The effect of emotion on conditional reasoning

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Abstract

In two experiments, we explore whether logical reasoning abilities are affected by emotion. In both experiments, we compared participants' performance on a conditional reasoning task when the content was emotional and neutral. In Experiment 1, conditional statements included either emotional words or neutral words. In Experiment 2, we manipulated the emotional connotation of initially neutral words using a conditioning procedure. Words were repeatedly paired with either positive, negative, or neutral images. These words were then used in a conditional reasoning task. In both experiments, participants' performance was more likely to deviate from prescriptions of normative logic when the content was emotional compared to when it was neutral.

The idea that emotions affect people's reasoning is widespread. There is a commonsensical notion that emotions have the power to disrupt logical thinking. This contrasts with current views in the scientific study of emotion that emphasize the functional aspects of emotions. There is however, a paucity of empirical work on the effect of emotion on reasoning. In two experiments reported here, we investigated whether conditional reasoning is affected by emotion.

Contemporary approaches to the study of affect in psychology and the neurosciences have consistently emphasized the adaptive value of emotion. In fact, a functionalist account of emotions is often regarded as the cornerstone of current investigations of affective phenomena (Cornelius, 1996; Ekman & Davidson, 1994; Keltner & Gross, 1999). The functionalist approach is based on the notion that emotions serve important functions and that they provide benefits to individuals and groups who experience them. Interactions between cognition and emotion have been studied within this framework.

Different types of empirical evidence support this general assumption. One type of evidence concerns the relation between reasoning abilities and the experience of affective states. Neurological research focusing on patients with specific brain lesions has shown that people who are unable to experience emotions are also seriously impaired on decision-making tasks, particularly when thinking about complex interpersonal situations (Damasio, 1994; Damasio, Grabowski, Frank, Galaburda, & Damasio, 1996; Dimitrov, Phipps, Zahn, & Grafman, 1999). This suggests that impairments in emotion actually produce deficits in normatively correct thinking. Thus, emotions may promote sound thinking rather than hinder it. This functionalist perspective is a radical departure from earlier philosophical views.

Studies on non-clinical samples also support the view that emotions are adaptive. A number of cognitive biases associated with different emotional states have been identified by recent research (e.g., Forgas, 2000). For instance, anxiety, related to the basic fear system, produces systematic biases in attention towards threat-related materials (Fox, Russo, Bowles, & Dutton, 2001; Mathews, Mackintosh, & Fulchner, 1997; Mogg, Bradley & Hallowell, 1994; Richards & French, 1992; Yiend & Mathews, 2001). Anxiety appears to modulate the cognitive system by channelling resources towards threat-related, highly relevant, materials. Thus, in most circumstances, and in moderation, cognitive biases associated with emotions are generally thought to be functional.

While beneficial effects of emotion on cognition have recently been emphasized, potential impairments related to emotion remain relatively unexplored. Research in psychopathology does document that certain clinical disorders involving important emotional dysfunctions may be associated with impairments in reasoning (e.g., Pelissier & O'Connor, 2002). However, it is not clear whether these impairments are directly caused by the emotional dysfunctions or whether both the emotional and reasoning dysfunctions are manifestations of a general underlying aetiology.

There are two specific issues concerning the effect of emotion on reasoning, and more specifically on logical reasoning performance. One possibility is that the affective state a person is experiencing affects their reasoning. Another is the possibility that the emotionality of the materials affects reasoning performance. In other words, do people reason differently when they reason about emotional and non-emotional materials? While there is some research on

the former issue (e.g., Bodenhausen, Kramer, & Susser, 1994; Oaksford, Morris, Grainger, & Williams, 1996) the latter remains largely unexplored. It is the issue we investigate in the experiments reported in this paper.

We set out to explore this issue by using a conditional reasoning task. Conditional reasoning is a form of deductive reasoning that involves statements of the form *If p, then q* (e.g.: If you ride a bicycle, then you burn calories). This form of reasoning is both the subject of rigorous prescription based on normative logic and frequently used in everyday thinking. Based on such statements, there are two inferences that are logically valid: Modus Ponens (MP): *p*, therefore *q* (e.g.: Chris rides a bicycle, therefore he burns calories), and Modus Tollens (MT): *not q*, therefore *not p* (e.g.: Chris does not burn calories, therefore he does not ride a bicycle). There are however two inferences that are not logically valid but that people often draw: Denying the antecedent (DA): *not p*, therefore *not q* (e.g.: Chris does not ride a bicycle, therefore he does not burn calories), and Affirming the consequent (AC): *q*, therefore *p* (e.g.: Chris burns calories, therefore he rides a bicycle). These inferences are logically incorrect because the rule does not specify what happens in the absence of *p*. The presence of *q* could be brought about by things other than *p* (i.e., Chris could not be riding a bicycle but still be burning calories through other means). People's performance on these tasks often departs from normative expectations (Evans & Over, 1996; Shafir & LeBoeuf, 2002). The semantic content of the rules often has an important influence on people's behaviour, contrary to what normative logic would prescribe. Yet, the effect of emotional content on people's performance has remained unexplored.

