How strong emotions influence reasoning: effects of spider phobia on a conditional inference task

Christina Wranke (Christina.Wranke@psychol.uni-giessen.de)
Experimental Psychology and Cognitive Science, Otto-Behaghel-Strasse 10F
D-35394 Giessen, Germany

Luzie Jung (Luzie.Jung@psychol.uni-giessen.de)
Experimental Psychology and Cognitive Science, Otto-Behaghel-Strasse 10F
D-35394 Giessen, Germany

Kai Hamburger (Kai.Hamburger@psychol.uni-giessen.de)
Experimental Psychology and Cognitive Science, Otto-Behaghel-Strasse 10F
D-35394 Giessen, Germany

Abstract

In recent years there has been a growing interest to investigate how emotions affect logical reasoning. There is evidence that emotional states and emotional task contents could impede performance on logical reasoning problems. The aim of our research was to investigate how strong emotions –occurring due to spider phobia– affect logical reasoning. Therefore, spider phobics and non-phobics completed a conditional inference task with different types of content: spider phobia relevant, negative, and neutral problems were presented. The results showed that spider phobics performed worst on phobia relevant problems compared to neutral and negative inferences. Thus, processing anxiety relevant topics may elicit a fear response resulting in a decrease of cognitive resources which might be responsible for the impaired reasoning performance.

Keywords: spider phobia; emotions; logical reasoning; inference task.

Introduction

The interaction between emotions and cognition has recently attracted increased interest (e.g., Bäuml & Kuhbandner, 2007; Perlstein, Elbert, & Stenger, 2002; Storbeck & Clore, 2005). Although recent studies explored how emotions affect reasoning, there is still the necessity to further address this topic. While some researchers referred to a facilitatory effect of emotions on reasoning (e.g., Chang & Wilson, 2004; Johnson-Laird, Mancini, & Gangemi, 2006), others described the detrimental aspect of emotional states (e.g., Oaksford, Morris, Grainger, & Williams, 1996; Wranke, Hamburger, & Knauff, 2009). Thus, our intention is to systematically investigate the influence of strong emotional states on reasoning. Therefore, we investigated how anxiety disorders affect reasoning since those disorders have strong emotional components. More precisely, we were interested in the performance of spider phobics on logical reasoning tasks with spider phobia relevant, negative, and neutral contents compared to the performance pattern of a control group (non-phobic). Is it more difficult for spider phobics to solve reasoning tasks containing phobia relevant topics, since this content frightens them? Or, are they even better in performing those tasks due to a more emotional understanding of phobia relevant emotions and implications? In the following we focus on a) studies which reported that emotions can facilitate reasoning performance and b) studies which found an impeding effect of emotions on reasoning.

Emotions facilitate reasoning: The mood congruency effect

Mood congruency effects are quite numerous in the literature, e.g., in terms of memory phenomena (e.g., Bower, 1981; Teasdale & Russell, 1983; Fiedler, Nickel, Muehlfriedel, & Unkelbach, 2001; Knight, Maines, & Robinson, 2002). Teasdale and Russell (1983) for instance reported that participants in elated mood recalled more positive words previously learned within a word list than participants in depressed mood. The opposite accounts for negative toned words: this type of word was better recalled by the depressed compared to the elated participants. Furthermore, a link between mood and the material that has to be processed was also realized by Blanchette, Richards, Melnyk, and Lavda (2007) and Chang and Wilson (2004) in terms of logical reasoning tasks. Blanchette and colleagues (Blanchette et al., 2007) carried out a study in which participants who actually experienced strong emotions (following terrorist attacks) reasoned about neutral, general emotionally, and emotionally syllogisms related to terrorism. Thus, they created a link between the emotional state arising from the terrorist attacks and the reasoning material which is related to terrorism. In this study the participants differed in their level of exposure to the terrorist attacks. Participants who were most directly affected by the events showed higher levels of emotions and were most accurate on reasoning tasks which were directly linked to their particular emotions, namely reasoning problems containing terroristic issues. The authors argued that the increased reasoning performance is due to the specific connection between experienced emotions and the related,

