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Working memory and emotion: Detecting the hedonic detector

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In an attempt to account for the impact of emotion on cognition, Baddeley (2007) proposed the existence of a hedonic detection system. Malfunctioning of this system was assumed to play a crucial role in depression. Exploring this hypothesis requires a simple and rapid way of assessing the neutral point of proposed hedonic detector. We describe two experiments that aim to develop such a method of investigating this system. Both are based on the assumption that the hedonic judgement of simple stimuli will be influenced by the valence of an induced mood. Experiment 1 showed that a negative mood leads to the more negative evaluation of words than the positive mood. Experiment 2 also includes a neutral condition and the evaluation of words, pictures, and faces. In each case the negative mood led to lower hedonic ratings, whereas no difference was found between neutral and positive moods. Implications for further investigating the hypothetical hedonic detector are discussed.

Keywords: Depression; Emotion; Hedonic detector; Mood; Working memory.

Michael Eysenck and the first author (AB) share a long-standing interest in the impact of emotion on cognition, in Michael's case, theoretically driven and based on extensive evidence, in AB's case sporadic and often divorced from theory, beginning as it did with an attempt to study a quite different issue, the impact of nitrogen narcosis on the capacity of divers to function at depth.

The study in question was an attempt to extend a US Navy experiment showing a modest decline in manual dexterity when divers in a dry chamber were exposed to pressures equivalent to a depth of 30 metres of water (Kiessling & Maag, 1962). The study in question (Baddeley, 1966) simply carried out the same experiment, with the exception that it was conducted both in the open Mediterranean, and in a dry pressure chamber. A substantial interaction occurred, with the 8% decrement shown at pressure under dry conditions increasing to a decrement of 49% underwater. Later studies replicated this broad finding when nonprofessional divers were operating under open sea conditions, but not when diving from the shore, suggesting an important role for anxiety (Baddeley, de Figueredo, Hawkswell-Curtis, & Williams, 1968; Baddeley & Flemming, 1967). The importance of anxiety to this result was further established under shore-based but comparatively threatening conditions off the coast of Scotland (Davis, Osborne, Baddeley, & Graham, 1972).

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This led to a series of studies investigating the role of anxiety in rather dryer conditions, including skydiving and preparing to give a talk at the MRC Applied Psychology Unit in Cambridge, events that, perhaps surprisingly, seemed to be equally anxiety-provoking (Idzikowski & Baddeley, 1983, 1987). We observed effects of anxiety, but they tended to be small. Given the logistic difficulty of collecting data in such environments (frequent disruption by weather in one case, and the limited number of speakers in the other), it proved difficult to carry out the kind of sustained programme necessary to develop a theoretical understanding of the underlying processes.

Michael Eysenck, however, avoided these limitations by capitalising on the individual differences in susceptibility to anxiety found within a normal population of undergraduate students, gradually building up an understanding of the probable mechanism whereby anxiety interferes with performance, together with the strategies that people adopt to counter these limitations. He showed that people are certainly susceptible to the impact of anxiety, but for many and for much of the time, it is possible to withstand these effects, using a range of strategies to resist the potential attentional disruption from threatening stimuli (Derekshan & Eysenck, 1998; Eysenck & Calvo, 1992).

Another approach to the study of anxiety is to focus on people who consistently fail to make such adaptations, resulting in the kind of emotional disorder that is the province of clinical psychology. This approach was taken by a group of experienced clinicians with an interest in cognitive psychology at the MRC Applied Psychology Unit in Cambridge, a group that focused on studies of anxiety and depression with considerable success, reflected by setting up a new journal, *Cognition and Emotion*, and producing two highly influential editions of a book applying cognitive psychology to emotional disorders (Williams, Watts, MacLeod, & Mathews, 1988, 1997).

This in turn led to a belated attempt by AB to incorporate such developments within the multicomponent working memory model (Baddeley, 2007).