Overview of the experiments

In two experiments, we compare the performance of participants on a conditional reasoning task when the reasoning materials are emotional and neutral. Conditional statements (If *p*, then *q*) were presented, and participants had to answer questions (e.g., *p* is present, is *q* present?) relating to each of four possible inferences. In Experiment 1, words used as *p* and *q* were emotional or neutral. In Experiment 2, we independently manipulated the emotional connotation of words used as *p* and *q* using a conditioning procedure.

Experiment 1

Method

Participants

Thirty individuals participated in this study.

Materials

We used 18 conditional statements. There were two classes of statements: emotional (e.g. If the situation is tragic, then one cries) and neutral (e.g. If one is in a library, then one sees books). Nine statements included emotional words as *p* and *q* and nine included neutral words. The emotionality of the words used was based on John's (1988) published norms of emotionality ratings. The words that we used in the emotional statements obtained an average rating of 5.71 (on a scale from 1 to 7), compared to 1.66 for the words used in the neutral statements. The emotional statements could be further differentiated according to the type of emotion they referred to. Three statements contained words relating to each of the following categories: anxiety, sadness, and joy.

For each conditional statement there were four questions. Each question presented a minor premise concerning the occurrence or non-occurrence of *p* or *q*, followed by a question about the other (e.g. Anne is in a tragic situation. Does she cry?). The four questions invited each of the four types of inferences based on a conditional statement: Modus Ponens (*p, therefore q ?*; e.g. Anne is in a tragic situation. Does she cry?), Denying the Antecedent (*not p, therefore not q?*; e.g. Christine is in a happy situation. Does she cry?), Affirming the Consequent (*q, therefore p?*; e.g. Laura is crying. Is she in a tragic situation?), and Modus Tollens (*not q, therefore not p?*; e.g. Gayle is not crying. Is she in a tragic situation?). In an equal number of cases we used "*not p*" (e.g. Gayle is not crying) and alternates (e.g. Gayle is smiling).

Procedure

The task was performed on a computer. Participants were initially told that they would read conditional statements (or rules) about how people act or feel in different situations. They were told these rules could appear more or less plausible but that they should answer the questions based on what follows logically from the rule they have been given. The order in which participants received each of the conditional statements was randomly determined. The conditional statement was first presented on the screen for five seconds. It then remained in the same position but turned to a light shade of grey while participants answered each of the four questions, which were presented in a random order. Each question was presented individually on the screen and remained on the screen until participants provided their answer by pressing the appropriate key on the computer keyboard. The specific instructions given to participants were: "You can answer each question by YES, NO, or MAYBE. Your answers should be based on the conclusions that follow logically from the rule.".

Table 1: Mean number of responses (and SD) (possible maximum = 9), Experiment 1. Significant pairwise comparisons are highlighted.

		Yes	No	Maybe
MP	Emotional	7.5 (2.3)	0.1 (0.3)	1.4 (2.2)
	Neutral	7.6 (2.1)	0.1 (0.3)	1.1 (2.0)
DA	Emotional	0.2 (0.7)	**4.4 (2.9)**	**4.4 (2.8)**
	Neutral	0.2 (0.5)	**2.9 (2.1)**	**5.9 (2.2)**
AC	Emotional	**2.8 (2.6)**	0.1 (0.4)	**6.1 (2.6)**
	Neutral	**1.9 (1.5)**	0.4 (0.7)	**6.7 (1.9)**
MT	Emotional	0.1 (0.4)	6.5 (2.7)	2.3 (2.5)
	Neutral	0.2 (0.4)	6.4 (2.1)	2.3 (2.0)