very specific and consequential reasoning problems. In the study of Chang and Wilson (2004) also a connection between experienced emotions and the semantic content of reasoning problems is present. After recalling an autobiographical situation like being cheated or receiving altruistic benefit, participants solved two Wason selection tasks (WSTs) based on cheater or altruist detection. Priming effects based on similarity between recalled situations and semantic task content were found for the cheater detection WST, but not for the altruistic detection WST. While best performance on the cheater detection problem was obtained for the group which recalled a situation of being cheated, the altruism detection problem was worst performed by the group who recalled a situation receiving an altruistic act. Thus, the authors argued against a domain-general facilitatory effect in terms of congruency between experienced emotions and semantic content of reasoning tasks. However, enhanced vigilance for subsequent cheating could result from experiencing a situation of being cheated. Thus, recollection of such a situation could help when reasoning about a semantically congruent problem which can be referred to as a facilitatory or priming effect. But, this effect does not seem to be available for the recollection of a situation receiving altruistic benefit when reasoning about a semantically congruent task because the authors "[…] did not expect facilitation of altruism detection after content-relevant recollection, because it seems unlikely that being a beneficiary of altruism increases the utility of vigilance for subsequent altruism in the same way that being a victim of cheating increases the utility of vigilance for subsequent cheating" (Chang & Wilson, 2004, p.269). While Chang and Wilson (2004) demonstrated a priming effect on a non-clinical sample, Johnson-Laird et al. (2006) showed that psychological illness can lead to better reasoning as well. Their "hyper-emotion theory of psychological illness" consists of five principles, one of which postulates that individuals suffering from psychological illness focus on their emotions and contemplate about them and their causes (Johnson-Laird et al., 2006). As a result, they reason better about content which was related to their illness. Johnson-Laird and colleagues could show that individuals with a tendency to obsessive-compulsive disorder reasoned more accurately compared to a control group, but only when the reasoning material was related to their illness. The same reasoning pattern was revealed for individuals with a tendency to depression. Therefore, due to the focus on emotions and the situations causing them, patients become experts on illness relevant topics which determine the enhanced reasoning performance for those matters.

In summary, these studies have depicted that emotions do not generally impair cognitive abilities like reasoning but can sometimes facilitate them when reasoning about emotion related and individually meaningful situations.

Emotions impede reasoning: Demand of working memory resources

While the previous studies showed an enhancement in reasoning due to mood congruency, other investigations revealed that emotions might rather decrease reasoning performance. Oaksford et al. (1996) for instance carried out a study in which participants were put into positive or negative mood, respectively. Those participants provided less logically correct answers on the WST compared to a control group. In a second experiment the authors showed that a concurrent working memory task impeded reasoning performance on the WST similar to the results obtained with positive or negative mood. Thus, the depletion of working memory resources- in terms of both experiencing emotional mood and performing a task in parallel which depletes such resources- was due to the decreased reasoning performance. Especially the central executive resources were required since participants in positive mood (not in negative mood) performed less accurately on the Tower of London, a task referring to central executive components which Oaksford and colleagues carried out in a third experiment. Thus, mainly positive mood impaired reasoning due to an increased demand of central executive components. Thereupon, fewer resources seemed to be available to perform the reasoning task. Oaksford et al. (1996) discussed this assumption in line with the "suppression theory". This hypothesis postulates that mood already binds working memory capacity. Since the experience of positive or negative mood facilitates the recall of stimuli from long-term memory which are congruent with individuals' mood, this could take up working memory resources. As a result, fewer resources are left for other cognitive tasks like logical reasoning. Supporting evidence concerning the restriction of working memory capacity was also provided in terms of anxiety and depression (Channon & Baker, 1994; Derakshan & Eysenck, 1998). In addition, Wranke et al. (2009) investigated the influence of positive and negative mood on reasoning. Participants' mood was altered by giving an excellent (success group), pour (failure group), or on average (neutral group) feedback about their performance on a manipulated intelligence test. Subsequently, participants completed a set of conditional inference tasks either in a WST paradigm or in an argument task. The emotional value of the inference problems was varied as well. In this regard, a link between experienced mood (based on success and failure, respectively) and the content of the reasoning material (success and failure situations) was established. In addition to positively and negatively toned problems, inferences with neutral content were presented. Results showed that mood impeded reasoning performance. The participants in a negative mood performed worse than the participants in a positive mood, but both groups were outperformed by participants in a neutral mood. There was no interaction between mood of the reasoner and the content of the problem, and therefore no facilitatory effect due to mood congruency could be observed. Consequentially, the authors argued that mood