The initial working memory model had three components, an attentionally limited control system, the *central executive*, aided by two subsystems, the *phonological loop* and the *visuospatial sketchpad*. The loop was capable of storing and manipulating verbal and potentially other auditory material, and the sketchpad performed a similar service for material processed visually or spatially. Michael Eysenck's work had provided strong evidence for what he termed the *processing efficiency hypothesis* (Eysenck & Calvo, 1992). Evolution has provided us with a mechanism whereby threatening stimuli break through normal attentional control to serve as a timely warning. Heightened level of anxiety increases the potency of such stimuli, a mechanism that is valuable if the anxiety is prompted by genuine increase in level of danger, but which can be disruptive in chronically anxious individuals, for whom the threshold of threat is set at an unreasonably low level, allowing constant disruption of normal cognitive processing, and reduced processing efficiency.

A broadly similar model has been developed in the study of patients with anxiety disorder, by Williams et al. (1997), and by Mogg and Bradley (1998). Patients with anxiety disorders are assumed to have a particularly low threshold for the detection of threat, leading both to excessive anxiety feelings and potentially to disruption of cognitive processing.

Disruption of cognition by anxiety fits relatively easily within the initial model of working memory if one assumes some kind of attentional filter that protects the central executive from unnecessary disruption. As Derakshan and Eysenck (1998) demonstrate, anxious people are sometimes able to adopt strategies such as subvocalisation (reflecting the phonological loop) or regressive eye movements (reflecting visuospatial sketchpad) that are able to help protect executive processes from disruption.

Baddeley (2007) initially hoped to apply a similar model to the effects of depression on cognition. However, this proved surprisingly difficult. Even though anxiety and depression often co-occur, there are a number of major differences between the nature of cognitive disruption shown by the two, as illustrated in Table 1.

As already described, anxiety has its major effect by disrupting attentional control, something that can occur, even for stimuli that are below the level of conscious awareness, whereas there is little evidence for this in the case of depression. Both can disrupt the capacity to learn, but for different reasons. Anxiety may disrupt attentional focus, whereas depression appears to lead to apathy and lack of initiative which in turn limits the development and use of optimal strategies. Depression may have a marked effect on

TABLE 1
A comparison between the affects on cognition of anxiety and depression

Fear and anxiety	*Depression*
Major preattentional and attentional disruption of cognition	Weaker purely postattentional effects
Effect on learning principally due to distraction	Disruption of learning attributable to lack of initiative
Little evidence of mood-congruent disruption of retrieval	Major mood-congruency
Evolutionary context clear	Evolutionary context controversial

retrieval, via mood-dependency, with depressed patients tending to recall negative memories, whereas no equivalent effect occurs for anxiety. Finally, the evolutionary value of anxiety is obvious; it is potentially highly valuable to have a system that interrupts when a major threat occurs. On the other hand, it is far from simple to know in what way depression might be useful, although there are many speculations on the issue (see Baddeley, 2007, Chap. 15, for further discussion).

In an attempt to account for these differences within a broad working memory framework, Baddeley (2007) proposed the following: Whereas anxiety reflects a malfunctioning of an alerting system responsible for detecting danger, depression reflects the malfunction of a motivational/choice system. The working memory framework, and indeed cognitive psychology in general, is principally concerned with the question of how behaviour is controlled. It neglects the question of "why" we act; why do we do anything? An answer to this very basic question was offered by Hume (1739/1978), who proposed that reason is controlled by "the passions", by which he did not mean the sort of extreme emotional response that today we think of as reflecting passion, but also "certain calm desires, more known by their effects than by their immediate feelings or sensation" (p. 407). We thus steer ourselves through the world by maximising the positive and minimising the negative consequences of our actions.

This view has elements in common with Damasio's (1998) *somatic marker hypothesis*. This assumes the capacity to use positive and negative features of the environment as positive "beacons of incentive" or negative "alarm bells". Damasio was led to this conclusion by studying patients with damage to certain areas of the frontal lobes who did not appear to be cognitively impaired, and yet lived chaotic lives because of their incapacity to make wise decisions. Such decisions are assumed by Damasio to be based on the capacity to sense the positive and negative nature of potential outcomes. Damasio assumes that such markers are physiologically based, but are reflected as feelings through the operation of working memory, although the exact nature of this link is not discussed.