Results and Discussion

We first performed a general analysis including responses to all four questions. Answers were scored in relation to a conditional response pattern. A conditional interpretation is the normatively correct interpretation. It corresponds to the following answers: YES answers to MP (*p ~ q?*) (e.g., Anne is in a tragic situation. Does she cry?), MAYBE answers to both DA (*not p ~ q?*) (e.g., Christine is in a happy situation. Does she cry?), and AC (*q ~ p?*) (e.g., Laura is crying. Is she in a tragic situation?), and NO answers to MT (*not q ~ p?*) (e.g., Gayle is not crying. Is she in a tragic situation?). We entered the average number of each of these responses as the dependent measure in a general ANOVA including two within-subject factors: question type (MP, DA, AC, MT), and emotion (emotional vs. neutral). The main effect of question type was significant, $F(3, 87)= 7.30$, $p<.05$, as well as the main effect of emotion, $F(1,29)=14.69$, $p<.05$, and the interaction between emotion and question type, $F(3,87)=4.40$, $p<.05$. Overall, participants provided more conditional-like answers in response to MP (M=7.6, SD=.39, out of nine possible trials), followed by MT (M=6.5, SD=.41), AC (M=6.4, SD=.40) and DA (M=5.1, SD=.43). The main effect of emotion reveals that, across all questions, participants were more likely to provide the normatively correct response in the case of neutral statements (M=6.7, SD=.26), compared to emotional statements (M=6.1, SD=.24).

These main effects were qualified by a two-way interaction. The difference between emotional and neutral statements varied across different questions. Specifically, while conditional answers to MP and MT were not different across the emotional and neutral statements, answers to DA and AC did differ. The complete distribution of answers is presented in Table 1.

We statistically compared the frequency of committing logical fallacies in response to DA and AC questions. We compared the mean number of No answers to DA questions for emotional and neutral trials using a paired-sample t-test. This showed a significant effect, $t(29)=4.04$, $p<.05$. Participants were more likely to answer No in response to emotional statements (see Table 1). We also compared the number of Yes responses to AC, again using a paired-sample t-test. This comparison was also significant, $t(29)=2.42$, $p<.05$, again showing that this fallacy was more frequent in response to emotional statements.

We examined the effect of specific emotional contents on the two inferences where emotion had a significant effect (DA and AC). We used paired-sample t-test to compare the difference between sadness, joy, and anxiety-related statements, taking into account the number of comparisons made. For DA, there were no differences in the number of No answers to statements including the different specific emotions (all ts>0.7) Similar comparisons on the proportion of Yes answers to AC again shows no differences between specific emotions (all ts>0.6).

Thus, overall, participants' performance was more likely to deviate from normatively correct responses when they reasoned about emotional, compared to neutral statements. This was similar when statements included joy, sadness, or anxiety related words.

Because we used existing emotional and neutral words, features other than the emotional connotation of these words may account for the results. Specifically, features associated with semantic content, independent of emotion, or other features differentiating between emotional and neutral statements may contribute to the results of Experiment 1. In order to isolate the effect of emotion on reasoning performance, we needed to vary the emotional valence independently of semantic content. This is what we did in Experiment 2.

Experiment 2

In Experiment 2, we use a conditioning paradigm to manipulate the emotional connotation of the words used as *p* and *q*, independently from semantic content. In the first block of the experiment, neutral words and non-words were repeatedly paired with emotional or neutral images. The neutral stimuli should this way take on some of the affective quality associated with the paired stimulus (Walther, 2002). This pairing was done randomly so that across participants, the same words

were paired with neutral pictures in some cases, and emotional pictures in other cases. In the second block, these words were used as *p* and *q* in the conditional reasoning task. We compared participants' responses to emotional and neutral statements. In a third block, we asked participants to rate the emotionality of the words, to verify that the conditioning procedure was effective.

Method

Participants

Forty individuals participated in this study.

Materials

The conditioning procedure paired neutral words and non-words with neutral or emotional (positive or negative) photographs. We used 18 neutral words, taken from published ratings of word emotionality (e.g., sandwich, vitamin, camera) (John, 1988). These words received an average emotionality rating of 1.62 (*SD*=0.32), on a scale from one to seven, where one represents "not at all emotional". We also created 18 non-words that sounded like English words (e.g., gruss, axpart, fisk). The words and non-words were divided into three lists. Each of these lists would be paired with photographs of either neutral, negative, or positive emotional valence. This pairing was determined randomly and was different for different participants. The photographs were taken from the International Affective Picture System. We used thirty-six photographs of each type. On negativity/positivity scales (1-9), the negative photographs received an average rating of 2.72 (*SD*=0.47), comparatively to 4.93 for the neutral ones (*SD*=0.42), and 8.06 for the positive ones (*SD*=0.31).

Procedure

The first block involved a conditioning procedure using the initially neutral words and non-words and the affective pictures. A blocked presentation of the word-picture pairs was used. For instance, all negative conditioning trials were presented first, followed by all neutral, and then all positive trials sequentially. This order was randomly determined. Each block involved 60 word-picture pairings. Each word was presented 5 times, each with a different photograph of the same emotional valence.