might result in a pre-load of cognitive resources and thus has a devastating effect on logical reasoning performance. While Oaksford et al. (1996) and Wranke et al. (2009) investigated the influence of emotional states on reasoning, Blanchette and colleagues were interested in how an emotional content of reasoning material affects performance (Blanchette & Richards, 2004; Blanchette, 2006). Participants solved a conditional inference task (argument task) based on statements with neutral and emotional content. The emotional statements were either actual emotional statements or statements with originally neutral words which were manipulated pertaining to their emotional content via classical conditioning: prior to the reasoning phase of the experiment an originally neutral word, like sandwich, was paired with emotional images of the International Affective Picture System (IAPS; Center for the Study of Emotion and Attention, 1995). For both types of emotional statements higher error rates were reported in comparison to neutral ones. As a possible explanation the authors referred to the demanding nature of working memory resources when processing emotional content so that less capacity is available for reasoning. In a nutshell, the studies reported in the previous paragraph showed the detrimental effect of emotions on reasoning due to a need for working memory resources.

Our current aim was to shed light on the debate about the role of strong emotions on reasoning. Thus, we wanted to specify whether strong emotions due to spider phobia may be helpful or not when the reasoning material mirrors the own pathological state. Therefore, we first carried out a pilot study to evaluate the emotionality and phobic relevance of the task contents which will be described in the following section.

Pilot study

Methods

Subjects 26 non-phobic students from the University of Giessen volunteered in the evaluation study (mean age: M=21.27 years; range 19-38 years; 20 female, 6 male).

Materials, Design and Procedure The statements used in the main study were taken from a pool of 48 'if, then' statements (16 spider phobia relevant, 16 negative, 16 neutral statements). All statements were presented in German language and contained an equal number of syllables. These statements had to be rated for emotionality and phobic relevance. Participants were given a booklet including all 48 sentences which had to be rated according to the following instruction (translated from German):

"Please read through the following sentences carefully and attentively. First, please rate each sentence concerning how it emotionally affects you. For this, please use the following scale:

very negative 1 – 2 – 3 – 4 – 5 very positive
O O O O O

Second, please rate whether you believe the sentences could be of relevance for a person with spider phobia with 'Yes' or 'No'."

Statement presentation was randomized across participants. The testing was self-paced and took place in the class room.

Results We computed descriptive statistics in order to find four statements per content category (spider phobia relevant, negative, neutral), being the most representative ones. Therefore, we chose only those spider phobia relevant statements which were close to the value "3" on the rating scale representing the most neutral point. This was important to rule out that spider phobia relevant statements were associated with negative valence since non-phobics should not rate them as negative. Likewise, for the neutral statements we chose only those rated as most neutral (close to the value "3") whereas the selected four negative statements were rated most negative (close to the value "1"). Within the four spider phobia relevant statements no difference in the emotional valence could be observed (ANOVA, $F(1.713,42.837)=.129$; $p>.05$; decimals for degrees of freedom result from Greenhouse-Geisser values). Similarly, neither the four neutral (ANOVA, $F(2.262,56.540)=1.978$; $p>.05$) nor the four negative sentences (ANOVA, $F(3,75)=1.097$; $p>.05$) differed in the rated emotionality. The means of the emotionality rating were computed for the three different content categories (spider phobia relevant, negative, neutral) based on the respective four selected statements and were compared in another ANOVA which revealed significant differences between them ($F(2,50)=62.934$; $p<.001$). Post hoc paired t-tests found that negative statements (M=1.67; SE=.14) were rated as more negative than neutral (M=3.47; SE=.12) ($t(25)=9.145$; $p<.001$) and spider phobia relevant ones (M=2.93; SE=.09) ($t(25)=-8.31$; $p<.001$). Furthermore, neutral statements were rated as more neutral than spider phobia relevant statements ($t(25)=3.85$; $p=.001$).