In an attempt provide such a link, Baddeley (2007) suggested the need to assume some form of hedonic detection system, capable of assessing stimuli so as to allow optimum actions to be chosen. It was suggested that this system would require both temporary storage and the capacity to manipulate such stored hedonic information, which in turn implies the involvement of working memory. It was suggested that the system would need the following characteristics.

1. The hedonic detection system would have a neutral point, with readings above that point reflecting a positive and below it a negative valence.
2. Its sensitivity and stability would be important if there were to be consistency of action over time.
3. If it is to be used in complex situations, then it may need to average across a number of features of each potential action, and this turn will require some form of memory storage.
4. The system must be able to discriminate between the averaged hedonic value of two or more such potential actions.
5. Such manipulation and judgement of hedonic information seems likely to depend on working memory in general and the central executive in particular.

It was suggested that depression might reflect an inappropriate setting of the neutral point of the hedonic detection system, with the result that previously neutral stimuli appear negative, and negative options become even more negative (Baddeley, 2007). It was further suggested that a number of factors are capable of influencing this neutral point. These include genetic factors such as temperament, gloomy versus happy-go-lucky, and it seems likely that the neutral point may also be influenced pharmacologically, by means of antidepressants. It is also assumed that the neutral

point can be influenced by events, either acutely or when for example your favourite football team loses a game, or chronically, for instance following a family bereavement. A long-term negative change in the hedonic neutral point could explain the tendency for depressed patients to view the world negatively and to retrieve evermore negative memories, hence deepening the depression. An important component of the cognitive treatment of depression does of course involve helping the patient to break out of this cycle. This hypothesis has a final advantage in that it provides an explanation of why evolutionary pressures have not removed the susceptibility to depression. If it is indeed a malfunction of an essential decision-making mechanism, the system's removal would have drastic consequences for survival.

Even if one accepts this view as a plausible hypothesis, however, the question arises as to how to take it further. One of the assumptions underpinning the hedonic detector hypothesis is that emotional tone or mood will influence the neutral point, with the result that a negative mood will result in a previously neutral event being perceived as negative. For example, Isen, Shalker, Clark, and Karp (1978) found that giving customers a small gift led to their giving a more positive subsequent rating of unrelated goods. Krosnick, Betz, Jussin, and Lynn (1992) required participants to make hedonic judgements about people performing neutral activities; they found that negative emotional primes led to lower hedonic ratings of the activities, even when the priming stimuli were masked. Similar effects have also been found when judging words (Fazio, 1986). Such effects are found even when the priming stimuli comprised meaningless items such as nonwords and irregular shapes that had previously been rated as positive or negative, with negative items facilitating an avoidance response whereas pleasant items facilitated approach responses (Duckwork, Bargh, Garcia, & Chaiken, 2002).

This study aimed to build on the work by developing a simple method that would allow multiple observations within a single session. We might for example wish to test the durability of an induced emotion or mood as a function of elapsed time or potential interference, or to explore the interaction of induced mood with executive processing. It seemed possible that a very simple task such as judging the pleasantness of a series of relatively neutral stimuli might provide such a measure. In order to investigate the potential sensitivity we designed two studies using well-established methods of mood induction. In each case we used a mood rating scale to determine whether the method had been successful. This has the disadvantage that participants may have responded to the demand characteristics of the situation. Without self-report, however, a negative result would be hard to interpret. More implicit mood induction techniques such as giving an unexpected present (Isen, 1970), relying on weather conditions (Schwarz & Clore, 1983), or inducing a positive mood by presenting easy tasks (Estrada, Isen, & Young, 1994) do not readily allow the observations of both positive and negative moods within the same session we thought would be necessary to adequately test our proposed task. Masked primes (Krosnik et al., 1992) was another possibility, but this introduces additional methodological complexity in setting an appropriate masking threshold. We decided therefore to use a range of well-established methods of mood-induction, leaving until later the further refinement of method, should our simple judgement task prove sensitive. We return to this issue in the Discussion.

Our experiments therefore aimed to treat the hypothetical hedonic detector as if it were a perceptual system by simply asking our participants to make judgements under positive or negative induced moods. In order to ensure generality, we used two different methods of mood induction, in each case followed by the presentation of a series of words whose pleasantness must be judged. By using mildly positive, neutral, and mildly negative words we are able to judge whether any effects observed operate only on neutral items, or whether items across a somewhat broader range of hedonic valences are influenced.

