (leading to a less rhythmic appearance of the items), and 8 CS–US pairings. The 5 target items and the 2 CSs were neutral novel cartoon characters identified with Icelandic[6] names—"Spardi" and "Keli". These 2 CSs were counterbalanced over the participants. Frightening USs consisted of 5 phobia-unspecific frightening pictures (e.g., woman held-up at knife point, conflagration)[7] and 5 frightening German adjectives (e.g., menacing, ominous (English translation)). Pleasant USs consisted of 5 pleasant pictures (e.g., sunset, baby) and 5 pleasant German adjectives (e.g., assuasive, empathetic (English translation)). Each US was twice paired with a CS distributed over the 5 blocks. The allocation of which cartoon character was associated with the frightening or pleasant stimuli was counterbalanced across participants. Trial length of each of the 86 trials per block was 1.5 s and the intertrial interval was 0 s within the blocks, resulting in a block length of 129 s. Thus there was a continuous sequence of pictures with no gaps (apart from 16 blank screens). After each block the participants received feedback on their reaction time to the target. For the following block a new target to watch for was introduced. The experimental software for all parts of the experiment was programmed with Presentation® (Neurobehavioral Systems, Inc., Albany, N.Y., USA).

2.4. Ratings

Subsequent to the conditioning procedure, participants were told that the researchers wanted to find out whether affective reactions to the distracter pictures interfere with the ability to respond rapidly to the targets. Therefore, we asked them to evaluate a subset of 10 pictures randomly chosen for each participant. In reality, we showed each participant the same set of 10 pictures, which included the 2 CSs, 2 comic figures that were shown as target items during the conditioning task, 4 neutral pictures (e.g, a sunset, a wall clock) that were shown as distractor pictures and 2 novel pictures of a greenback (1 dollar note) and of a milk can. The pictures were presented on a computer screen and participants judged them on a paper-and-pencil 6-point Likert scale with respect to how positive or negative they judged each picture (1 = *positive*, 6 = *negative*) and how anxious they felt when looking at each picture (1 = *not anxious*, 6 = *anxious*).

2.5. Measurement of explicit contingency awareness

Participants completed a post-experimental interview assessing their awareness of the experimental hypotheses and the US–CS association. As we wanted to compare more spontaneous answers to more directed answers, we formulated the open-ended questions from more general focusing on the experiment to more specific focusing on the contingency between the CS and US. As such, the interview started with the question "Was your attention drawn to something in particular during the experiment? (If so, what was it?)." Then, participants were asked about the stimuli presentation ("Did you recognize any regularity in the stimuli presentation?"). The following questions were more specific, asking the participant about recognizing regularity in the presentations of the comics and ending with the question "Did you think that the comics were paired with certain stimuli? (If yes, with which stimuli?)." 2 research assistants who were blind to the diagnostic group of the participants separately rated the answers of the contingency awareness interview on a 7-point scale (from 1 if the participant had absolutely no idea about the logic or pairings of the experiment to 7 if the participant recalled at least one example of the 10 CSpleas–US pairings and at least one example of the 10 CSfear–US pairings. We then summarized these answers on a 3-point scale (1–3 as 1, *no awareness*; 4 and 5 as 2, *aware of pairings, but not contingency aware* [examples of participants' answers are "sometimes pictures appeared alone, sometimes together," "there were pairings of pictures/words, 'umbrella' was paired with the word 'clock'"]; and 6 and 7 as 3, *awareness of CS–US contingencies with at least one correct example* [i.e., "Spardi was paired with a picture of a man with a knife"]). Agreement between these raters was assessed at 96%. An independent blind third rater rated the 3 cases that showed disagreement in ratings (only in codes 1 and 2). The third rater agreed 100% with 1 of the other 2 ratings. The score with agreement was used. We summarized this variable into aware and non-aware participants. Participants who had a score 3 on our scale were rated as participants with explicit contingency awareness.

2.6. Statistical analysis

Differences in responses were tested using the generalized linear model (GLM) with CS Type (CSpleas versus CSfear) as within-participant factor and diagnostic Group (flying phobia, healthy

[5] A standard affective priming task was conducted as an implicit measure of conditioning (Field, 2006). It is not described, nor are its results reported, as the patient groups were significantly slower than the healthy participants for whom the task was designed and they frequently exceeded the allowed time limit for responding. Therefore, the task did not yield valid results in this study.

[6] Icelandic names are very uncommon in Switzerland, hence, they are unlikely to be recognized by our research participants.

