

Research Article

Reasoning About Emotional
and Neutral Materials

Is Logic Affected by Emotion?

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ABSTRACT—*In two experiments, we investigated whether people reason differently when they reason about emotional and neutral contents. We gave participants a conditional reasoning task (“If p, then q”) and varied the emotionality of the items used as p and q. Participants were asked to draw inferences based on these statements. In Experiment 1, we compared statements including pre-existing emotional and neutral words. In Experiment 2, we experimentally manipulated the emotionality of initially neutral words using classical conditioning. In both experiments, emotionality affected participants’ responses. They were more likely to draw invalid inferences in response to emotional compared with neutral statements.*

When people reason about important issues, emotions are likely to be involved. Be it personal relationships, important social issues, or material possessions that cost a lot of money, people frequently reason about things that have strong emotional value. Are there differences between reasoning about emotionally involving situations and neutral situations? Empirical evidence concerning the way in which emotions affect reasoning in nonclinical populations is scarce. We investigated this question in two experiments.

There is a commonsensical notion that emotions have the potential to impair logical reasoning, that a cool head is more rational than a hot head. This idea may find its roots in several important philosophical traditions. Dating back to the Stoics, various philosophical theories have portrayed emotion and cognition as working in opposition, with passions having a disruptive influence on reason and rationality (De Sousa, 1987;

French & Wettstein, 1998; Lyons, 1980). Some early psychological theories adopted similar assumptions (Dewey, 1895; Hebb, 1949).

Current perspectives in emotion research offer a radically different view. Contemporary approaches to the study of affect in psychology and the neurosciences have consistently emphasized the adaptive value of emotion (Ekman & Davidson, 1994; Frijda, 1994; Keltner & Gross, 1999; Levenson, 1994). Widespread in current research is a functionalist approach, based on the notion that emotions serve important roles and that they provide benefits to individuals and groups who experience them. Interactions between cognition and emotion have frequently been studied within this framework. One type of empirical evidence supporting the functionalist view concerns the relation between decision making and the experience of affective states. Neuropsychological studies show that people who are unable to experience emotions, but have preserved cognitive skills, may be seriously impaired on certain decision-making tasks (Damasio, 1995; Dimitrov, Phipps, Zahn, & Grafman, 1999). Thus, emotions may promote sound thinking rather than hinder it.

The question of whether emotion affects reasoning actually encompasses two related but separate questions. One is whether the affective state currently experienced influences reasoning, independently of what one is reasoning about. The other is whether people reason differently about emotional and neutral content, independently of their current affective state. There is some empirical evidence concerning the former question, which we describe next, but little evidence bearing on the latter question, which is the focus of the two experiments reported in this article.

Oaksford and his colleagues (Oaksford, Morris, Grainger, & Williams, 1996) have provided evidence that affective state, or mood, affects reasoning behavior. They manipulated participants’ mood and looked at the effect on the Wason selection

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task.¹ Participants in both positive and negative moods were less likely to provide normatively correct answers, compared with participants in a neutral control group. Although this study showed similar effects of positive and negative moods on reasoning behavior, some studies have provided evidence that the specific mood experienced may lead to a specific style of reasoning. For instance, research on social cognition shows that positive moods generally promote the use of top-down strategies, whereas negative moods increase more systematic processing (e.g., Fiedler, 2000). This finding is consistent with a functional view of emotion, according to which specific emotions promote particular ways of thinking, or increase the likelihood of drawing certain inferences.

Thus, there is evidence that affective states influence reasoning; however, little research has examined whether the emotionality of the content has an effect. The present experiments explored whether people reason differently about emotional and neutral content, independently of their current affective state.