Besides the emotionality rating of the sentences participants had to quote whether or not a statement is phobic relevant. Overall, the four selected spider phobia relevant items were rated with 92.31% as phobic relevant. The four neutral statements obtained a phobic relevance rating of 2.88% while the selected negative statements were rated as phobic relevant with 19.23%. These 12 selected statements were used for the conditional inference task presented in the main study since they fulfilled the previously described requirements.

Main study

Methods

Subjects 9 spider phobic students (mean age: M=22.33 years; range 20-26 years; 7 female, 2 male) and 7 non-phobic control students (mean age: M=22.86 years; range 20-26 years; 7 female) participated in the experiment. They were recruited via announcements in newspapers and at the campus. Participants were selected from a larger sample by

means of scores on the Spider Phobia Questionnaire (SPQ; Klorman, Weerts, Hastings, Melamed, & Lang, 1974). SPQ-scores of spider fearful students (M=20.22; SE=.878) were significantly higher than those of the non-fearful control students (M=2.00; SE=.873) (t(14)=-14.459; p<.001). Each subject received 5 Euros or a course credit for participation. Moreover, we controlled for participants being no psychology students (thus, no pre-experience with logical reasoning tasks) and all were native German speakers.

Materials and Design We carried out a conditional reasoning task in form of an argument task. An argument task is composed of a first premise, a second premise, and a conclusion (three-term series). The first premise consists of an 'if p, then q' statement that posits q to be true if p is true. The second premise refers to the truth of the antecedent ('if' part) or the consequent ('then' part). The participants` task is to decide whether the conclusion logically follows from the two given premises. In this regard, two inferences are valid and two are invalid. Valid inferences are modus ponens (MP; 'if p, then q, and p is true, then q is true') and modus tollens (MT; 'if p, then q, and q is false, then p is false'), whereas the two invalid inferences are affirmation of consequent (AC; 'if p, then q, and q is true, then p is true') and denial of antecedent (DA; 'if p, then q, and p is false, then q is false'). From each of the 12 statements acquired by the pilot study (four with spider phobia relevant, four with negative and four with neutral contents), a set of MP, MT, AC and DA inferences was generated resulting in a total of 48 problems. The presentation of the 48 three-term problems was randomized across participants. Examples of the statements are presented in Table 1.

Table 1: Examples of statements with different contents.

Type of content	Example of statement
Spider phobia relevant	When a person sees a toy spider then the person is scared witless.
Negativ	When a person is anorexic then the person has to be force-fed.
Neutral	When a person is craftsman then the person has served an apprenticeship.

Procedure All participants were tested individually in a quiet room at the Psychology Department of the University of Giessen. At the beginning participants filled out the SPQ. Afterwards the logical reasoning tasks had to be solved. These argument tasks were presented on a computer screen using the SuperLab 4.0 software (Cedrus Corporation, San Pedro, CA) which encoded participants` responses and decision times. A self-paced design was used. Each premise and the conclusion were presented one at a time. By pressing the spacebar participants proceeded from one to the next. While both premises were presented in black letters the conclusion was presented in red. The task required to evaluate whether the conclusion necessarily followed from the two premises. By pressing a "Yes" key or a "No" key on the keyboard participants responded whether the conclusion was valid or not. Prior to the experiment two practice trials were presented to familiarize participants with the procedure but no feedback was given.

Results

We wanted to investigate whether spider phobic relevant reasoning task contents were worse or even better performed by spider phobics compared to the reasoning pattern of a control group. Thus, error rates of the argument task were compared using an ANOVA with the between-subject factor group (spider fearful students, non-fearful students) and the two within-subject factors content (spider phobia relevant, negative, neutral) and type of reasoning (MP, MT, AC, DA). We obtained a significant interaction between the content and the group factor (F(2,28)=6.807; p<.01). A post hoc paired t-test revealed that spider phobics performed significantly worse for inference problems with spider phobia relevant content (43.06%; SE= 4.47%) compared to negative ones (34.72%; SE=5.01%) (t(8)=2.667; p<.05). Furthermore, phobia relevant problems were more error prone than neutral ones (36.81%; 4.71%) but marginally failed to reach significance (t(8)=2.268; p=.053). The reasoning error pattern of the non-phobics was contrary to those of the spider phobics. Non-phobics made significantly more errors for inferences with negative content (M=33.93%; SE=6.38%) compared to spider phobia relevant (28.57%; 7.20%) (t(6)=-2.521; p<.05) and neutral problems (22.32%; 7.33%) (t(6)=-3.653; p<.05). This interaction pattern between the groups and the task content of the argument task is visualized in Figure 1.