EXPERIMENT 1

Method

Participants

A total of 80 undergraduate students (mean age 20.58 years) were tested. Fifty of these were female. On entering the study, each participant was required to complete the Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). For ethical reasons, three further

participants who had scored above 16, indicating mild mood disturbance, were exposed only to positive mood induction, and were excluded from the study.

Evaluation words

These comprised 60 words selected from the Affective Norms for English Words (ANEW database) which rates words from 1 (''negative'') to 9 (''positive''). The mildly negative words were rated between 4.02 and 5.08, (e.g., *skull*, *dirt*), the neutral between 5.14 and 5.34 (*kettle*, *finger*), and the mildly positive ranged from 5.61 to 6.57 (*jelly*, *whistle*). We chose to avoid extremely negative or positive words because of the observation that less extreme stimuli are more likely to be influenced by mood (Isen & Shalker, 1982).

Mood induction

Participants were explicitly informed that the study involved a comparison between methods that aimed to induce different moods and that these would be followed by questionnaires. They were informed that they could withdraw at any time and signed a consent form.

Two methods of inducing mood were included, with half the participants using each. They were:

The Velten Mood Induction Procedure (MIP). We used a total of 60 statements, of which half were positive and half were negative, which participants were required to read and then repeat in an empathic way. Positive mood was induced by requiring statements such as ''I feel cheerful and lively'', whereas a typical negative statement might be ''People annoy me; I wish I could be by myself''. Half the participants started with the positive statements and half with the negative (Velten, 1968).

Induction by Music and Pictures (MAP). This combined two methods that had previously been used for mood induction, music and pictures. We selected two pieces of music that had been successfully used by Etzel, Johnsen, Dickerson, Tranel, and Adolphs (2006), who found that the music induced physiological effects consistent with the two emotions, and Johnsen (2004) produced evidence confirming that they induced appropriate subjective experiences of happiness or sadness. The pieces in question were ''Mammy'', involving a quick rhythm and melody, and a sad piece from ''Brothers'', which involved a slower tempo. The music was combined with emotionally toned pictures from the International Affective Picture System (IAPS) database (Lang, Bradley, & Cuthbert, 2005). This set of pictures was rated on a number of dimensions by Mikels et al. (2005). This allowed us to exclude for ethical reasons any pictures that were included in the top 50 when rated for disgust. We also excluded any items that showed pronounced sex differences or that appeared to have a cultural basis, for example piles of dollar bills. In order to match the rate of presentation to the slower tempo of sad music we elected to show negative images for 8 s each, and positive for 5 s.

Music and pictures were combined to provide two happy and two sad presentation sets. In each of the sad sets, 11 different pictures were displayed for 8 s each, and then repeated in a random order. The tempo of the happy sets was faster with 18 pictures each being shown for 5 s, and then repeated. Both the happy and sad sets therefore lasted approximately 3 min.

Mood checklist

Participants rated their current mood on a scale between 0 (''not at all'') and 6 (''very much''), on each of 10 mood adjectives. Three were positive, namely happy, content, and hopeful; three were negative, namely depressed, gloomy, and sad; and the remaining four were filler items relating to more mixed emotions of which two were negative, namely guilty and angry, and two were positive, namely lively and cheerful. The mood checklist was administered on arrival and was used throughout the experiment to monitor the effectiveness of the induction procedures. The three positive and three negative ratings were combined by subtracting mean negative from mean positive scores. Hence, a positive overall rating would reflect an overall positive mood.

Word evaluation task

This involved the presentation of each word for 1 s, after which participants had to evaluate that word on a scale ranging between 1 (''very negative'') and 8 (''very positive''), responding by pressing the numbers on the top of the computer keyboard. The range was selected so

as to avoid a mid point, and a possible strategy of pressing the neutral point when in doubt.

Procedure

After completing a consent form and the Beck Depression Inventory, participants completed the initial mood adjective checklist to assess their mood on entering the study. Participants were then practiced on the evaluation task, judging six words, using the 8-point scale displayed at the bottom of the computer screen.