Research on reasoning has shown that content has an important effect on the type of inferences that will be drawn (for reviews, see Evans, Over, & Manktelow, 1993; Manktelow, 1999). A number of content variables have been systematically investigated, including familiarity with the rule² (Cheng & Holyoak, 1985), agreement with the conclusions (Evans, Barston, & Pollard, 1983; Markovits & Nantel, 1989), and perceived necessity and sufficiency (Cummins-Dellarosa, Lubart, Alksnis, & Rist, 1991; Markovits, 1984, 1986; Thompson, 1995, 2000). Thus, there is evidence that content affects reasoning; however, most of the content variables investigated have been cognitive in nature.

There is research showing that people are more likely to endorse attitudinally congenial conclusions as logically valid than they are to endorse conclusions with which they disagree (Henle & Michael, 1956; Morgan & Morton, 1944). Attitudes typically involve affective components. However, attitudes also involve cognitive components, and these studies do not allow us to differentiate between the affective and cognitive components of attitude congruence. The present experiments focused specifically on the emotional value of the reasoning contents so we could determine whether emotional content affects reasoning.

To investigate this question, we used a conditional reasoning task. Conditional reasoning involves statements of the type “If p , then q .” Although it is formalized in propositional logic, this

type of reasoning is prevalent in everyday situations. From a conditional statement such as “If a person rides a bicycle, then she burns calories,” various inferences can be drawn; some of these are logically correct, and some are not. Four possible inferences are as follows:

- Modus ponens (MP) takes the form “ p , therefore q ”: “Chris is riding a bicycle; therefore, she is burning calories.”
- Modus tollens (MT) takes the form “not q , therefore not p ”: “Chris is not burning calories; therefore, she is not riding a bicycle.”
- Denying the antecedent (DA) takes the form “not p , therefore not q ”: “Chris is not riding a bicycle; therefore, she is not burning calories.”
- Affirming the consequent (AC) takes the form “ q , therefore p ”: “Chris is burning calories; therefore, she is riding a bicycle.”

Logically speaking, the first two inferences (MP and MT) are correct, but the latter two (DA and AC) are not. It is logically possible that Chris is not riding a bicycle but is burning calories nevertheless (thus, to infer “not p , therefore not q ” is incorrect). Similarly, it is possible that Chris is burning calories but not riding a bicycle (thus, “ q , therefore p ” is also incorrect).

Because conditional reasoning is both commonly used and the subject of rigorous prescriptions based on normative logic, it provides a formal and relevant framework for studying the effect of emotional content on logical reasoning.

OVERVIEW OF THE EXPERIMENTS

Participants read conditional statements (“If p , then q ”) in which the words used as p and q were either emotional or neutral. In Experiment 1, we used preexisting emotional and neutral words. In Experiment 2, we independently manipulated the emotional connotation of initially neutral words. We used a conditional-arguments task (see Thompson, 2000) to measure which inferences participants drew on the basis of these statements.

If people are perfectly logical, their reasoning should not be affected by the emotional content of conditional statements, which does not change the logical structure of those statements. Another possibility is that emotional content may have effects similar to those of affective states. In that case, research on mood and conditional reasoning (Oaksford et al., 1996) would predict both negative and positive contents would increase deviations from the prescriptions of normative logic. Another possibility is that different emotional contents may have specific effects on reasoning, as would be predicted by a functional view of the effect of emotion on reasoning.

EXPERIMENT 1

Experiment 1 used neutral and emotional words in conditional statements. We used emotional words related to anxiety, sad-

¹In the Wason selection task, participants are given a conditional rule (“If p , then q ”) along with four possibilities and asked to see whether the rule is being violated. For example, given the rule “If a card has a D on one side, it has a 5 on the other,” participants would see two cards with a letter on top (p and not p —e.g., “D” and “G”) and two cards with a number on top (q and not q —e.g., “5” and “7”). Participants’ task is to choose the cards they will turn over to verify whether the rule has been violated.

²In general, participants tend to adopt the logically valid answers more often for rules that they are familiar with (e.g., “If you want to drink, you must be over 18”) than for rules that they are unfamiliar with.