In addition to this interaction we obtained a significant main effect for the type of reasoning (F(1.244,17.409)=14.532; p=.001). Post hoc paired t-tests revealed a significant difference in error rates for MP compared to MT (t(15)=-2.796; p<.05), AC (t(15)=-4.832; p<.001), and DA inferences (t(15)=-6.128; p<.001). Furthermore, significant differences were found between MT and AC (t(15)=-2.475; p<.05) as well as between MT and DA (t(15)=-3.31; p<.01). Overall, the fewest errors were made with MP inferences (M=5.73%; SE=2.37%), followed by MT (M=19.79%; SE=6.22%), AC (M=51.04%; SE=8.77%) and DA (M=58.85%; SE=8.14%).

The content factor was also significant (F(2,28)=4.645; p<.05). Further paired t-tests showed that error rates for spider phobia relevant problems (M=36.72%; SE=4.30%) were significantly more error prone than neutral ones (M=30.47%; SE=4.41%) (t(15)=2.928; p=.01). However, this was due to worse performance of spider phobics on phobia relevant contents (see the above interaction between the group and content factor).

Moreover, a significant interaction was found between the content and type of reasoning factor (F(3.193,44.699)=3.721; p<.05). Post hoc paired t-tests revealed that for DA inferences significantly less errors were made with neutral (M=50.00%; SE=8.85%) compared to spider phobia relevant contents (M=67.25%; SE=8.85%)

(t(15)=2.905; p<.05). For AC inferences we observed significant differences between neutral (M=39.00%; SE=9.95%) and spider phobia relevant problems (M=56.25%; SE=8.975%) (t(15)=2.905; p<.05) as well as between neutral and negative problems (M=57.75%; SE=8.75%) (t(15)=-3.503; p<.01).

Besides the error rate analysis we also computed an ANOVA based on decision time with the between-subject factor group (spider fearful students, non-fearful students) and the two within-subject factors content (spider phobia relevant, negative, neutral) and type of reasoning (MP, MT, AC, DA). The results did not reveal an interaction between the content and the group factor. However, this ANOVA obtained a significant main effect for the type of reasoning factor (F(3,42)=8.583; p<.001). Post hoc t-tests showed that MP inferences were much faster solved than MT (t(15)=-2.871; p<.05), AC (t(15)=-4.356; p=.001), and DA problems (t(15)=-4.423; p<.001).

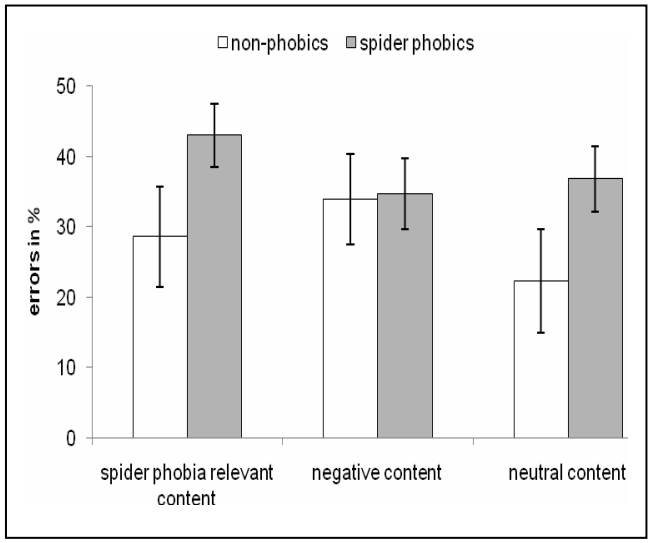

Figure 1: Error rates (%) and standard errors (SE) for the non-phobics and spider phobics in the conditional reasoning task.