[7] Pictures used as USs were numbers 2900, 9230, 6313, 3230, 9440, 2550, 2540, 2050, 5700, and 1750 of the International Affective Pictures System (Lang, Bradley, & Curtbert, 1999). The valence mean (SD) of frightening pictures was 2.80 (.91) and that of pleasant pictures 7.90 (.32). The arousal mean (SD) of frightening pictures was 5.55 (.90) and that of pleasant pictures 4.60 (.67).

controls) as between-participants factor. We expected that the CS paired with the frightening USs (CSfear) would be rated differently from the CS paired with the pleasant USs (CSpleas). Thus, successful conditioning should result in a main effect for CS Type. A significant interaction between Group and CS Type would indicate differences in conditionability across the groups, expressed as a difference in differentiating between the CSpleas and the CSfear. A significant main effect of Group for both CSs in flying phobia would indicate a stimulus generalization effect. To exclude a general negative rating effect in flying phobia, the mean ratings of 2 other comic figures were compared between the groups with a *t*-test. Differences in contingency awareness between the diagnostic groups were tested with a chi-square test. An alpha level of .05 determined statistical significance. Effect sizes were computed as partial Eta squared (η_p^2) and reported as percentage of explained variance. Statistical analyses were carried out with SPSS 11 for Mac OS X.

3. Results

3.1. Did the conditioning procedure succeed?

As can be seen in Table 2, the main effect for CS Type was significant for fear and valence ratings of the counterbalanced CSs (resp. $F(1, 70) = 5.635$, $p = .020$, $\eta_p^2 = 7.5\%$ and $F(1, 70) = 4.876$, $p = .031$, $\eta_p^2 = 6.5\%$). The CS that was paired with frightening USs (CSfear) was rated significantly more frightening and more negative than the CS that was paired with pleasant USs (CSpleas) (see Fig. 1 for the means of the CSs in both groups), indicating successful conditioning on both rating scales.

3.2. Associative learning in flying phobia

Although patients with flying phobia showed a higher discrimination between the CSs than healthy controls (HC) for fear ratings (Δ CSpleas − CSfear = −.36 in patients with flying phobia versus Δ CSpleas − CSfear = −.15 in HC, see Fig. 1), the CS Type × Group interaction was not significant ($F(1, 70) = .801$, p = n.s.), but there was a significant Group effect ($F(1, 70) = 4.077$, $p = .047$, $\eta_p^2 = 5.5\%$). Patients with flying phobia rated both CSfear and CSpleas more frightening than healthy controls. Main Group and CS Type × Group interaction effects of the fear and valence ratings are also summarized in Table 2.

For valence there was no significant Group main effect ($F(1, 70) = .003$, p = n.s.). Here, the CS Type × Group interaction was significant ($F(1, 70) = 5.287$, $p = .024$, $\eta_p^2 = 6.5\%$). Patients with flying phobia showed stronger discrimination between CSfear and CSpleas on the valence scale than the healthy controls (Δ CSpleas − CSfear = −.70 in patients with flying phobia versus Δ CSpleas − CSfear = −.03 in HC, see Fig. 1). A non-significant post hoc *t*-tests revealed that this discrimination was not specifically based on the more negative ratings of the CSfear nor on the more positive ratings of the CSpleas.

Table 2
Main and interaction effect statistics of anxiety and valence ratings after the conditioning task.

Factor	*SS*	*df*	*F*	p	η^2
Anxiety ratings					
CS Type	2.39	1	4.88	.03	6.5%
Group	15.12	1	4.08	.05	5.5%
CS Type × Group	.39	1	.80	>.05	1.1%
Valence ratings					
CS Type	4.67	1	5.64	.02	7.5%
Group	.01	1	.00	>.05	.0%
CS Type × Group	4.34	1	5.29	.02	6.5%

Note. CS Type = CS_{pleas} versus CS_{fear}, Group = patients with flying phobia versus healthy controls.

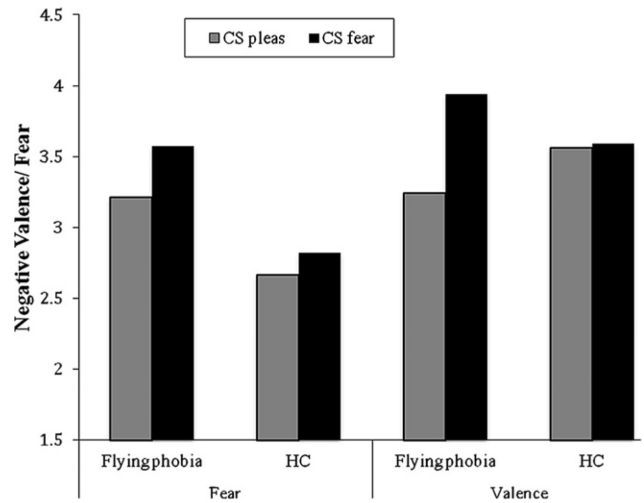

Fig. 1. Means of conditioned stimuli (pleasant, CSpleas, and frigthening, CSfear) for both diagnostic groups (flying phobia patients vs. healthy controls, HC).