TABLE 1
Examples of Conditional Statements Used in Experiment 1

Emotional	Neutral
If there is danger, then one feels nervous. (anxiety)	If a man is an actor, then he is an extrovert.
If a person is being punished, she will feel hurt. (sadness)	If one is in a library, then one sees books.
If someone is friendly, then he is loved. (happiness)	If one eats a sandwich, then he is eating cheese.

ness, and happiness. Because the words varied, both the semantic content and the emotionality of the statements differed across conditions. Nevertheless, if reasoning differed across conditions, this would provide preliminary evidence that emotionality of content may affect reasoning.

Method

Participants

Thirty individuals participated in this study. They were compensated £5 for their time.

Materials

We used 18 conditional statements of the form “If *p*, then *q*.” All the statements represented factual relations. Nine statements included emotional words as *p* and *q*, and 9 included neutral words (see Table 1 for examples of the statements). Within the emotional statements, we used words associated with happiness, sadness, and anxiety; there were 3 statements of each type. We selected emotional and neutral words on the basis of published norms of emotionality ratings (John, 1988). The words that we used in the emotional statements obtained an average rating of 5.71, compared with 1.66 for the words used in the neutral statements.

For each conditional statement (e.g., “If someone is in a tragic situation, then she cries”), there were four questions. Participants saw two premises: the major premise as a statement about either *p* or *q*, and the minor premise phrased as a question about either *q* or *p* (see Table 2). The four possible combinations of the occurrence and nonoccurrence of *p* and *q* were presented,

corresponding to the four types of inferences based on a conditional statement. Participants could answer each question by “yes,” “no,” or “maybe.” In an equal number of cases, we used explicit negations (e.g., “Gayle is not crying”) and alternates (e.g., “Gayle is smiling”).

Procedure

The task was presented on a computer. Participants were initially told that they would read statements (or rules) about how people act or feel in different situations. They were also given an example. They were told these rules could appear more or less plausible, but that their answers to the questions should be based on what follows logically from each rule. The order of presentation of the statements was randomly determined for each participant.

Results

We analyzed answers to individual questions, but answers were scored in relation to a conditional response pattern. A conditional interpretation is the normatively correct interpretation (see Table 2 for the list of conditional answers). We entered the proportion of conditional responses as the dependent measure in a general analysis of variance (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, $F(3, 87) = 7.30, p < .001, \eta_p^2 = .20$, as was the main effect of emotion, $F(1, 29) = 14.69, p < .001, \eta_p^2 = .34$. Overall, participants provided the most conditional answers in response to MP questions ($M = .84, SD = .24$), followed by MT ($M = .72, SD = .27$), AC ($M = .71, SD = .25$), and DA ($M = .57, SD = .26$) questions. The main effect of emotion revealed that, across all questions, participants were more likely to provide the normatively correct response in the case of neutral statements ($M = .74, SD = .23$), compared with emotional statements ($M = .68, SD = .28$).

These main effects were qualified by a two-way interaction between emotion and question type, $F(3, 87) = 4.41, p = .006, \eta_p^2 = .13$, which is depicted in Figure 1. The difference between emotional and neutral statements varied across the question types. Specifically, although the difference was in the

TABLE 2
Example of the Structure and Format of Materials Used in Experiment 1

Question type	Logical expression	Major premise	Minor premise	Conditional answer ^a	Typical error
Modus ponens	<i>p</i> , therefore <i>q</i>	Anne is in a tragic situation.	Does she cry?	Yes	—
Denying the antecedent	not <i>p</i> , therefore not <i>q</i>	Christine is in a happy situation.	Does she cry?	Maybe	No
Affirming the consequent	<i>q</i> , therefore <i>p</i>	Laura is crying.	Is she in a tragic situation?	Maybe	Yes
Modus tollens	not <i>q</i> , therefore not <i>p</i>	Gayle is not crying.	Is she in a tragic situation?	No	—

Note. This example is based on the rule “If someone is in a tragic situation, then she cries.”
^aThis is the answer corresponding to a conditional interpretation of the rule.