Discussion

The aim of our study was to investigate whether strong emotions due to an anxiety disorder enhance or impede performance when reasoning about inference problems with illness relevant topics. Our results showed that spider phobics performed worst on the argument tasks with spider phobia relevant contents. Although Johnson-Laird et al. (2006) referred to an increased reasoning performance of patients with a tendency toward obsessive-compulsive or depressive behavior for illness-related material, our results did not support this assumption. This might be due to the extent of being an expert on a special topic. While Johnson-Laird and colleagues described that "[…] as a result of prolonged rumination, patients become expert reasoners about those matters pertaining to their illness" (Johnson-Laird et al., 2006, p. 836), suffering from spider phobia does not lead to more accurate reasoning on topics that are related to the own emotional anxiety state. This might be due to the different symptoms of psychological disorders of a major depression and specific phobias including spider phobia. Spider phobics show a pronounced tendency to avoid the phobic object and show an intense fear response during exposure (American Psychiatric Association, 1994). Thus, contrary to patients with a major depression they do not tend to confront themselves in their thoughts with illness relevant matters which might involve that spider phobics are no expert reasoners on phobia related topics. Hence, spider phobics did not reason more accurate on inference problems containing spider phobia contents. In fact, they even showed worst performance on those problems compared to negative and neutral ones. Thus, the results suggest that illness related tasks impair reasoning for anxiety patients. These results support the suppression theory (Oaksford et al., 1996): processing phobia relevant material comprised the confrontation with the phobic object which causes fear. This yields a strong emotional response resulting in a pre-load of working memory resources. This restriction of cognitive capacity might be responsible for the less logically correct performance of spider phobics on phobia relevant problem contents. The worst performance on such problems is not due to a premature decision pattern –resulting from avoidance behavior, lower attention, or lack of motivation– since the decision times did not differ across the spider phobic and the non-phobic group. Hence, it seems plausible that anxiety limits cognitive resources and determines the bad performance on phobia relevant problems. Furthermore, there are studies in the literature describing that trait anxiety interrupts working memory functions (MacLeod & Donnellan, 1993) and in particular those of the central executive (Eysenck, 1985). In similar fashion, Eysenck and Calvo (1992) assumed that state anxiety is related to worries which load processing and storage capacities of the working memory. Thus, the detrimental effects of state anxiety are more pronounced in tasks demanding working memory capacity, especially of the central executive and the articulatory loop. In fact, these two systems are associated with logical reasoning performance (e.g., Gilhooly, Logie, & Wynn, 2002; Klauer, Stegmaier, & Meiser, 1997).

Moreover, there is evidence that spider phobia could change reasoning patterns. De Jong, Mayer, and van den Hout (1997) showed that spider phobics tend to rely on a danger-confirming reasoning strategy while solving phobia relevant WSTs. The authors argued that the mere perception of threat leads to this reasoning pattern which may maintain the specific phobia.

While spider phobics performed worst on phobia relevant problems in our study, non-phobics revealed worst performance on problems with negative content. These results are in line with Blanchette and Richards (2004) and Blanchette (2006). It is possible that processing negative toned material demands cognitive capacity leading to the impaired reasoning since "emotional contents may prime a

number of associations that load working memory" (Blanchette, 2006, p.1123).

Overall, AC and DA inferences with spider phobia relevant and negative content were more error prone. Similar results were also obtained by Blanchette and Richards (2004). The authors argued that this error pattern might result from a misinterpretation of emotional problems as biconditionals. At present, we would like to retain this assumption, but such effects should be examined carefully in the future.

In summary, this research showed that reasoning tasks with phobia relevant topics can impede performance of spider phobics. Thus, the perceived connection with the own anxiety and the anxiety related problems can hinder to reason accurately. Contrary, non-phobics did not reason worst on spider phobia relevant inferences since those problems represent individually meaningful and emotion eliciting contents in particular for spider phobics but not for non-phobics.

Acknowledgments

This research was supported by the German Science Foundation (Graduate Program 'Neural representation and action control – NeuroAct' 885/2).