3.3. General rating behavior

Patients with flying phobia (FP) and healthy controls (HC) rated 2 other comic figures that were not paired with USs similar (resp. $M_{FP} = 1.87$, $M_{HC} = 1.64$, $t = 1.056$, p = n.s.; $M_{FP} = 2.39$, $M_{HC} = 2.63$, $t = -1.007$, p = n.s.). Both groups also rated 2 novel pictures that were not shown during the conditioning task similarly (fear $M_{FP} = 2.05$, $M_{HC} = 1.68$, $t = 1.632$, p = n.s.; valence $M_{FP} = 2.22$, $M_{HC} = 2.24$, $t = .107$, p = n.s.). Thus, patients with flying phobia did not show a general elevation in rating behavior.

3.4. Explicit awareness of contingency and stronger associative learning in flying phobia patients

1 (3%) of 33 patients with flying phobia and 9 (23%) of 39 healthy controls were explicitly aware of the contingency between at least 1 of the 20 US–CS pairings. A chi-square test revealed that patients were significant less explicitly contingency aware ($\chi^2 = 3.999$, $p = .046$) than healthy controls. Thus, it seems unlikely that increased awareness accounted for the associative learning effects in patients with flying phobia.

4. Discussion

In this study we found that after a conditioning procedure, in which 1 neutral stimulus was paired with pleasant and 1 neutral stimulus was paired with frightening pictures and words, patients with flying phobia rated both stimuli as more frightening, and discriminated better between the stimuli on valence ratings than healthy controls. The effects in this study were small, though they are remarkable in the light of the used conditioning paradigm that interspersed 40 conditioning trials with mild USs into a detection task that displayed hundreds of words and pictures, making the experimental conditioning procedure lifelike.

The finding of increased CRs with respect to the fear rating fits well with other associative learning studies that found larger CRs (indicating enhanced fear) among patients with anxiety disorders vs. controls to both the unpaired and paired conditioned stimulus (Fayu, 1961; Grillon & Morgan, 1999; Orr et al., 2000; Peri et al., 2000; Wessa & Flor, 2007). Increased fear for both CSs among patients possibly indicates generalization of fear (Mineka & Zinbarg, 1996) or may be understood as a deficiency to process the safety information that distinguishes the CS paired with pleasant USs from the CS paired with frightening USs (Davis et al., 2000). That both CSs were rated as more frightening could also be interpreted as the result of a general bias of the patient group to rate stimuli in general as more frightening/negative. However, patients with flying phobia in the present study did not rate other comic figures that were not paired with USs or novel pictures as more frightening or more negatively valenced than the healthy controls.

Regarding valence ratings, we found better discrimination between the CSpleas and CSfear in patients with flying phobia than in healthy controls. Enhanced discrimination between CSs in patients with anxiety disorders compared to healthy controls has been reported in other studies as well (Orr et al., 2000; Schweckendiek et al., 2011) and is usually interpreted as enhanced conditionability (Orr et al., 2000). As the present study included pleasant USs (instead of the absence of USs, which is usually the case in aversive conditioning paradigms), it remains open whether the current results reflect the same conditioning mechanism.

Inconsistencies between different outcome measures are, however, not exceptional in conditioning studies (Blechert et al., 2007; Hermann et al., 2002). For example, Schweckendiek et al. (2011) found a similar inconsistency. Patients with spider phobia rated the CS, which was paired with aversive non-phobic USs, as more unpleasant but not more fear-inducing compared to the CS that was paired with neutral USs, indicating better discrimination between the CSs regarding valence ratings but not fear ratings. It seems that valence learning and fear learning are 2 different processes that can occur in parallel, but that can also be dissociated. Indeed in the past decade evaluative conditioning (which refers to changes in the liking of a stimulus) and fear learning have been recognized as distinct processes (see for an overview De Houwer, Thomas, & Baeyens, 2001). Although changes in valence can be observed in fear learning paradigms, these do not necessarily go hand in hand with changes in fear. As a matter of fact, there can be strong dissociations (e.g., De Houwer et al., 2001; Vansteenwegen, Francken, Vervliet, De Clercq, & Eelen, 2006). Nevertheless the present findings with respect to the fear and valence ratings might both be interpreted as stronger conditioning in flying phobia because in both cases the CR to the CSfear is higher in patients than in controls.