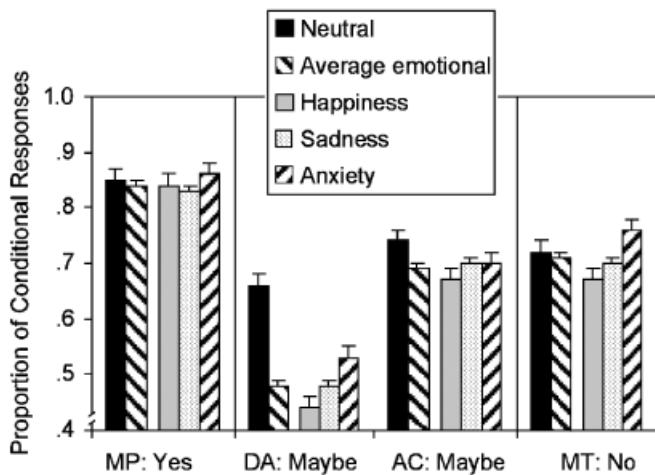


Fig. 1. Mean proportion of conditional responses for each question type in Experiment 1. Results for the questions with emotional content are shown both as overall averages and separately for each of the three specific kinds of emotion. Error bars show standard errors. AC = affirming the consequent; DA = denying the antecedent; MP = modus ponens; MT = modus tollens.

same direction for all questions, it seemed more pronounced for DA and AC questions than for the other two types.

We specifically examined the frequencies of committing the logical fallacies of denying the antecedent and affirming the consequent. Participants were significantly more likely to answer “no” for DA questions in response to emotional statements ($M = .49, SD = .32$) compared with neutral statements ($M = .31, SD = .23, t(29) = 4.04, p < .05$). “Yes” responses to AC questions were also more frequent when reasoning about emotional statements ($M = .30, SD = .28$) than when reasoning about neutral statements ($M = .21, SD = .16, t(29) = 2.42, p < .05$). Thus, both common logical fallacies were more frequent in response to emotional compared with neutral statements.

We also examined the effect of specific emotional contents on responses to DA and AC questions (see Fig. 1). We first entered the mean proportion of “no” answers to DA questions into a within-subjects ANOVA including emotion type (happiness, sadness, anxiety) as a factor. This analysis revealed a marginally significant effect of emotion type, $F(2, 58) = 2.88, p = .07, \eta_p^2 = .09$. However, testing between individual means using the Bonferroni procedure for post hoc comparisons revealed no significant differences between any of the means. The mean for each specific kind of emotional sentence was higher than that for the neutral statements. A similar analysis performed on “yes” answers to AC questions revealed no differences between specific emotions, $F(2, 58) = 1.71, p = .19, \eta_p^2 = .06$. Again, the likelihood of committing this fallacy was lower for the neutral statements than for any specific kind of emotional statement.

Discussion

The results of Experiment 1 suggest that the emotional value of reasoning materials may influence people’s responses on con-

ditional reasoning tasks. However, in order to vary emotionality, we used different words in the emotional and neutral statements. Although we know that we varied emotionality, it is possible that other factors besides emotion were responsible for the effects we found. Differences related to semantic content, rather than emotion, may account for the differences that we observed. To disentangle the semantic and emotional effects on reasoning, we needed to vary emotionality independently of semantics. This is what we did in Experiment 2, using a conditioning paradigm.

EXPERIMENT 2

Classical conditioning can be used to make a specific stimulus take on some of the emotional characteristics of another stimulus, simply by way of association (Cacioppo, Marshall-Goodell, Tassinari, & Petty, 1992; Montoya, Larbig, Pulvermueller, & Flor, 1996). In Experiment 2, neutral words and nonwords were conditioned to become emotional or remain neutral through repeated presentation with images of negative, positive, or neutral emotional connotation. This pairing was different across participants. The use of nonwords was motivated by the assumption that it might be easier to manipulate the emotional connotation of meaningless stimuli. After the conditioning procedure, the conditioned words were used as *p* and *q* in the reasoning task.