References

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders, 4th edition*. Washington, DC: American Psychiatric Press.

Bäuml, K.-H., & Kuhbandner, C. (2007). Remembering can cause forgetting- but not in negative moods. *Psychological Science, 18*, 111-115.

Blanchette, I. (2006). The effect of emotion on interpretation and logic in a conditional reasoning task. *Memory & Cognition, 34*, 1112-1125.

Blanchette, I., & Richards, A. (2004). Reasoning about emotional and neutral materials: Is logic affected by emotion? *Psychological Science, 15*, 745-752.

Blanchette, I., Richards, A., Melnyk, L., & Lavda, A. (2007). Reasoning about emotional contents following shocking terrorist attacks: A tale of three cities. *Journal of Experimental Psychology: Applied, 13*, 47-56.

Bower, G.H. (1981). Mood and memory. *American Psychologist, 36*, 129-148.

Center for the Study of Emotion and Attention. (1995). *The International Affective Picture System*. Gainesville: University of Florida.

Chang, A., & Wilson, M. (2004). Recalling emotional experiences affects performance on reasoning problems. *Evolution and Human Behavior, 25*, 267-276.

Channon, S., & Baker, J. (1994). Reasoning strategies in depression: Effects of depressed mood on a syllogism task. *Personality and Individual Differences, 17*, 707-711.

de Jong, P.J., Mayer, B., & van den Hout, M. (1997). Conditional reasoning and phobic fear: Evidence for a fear-confirming reasoning pattern. *Behaviour Research and Therapy, 35*, 507-516.

Derakshan, N., & Eysenck, M.W. (1998). Working memory capacity in high trait-anxious and repressor groups. *Cognition and Emotion, 12*, 697-713.

Eysenck, M.W. (1985). Anxiety and cognitive-task performance. *Personality and Individual Differences, 6*, 579-586.

Fiedler, K., Nickel, S., Muehlfriedel, T., & Unkelbach, C. (2001). Is mood congruency an effect of genuine memory or response bias? *Journal of Experimental Social Psychology, 37*, 201-214.

Gilhooly, K.J., Logie, R.H., & Wynn, V.E. (2002). Syllogistic Reasoning Tasks and Working Memory: Evidence from Sequential Presentation of Premises. *Current Psychology: Developmental, Learning, Personality, Social, 21*, 111-120.

Johnson-Laird, P.N., Mancini, F., & Gangemi, A. (2006). A hyper-emotion theory of psychological illnesses. *Psychological Review, 113*, 822-841.

Klauer, K.C., Stegmaier, R., & Meiser, T. (1997). Working memory involvement in propositional and spatial reasoning. *Thinking and Reasoning, 3*, 9-47.

Klorman, R., Weerts, T., Hastings, J., Melamed, B., & Lang, P. (1974). Psychometric description of some fear-specific questionnaires. *Behavior Research, 5*, 401-409.

Knight, B.G., Maines, M.L., & Robinson, G.S. (2002). The effects of sad mood on memory in older adults: A test of the mood congruence effect. *Psychology and Aging, 17*, 653-661.

MacLeod, C., & Donnellan, A.M. (1993). Individual differences in anxiety and the restriction of working memory capacity. *Personality and Individual Differences, 15*, 163-173.

Oaksford, M., Morris, F., Grainger, B., & Williams, J.M.G. (1996). Mood, reasoning, and central executive processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22*, 476-492.

Perlstein, W.M., Elbert, T., & Stenger, V.A. (2002). Dissociation in human prefrontal cortex of affective influences on working memory-related activity. *Proceedings of the National Academy of Sciences, 99*, 1736-1741.

Storbeck, J., & Clore, G.L. (2005). With sadness comes accuracy; with happiness, false memory - Mood and the false memory effect. *Psychological Science, 16*, 785-791.

Teasdale, J.D., & Russell, M.L. (1983). Differential effects of induced mood on the recall of positive, negative and neutral words. *British Journal of Clinical Psychology, 22*, 163-171.

Wranke, C., Hamburger, K., & Knauff, M. (2009). Emotions can be a nuisance in logical reasoning. In preparation.