Each trial lasted 2000 ms. The photograph first came up on the computer screen for 500 ms. While the picture remained on the screen, the word, written in white on a small black rectangular, then appeared in the middle of the screen for 1500ms. There was a 500ms blank before the start of the next trial.

The second block consisted of the conditional reasoning task. We used the same procedure as in Experiment 1 but the statements were different as we used the conditioned words and non-words as *p* and *q*. Participants again saw conditional statements, followed by a minor premise in the form of a question which they had to answer by either Yes, No, or Maybe. There were 18 conditional statements, six of which were "positive", six "neutral", and six "negative".

In the third block, following the reasoning task, participants completed a word rating task meant to assess whether the conditioning procedure had been successful. The words were presented one by one on the computer screen. Participants were asked to rate their emotional connotation. Answers were given on a scale from one (very negative) to seven (very positive).

Results and Discussion

We analysed participants' responses in the same way as in Experiment 1, first entering the number of conditional-like responses in a general ANOVA. Three variables were included in this ANOVA: question type (MP, DA, AC, and MT), word type, (word, non-word), and emotionality (emotional, neutral). The three main effects were significant: question type, $F(3,117)=23.77$, $p<.05$, word type, $F(1,39)=34.17$, $p<.05$, and emotionality, $F(1,39)=5.42$, $p<.05$.

The main effect of question type is as expected. Participants were more accurate in response to MP (*M*=.87, *SD*=.03) and MT (*M*=.79, *SD*=.04), followed by AC (*M*=.51, *SD*=.05) and DA (*M*=.45, *SD*=.05), $F(1,39)=34.26$, $p<.05$. The main effect of word type confirms participants provided more conditional-like answers when rules included actual words (*M*= .72, *SD*=.03) compared to non-words (*M*=.60, *SD*=.03).

Emotionality had a significant impact on participants' performance. Participants were more accurate when the statements were neutral (*M*=.67, *SD*=.03), than when they were emotional (*M*=.63, *SD*=.03). Although this did not interact with question type in this experiment, we performed planned comparisons to compare responses to emotional and neutral statements for each specific question. Although all comparisons show the same pattern of means (responses to neutral statements being more likely to conform to conditional interpretations, see Figure 1), this only reached significance for AC, $t(39)=2.3$, $p<.05$.

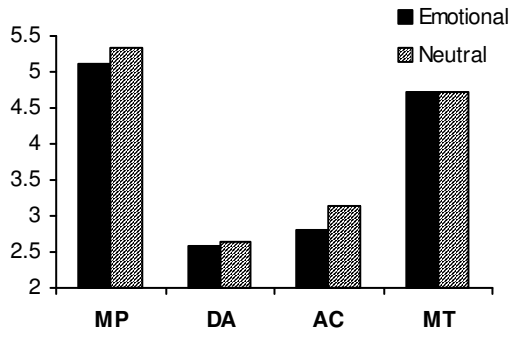

Figure 1: Mean number of conditional responses (possible maximum = 6) to each of the four questions, Experiment 2.

We compared participants' responses to positive and negative trials more specifically. Collapsing over words and non-words, we entered the number of conditional answers in a 4x2 ANOVA involving question type and valence (positive vs. negative). No effect was significant. Conditioning words with positive or negative pictures produced similar effects on the reasoning task.

Evidence of the effectiveness of the conditioning procedure is found in participants' subsequent ratings of the word stimuli. We entered the average ratings in a 2x3 ANOVA involving word type (word vs. non word) and picture type (negative, neutral, positive). There was a main effect of word type, $F(1,39)=134.4$, $p<.05$. Participants rated actual words more positively than non words ($M=5.4$, $SD=.12$, and $M=3.5$, $SD=.09$ respectively). There was also a main effect of picture type, $F(2,78)=3.5$, $p<.05$, showing that the conditioning paradigm produced the expected effects on the word ratings (see Figure 2). The negative conditioning however appears to have had a stronger effect on the word ratings than positive conditioning. Planned comparisons reveal that while the difference between the negative and neutral conditions was significant, $F(1, 39)=5.35$, $p<.05$, that between neutral and positive conditions was not, $F(1, 39)=0.12$, $p>.05$.