Method

Participants

Forty volunteers participated in this study. Participants were compensated £5 for their time.

Materials

We used a total of 36 words and nonwords in 18 conditional statements (see Table 3 for examples of the statements). We used 18 neutral words, taken from published ratings of word emotionality (John, 1988). These words received an average emotionality rating of 1.62 ($SD = 0.32$). We also created 18 nonwords that sounded like English words. The words and nonwords were divided into three lists, each of which was paired

TABLE 3

Examples of Conditional Statements Used in Experiment 2

Words	Nonwords
If someone eats a sandwich, then he eats bread.	If someone looks like a clorious, then he is a careful.
If a person is drinking juice, then she is getting vitamins.	If a person is canting, then she is piout.
If someone is using a camera, then he is using a lens.	If someone is a nock, then he is a fisk.

with photographs of neutral, negative, or positive emotional valence. The photographs were taken from the International Affective Picture System (Center for the Study of Emotion and Attention, 1995). We used 36 photographs of each type. On negativity-positivity scales (1–9), the negative photographs received an average rating of 2.72 ($SD = 0.47$), compared with 4.93 for the neutral ones ($SD = 0.42$) and 8.06 for the positive ones ($SD = 0.31$).

Procedure

The experiment included three phases. The first phase involved conditioning neutral words and nonwords to become emotional or remain neutral. The second phase involved the use of these words in a conditional reasoning task. In the third phase, participants rated the emotional connotation of the same words and nonwords.

In the conditioning paradigm, the pairing of word lists and picture type was determined randomly for each participant. 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. The order of the blocks was also randomly determined for each participant. Each block involved 60 word-picture pairings. Each word was presented five times, each time with a different photograph of the same emotional valence. The pairing of words and individual images was determined randomly. Some of the images were presented more than once.

Each conditioning trial lasted 2,000 ms. The photograph first appeared on the computer screen for 500 ms. Then, while the picture remained on the screen, the word, written in white on a small black rectangle, appeared in the middle of the screen for 1,500 ms. There was a 500-ms blank before the start of the next trial.

After the conditioning trials were concluded, participants completed the reasoning task. The words that had previously been conditioned were used as p and q in the conditional statements. The procedure for this task was identical to that of Experiment 1.

Following the reasoning task, participants completed a word-rating task meant to assess whether the conditioning procedure had been successful. Participants were asked to rate the emotional connotation of each word and nonword on a scale from 1 (*very negative*) to 7 (*very positive*).

Results

Manipulation Check

We entered the average ratings of emotional connotation in a 2×3 ANOVA involving word type (word, nonword) and picture type (negative, neutral, positive). There was a main effect of word type, $F(1, 39) = 134.4$, $p < .05$, $\eta_p^2 = .76$. Participants rated actual words more positively than nonwords ($M = 5.4$, $SD = 0.12$, and $M = 3.5$, $SD = 0.09$, respectively). There was

also a main effect of picture type, $F(2, 78) = 3.5$, $p < .05$, $\eta_p^2 = .08$, showing that the conditioning paradigm produced the expected effects on the ratings (see Fig. 2). The negative conditioning, however, appeared to have had a stronger effect on the ratings than the positive conditioning did. Planned comparisons revealed that although the difference between the negative and neutral conditions was significant, $t(39) = 2.3$, $p = .02$, the difference between the neutral and positive conditions was not, $t(39) = 0.05$, $p = .95$. The interaction between word type and picture type was not significant, $F(2, 78) = 0.06$, $p = .95$.