How can the present findings contribute to the etiology of specific phobia? First, we showed that a conditioning paradigm, in which the USs are mild and interspersed within a row of distracting stimuli, can successfully associate fear to neutral stimuli. Such a paradigm is useful to investigate anxiety disorders, in which mild aversive experiences might play a role in the development or persistence of the disorder. This might, for example, be the case in conditioning through fear information (Field, 2006) as in children who have a dentist phobia without having ever been to the dentist. They might have heard frightening stories (hence mildly aversive US) about the dentist, which has contributed to the development of the phobia. The assumption that associative learning through mild stimuli such as information might play a role in flying phobia has a logical fit with the findings of Nousi, Haringsma, Van Gerwen and Spinhoven (2008), who found that 8.7% of their large sample with adults who applied for a flying phobia treatment program had never even flown before. Further, of those who had flown, 85.6% indicated that their flights had been uneventful. Nousi et al.'s results indicate that other ways than direct aversive conditioning also play a role in the development of flying phobia. Associative learning through mild USs might be one of those. Second, the finding that patients with flying phobia showed stronger CRs at both outcome measures of the CSfear may indicate that conditioning mechanisms contribute to the development of a specific phobia. Patients with flying phobia might have had stronger CRs during frightening events associated with flying (frightening media, accident, strong turbulence) than people who did not develop a flying phobia after a frightening flying experience. Such a mechanism would explain the findings of retrospective studies, in which patients with flying phobia as well as healthy controls reported aversive associative learning events, but only the patients subsequently developed a phobia (Schindler et al., submitted for publication; Wilhelm & Roth, 1997).

The current study has several strengths and limitations. The comparison of a clinical sample with healthy controls and the use of a conditioning paradigm with both mildly aversive and positive USs interspersed within a row of distracters represent strengths. These aspects of our laboratory investigation in associative learning closely approximated real-life learning conditions reported by patients (e.g., media or information learning). Indeed, we found that most participants were not aware of the CS–US pairings. However, we only included a verbal explicit contingency-awareness test, which might not reflect all types of knowledge that participants have about the contingency (Field, 2000). It might be possible that a participant cannot spontaneously recall the CS–US pairings, but would recognize these pairings, if they would be depicted. Thus, future studies should also measure contingency awareness with an expectancy dial (Purkis & Lipp, 2001), measure CS–US contingency between the trials (Lovibond & Shanks, 2002) or use a recognition task (Pleyers et al., 2007), optimally discriminated for US valence and US identity awareness (Stahl, Unkelbach, & Corneille, 2009). On the other hand, the observation that the present associative learning effect for participants with flying phobia appears to have been obtained in the absence of contingency awareness is consistent with findings that typically distinguish the surveillance paradigms (as performed in the present study) and picture–picture paradigms without such a surveillance task (see Jones, Olson, & Fazio, 2010).

Furthermore, the study paradigm had the advantage of investigating aversive and appetitive conditioning at the same time, although the present results do not consistently demonstrate that flying phobia is associated with enhanced appetitive and/or fear conditioning. Also, ratings of the CSs prior to conditioning would make investigation of the change of fear and valence of the CSs through conditioning possible. The disadvantage of such a procedure would most likely be enhanced contingency awareness and making the procedure less life-like. Due to the length of the paradigm, we did not include an extinction procedure. Future studies should include such a phase. Several studies on associative learning in anxiety disorders have found clinically relevant differences between patients with anxiety disorders and healthy controls within the extinction phase of associative learning paradigms. Patients with anxiety disorders show slower extinction of learned associations (Blechert et al., 2007; Guthrie & Bryant, 2006; Orr et al., 2000; Peri et al., 2000).

Our findings indicate that stronger associative learning plays a role in the development of flying phobia. A related issue requiring investigation is whether persons who develop flying phobias show stronger associative learning before the onset of the phobia. Moreover, it would be important to assess whether the effect of subjective valence and fear ratings are associated with avoidance behavior, or associated with more automatic neurobehavioral responses, such as amygdala activation or the size of the hippocampus, that would best be measured with psychophysiological and imaging techniques. Finally, future research is needed to investigate whether the findings of this study can be generalized to other specific phobias (e.g., blood phobia, fear of heights) or other anxiety disorders.

Declaration of interest

The authors explicitly declare that there is no actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations within 3 years of beginning the submitted work that could inappropriately influence, or be perceived to influence the present manuscript.

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