Thus, overall, the conditioning procedure was successful in attaching emotional connotations to neutral words and non-words and this emotional connotation had a significant impact on the way participants reasoned. Across participants, the same words were associated with different types of pictures (negative, neutral, or positive). Thus, the effect cannot be attributed to the semantic content of the words. Rather, we argue that the emotional valence of the words, acquired through conditioning, lead to deleterious effects on logical performance.

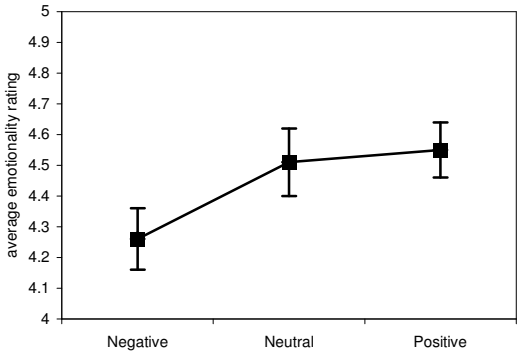

Figure 2: Mean rating of emotional valence of conditioned words, Experiment 3. (1=very negative, 7=very positive)

General Discussion

In two experiments, participants' performance on a conditional reasoning task was significantly affected by the emotionality of the materials they reasoned about. In both cases, participants' responses were more likely to deviate from normatively correct responses when they reasoned about emotional, compared to neutral materials. This was evident both when materials were positive, and negative in emotional content. We believe the findings of Experiment 2 are particularly important, as this is a controlled demonstration that individuals reason differently when they reason about emotional and non-emotional materials. In that experiment, the emotional connotation was varied independently of semantics. The same words were for some participants emotional, and for other participants neutral. Thus, differences in reasoning cannot be attributed to confounded semantic factors.

The conditioning procedure was relatively successful in attaching novel emotional connotations to initially neutral stimuli, if judged by participants' emotionality ratings at the end of the experiment. Clearly, the emotion induction was mild. We think this is significant as it shows that even relatively mild changes in the degree of emotionality of the reasoning materials will significantly affect the way that people reason logically. While clearly we cannot extrapolate from these results to situations in which the degree of emotion is very high, such as in traumatic events, it does suggest that it is important to consider the affective dimension in order to come to a fuller understanding of human reasoning.

One important experiment has previously examined emotion and conditional reasoning, and produced results congruent with ours. Oaksford and colleagues (Oaksford, Morris, Grainger, & Williams, 1996) manipulated participants' mood and then compared their performance on the Wason selection task. Participants in both positive and negative moods were less likely to provide normatively correct answers, compared to participants in a neutral control group. This is consistent with the results of our experiments. The study by Oaksford and colleagues addressed the question of whether the emotional state of the reasoner affects their performance. That is, do people reason the same way when they are in positive, negative, or neutral affective states. We did not manipulate participants' mood, but examined the effect of the emotionality of content. In other words, we asked whether people reason differently when they reason about emotional and neutral materials. Crucially, it appears that answers to these two questions offer important parallels.

There are a number of possible mechanisms that may be responsible for the effect of emotion on reasoning. Oaksford and colleagues (1996) investigated the possible involvement of working memory (WM)

capacity. At least for positive moods, there was some suggestion that performance on the reasoning was related to reduced central executive capacity. If processing emotional content is similar in nature to experiencing an affective mood, then the effect we identified may as well be mediated by WM capacity. This is a possibility that we are actively exploring in ongoing experiments.

The fact that our findings show mainly impairments in normatively correct reasoning as a result of emotion is consistent with the commonsensical notion that emotions impair logical reasoning abilities. It is also consistent with important philosophical traditions, going back to the Stoics, that have emphasized the deleterious effects of passion on reason. Nevertheless, we believe this is not incompatible with a general functionalist account of emotions. The effect of emotion may generally be beneficial, but there are circumstances under which their contribution will be disruptive. This is readily acknowledged in the case of dysfunctions of emotions, either through their unusual duration or intensity. A number of factors may influence whether emotions will be beneficial or detrimental for reasoning performance. Among others, task difficulty, the nature of the reasoning materials, and the relevance of the emotional dimension for the response could affect whether emotions promote or hinder logicality. We have identified an effect whereby in non-clinical samples, and with relatively mild emotion-inductions, we can produce decrements in logical reasoning performance. In the case we studied, the emotional dimension was irrelevant for the reasoning task (i.e. the information conveyed by the affective dimension of the stimuli was unrelated to the response participants had to make), yet produced a systematic effect. This suggests the relation between emotion and cognition is highly complex. Moreover, while it has often been ignored in the past in most disciplines of cognitive sciences, our results exemplify how affective information processing must6 be acknowledged in order to come to a full understanding of human cognitive processes.

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