Reasoning Task

Proportions of conditional responses to individual questions were compared using a 2 (word type: word, nonword) $\times 4$ (question type: MP, DA, AC, MT) $\times 2$ (emotion: emotional, neutral) ANOVA. The three main effects were significant: question type, $F(3, 117) = 23.77$, $p < .001$, $\eta_p^2 = .38$; word type, $F(1, 39) = 34.17$, $p < .001$, $\eta_p^2 = .47$; and emotion, $F(1, 39) = 5.42$, $p < .05$, $\eta_p^2 = .12$. Participants were again most likely to provide conditional answers in response to MP questions ($M = .87$, $SD = .34$) and MT questions ($M = .79$, $SD = .41$), followed by AC ($M = .51$, $SD = .50$) and DA ($M = .45$, $SD = .50$) questions. The main effect of word type showed that participants' performance was more in line with prescriptions from normative logic when rules included actual words ($M = .72$, $SD = .32$) than when they included nonwords ($M = .60$, $SD = .34$).

Emotion also had a significant effect on participants' responses. Overall, participants were more likely to provide conditional responses when the reasoning materials were neutral ($M = .67$, $SD = .47$) than when they were emotional ($M = .63$, $SD = .48$).

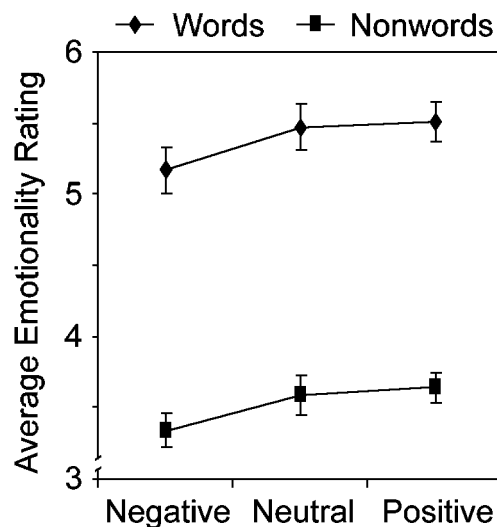


Fig. 2. Mean ratings of emotional valence of conditioned words and nonwords in Experiment 2 (1 = *very negative*, 7 = *very positive*).

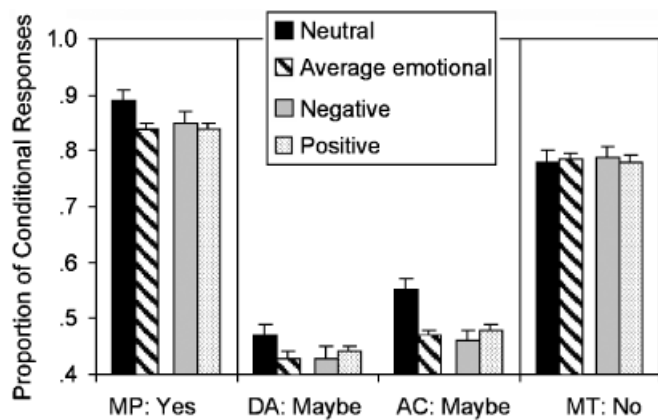


Fig. 3. Mean proportion of conditional responses, collapsed over words and nonwords, for each question type in Experiment 2. Results for the questions with conditioned emotional content are shown both as overall averages and separately for negative and positive emotion. Error bars show standard errors. AC = affirming the consequent; DA = denying the antecedent; MP = modus ponens; MT = modus tollens.

The interaction between emotionality and question type did not reach significance in this experiment, $F(3, 117) = 1.16$, $p = .33$, $\eta_p^2 = .03$. It can be seen from Figure 3 that the difference was in the direction of more normatively correct answers in response to neutral statements, compared with emotional statements, for MP, DA, and AC questions.

We examined whether positive and negative trials had similar effects. Collapsing over words and nonwords, we compared conditional answers to positive and negative statements using a 4×2 ANOVA involving question type and valence (positive, negative). Neither the main effect of emotion nor the interaction with question type was significant, $F_s < 0.24$, $p_s > .76$. Conditioning words with positive pictures and conditioning words with negative pictures produced similar effects on reasoning. This pattern is apparent in Figure 3.

GENERAL DISCUSSION

Our goal in these experiments was to investigate whether people reason differently about emotional and neutral materials. Our results show that emotional content does influence the way in which people reason logically. This effect was evident both when we asked participants to reason about preexisting emotional and neutral words and when we independently manipulated the emotional connotation of initially neutral words.

In Experiment 2, across different participants, the same words were made either positive, negative, or neutral. Results of this experiment allow us to unambiguously ascribe the effect to emotional connotation, and not to some confounded factor related to semantic content.

The conditioning procedure used in Experiment 2 was moderately successful in attaching emotional connotations to ini-

tially neutral words. Because the effects of the conditioning procedure were consistent but small, it is all the more surprising that it led to changes in reasoning. These results suggest that the effect of emotion on reasoning is important. The words used were initially neutral, and the conditioning procedure produced significant, but modest changes in emotionality. Clearly, we did not expect the word *sandwich* to become traumatizing for participants by being paired with five negative images. Thus, even relatively small changes in emotionality have systematic and significant effects on the way people reason logically.

Our results are generally consistent with commonsensical notions about the ways in which emotion (state or content) affects logical reasoning. Furthermore, our results are consistent with prior results obtained exploring the effect of emotional state on conditional reasoning (Oaksford et al., 1996). Overall, our participants were less likely to draw logically valid inferences when reasoning about emotional content than when reasoning about neutral content, just as participants in either positive or negative moods were less likely than participants in neutral moods to provide the normatively correct choices on the Wason selection task. These findings on the effect of emotion on logicity, however, do not necessarily conflict with a functionalist view of emotion. Most theorists of emotion recognize that even though the general features of emotions will be adaptive, it does not follow that every specific instance, or indeed every consequence, of emotion will be beneficial (Frijda, 1994). The effect of emotion on reasoning may be a consequence of the way in which emotional content is processed and, in itself, may not serve an adaptive function. The effect may nevertheless be systematic and robust.

Our results also showed no difference between the effects of negative and positive emotional contents (in the case of Experiment 2) or specific emotions (in the case of Experiment 1). This absence of difference does conflict with predictions from functionalist theories. Specific emotions serve specific goals, and therefore should promote particular types of inferences. There is some evidence that this is the case when the emotionality of the contents has informational value, for instance, in the case of safety or danger rules (de Jong, Mayer, & van den Hout, 1997). In such cases, the affective value of the contents provides information that affects the type of conclusions people will draw. In the case we examined, emotional contents of opposite types had similar effects. This finding suggests there might be something about processing emotional content per se, independent of the informational value provided by the emotion, that affects reasoning in a certain way.

The precise mechanisms through which processing emotional content affects logical reasoning should be made clear by future research. We are currently investigating two possible mechanisms. One is that emotion may affect working memory; the other is that emotion may affect the way in which conditional statements are interpreted.

There is some speculation, and some evidence, that affective states take up working memory capacity. This is the case for anxiety, as worry may consume processing capacity in working memory (Eysenck, 1985; Macleod & Donnellan, 1993). Positive mood has also been shown to be associated with decrements in working memory function (Oaksford et al., 1996). Processing emotional content may have similar effects and take up processing capacity. This would mean that less capacity is left over for reasoning, which would result in more errors. We are currently carrying out experiments to test this hypothesis.

Although emotion may affect reasoning itself, it may also have an effect prior to when reasoning is actually carried out. In a conditional reasoning task, participants initially construct a mental representation of the statement. They then perform logical computations and draw inferences based on that representation. Emotion may affect the initial representation, before any logical computations are carried out. In both experiments reported here, the effect of emotion was particularly potent for DA and AC questions. These two logical fallacies may be the result of misinterpreting conditional rules as biconditional (i.e., "If p , then q , and if q , then p "). We are currently investigating empirically the possibility that participants misrepresent emotional rules as biconditionals more frequently than neutral ones.

These two experiments have provided evidence that the emotionality of contents influences the way people reason logically. This is a fundamental issue that had been neglected by recent empirical research. We believe we have developed a novel methodology for investigating this important issue and that this methodology has already provided intriguing results. This type of research has important implications for understanding the ways in which people reason in situations in which emotions are involved.

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