This was then followed by the first mood induction procedure, with half of the group randomly assigned to the Velten and half to the music and pictures (MAP) procedures. In each case, half began with negative and half with positive induction. Immediately after mood induction, participants filled out a second mood checklist, before proceeding to the initial word evaluation, after which a third assessment of mood was made using the checklist, thereby completing the first half of the experiment.

Before proceeding to the second mood induction, participants were given a filler task involving completion of a series of six mazes selected from an online database at yahoo.com. These had been found to be sufficiently difficult to keep participants occupied for 2 min, during which it was hoped that the previously induced mood would tend to dissipate. The filler task was then followed by the second mood induction procedure, which always involved the opposite mood to that induced in the first part. The efficacy of this second induction was then evaluated, again using the adjective checklist, before requiring evaluation of the next 30 words, followed by a fifth mood checklist, included to assess any change in mood during the word evaluation task.

Results

Mood induction

Data were analysed using a mixed ANOVA. Between-subject variables were method of mood induction (Velten or MAP) and test order (positive first or negative first). Within-subject factors were evaluation valence (positive or negative) and time of evaluation (before or after mood induction).

The order of presentation of positive and negative mood induction did not influence ratings, either as a main effect or an interaction, and hence the two orders were combined for further analysis. As Figure 1 suggests, there was a main effect of induction valence, $F(1, 76) = 150.34$, $p < .001$, with mean ratings of 1.36, $SE = 0.22$ after negative, and of 3.46, $SE = 0.15$ after positive induction, and a significant interaction between induction valence and subsequent mood rating, $F(1, 76) = 69.70$, $p < .001$. There was a main effect of type of induction, $F(1, 76) = 7.89$, $p < .001$, with the MAP condition leading to lower levels of negative mood than did the Velten technique. As Figure 1 suggests, there is also an effect of mood check position with the induced mood effect tending to be less marked following the word evaluation task, $F(1, 76) = 24.27$ $p < .001$.

To summarise, we appear to have been successful in manipulating mood, with effects being particularly marked in the case of the MAP procedure and negative mood.

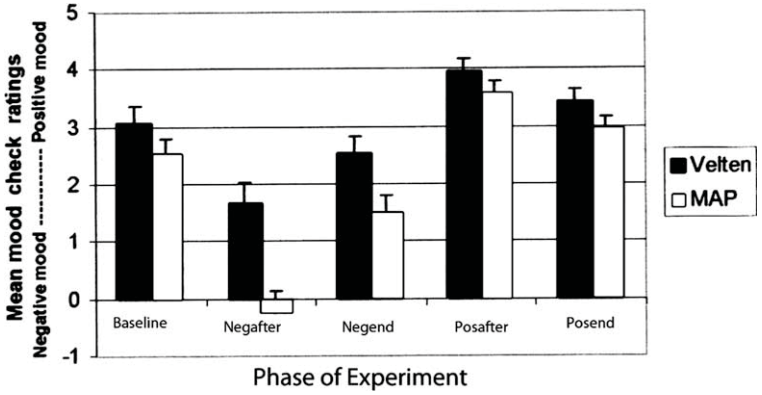

Figure 1. Mean mood checklist ratings across the phases of Experiment 1.

Word evaluation

There was no significant effect of order of presentation either as a main effect or an interaction, hence both orders were combined. The results are shown in Figure 2. Unlike the mood induction procedure there was no effect of method of induction, $F(1, 76) = 1.24$, $p > .05$. There was, as expected, a substantial effect of word type, with ratings of negative words significantly lower than neutral, $F(1, 76) = 264.86$, $p < .001$, whereas positive words were given significantly higher ratings, $F(1, 76) = 280.68$, $p < .001$. This result of course simply reflects the fact that the words were selected appropriately. A crucial prediction of our hypothesis is that mood evaluation should influence the ratings of the words, and this was indeed the case, $F(1, 76) = 8.29$, $p < .01$, with words rated significantly more positively after positive than negative mood induction.

Discussion

Both of our mood induction procedures were effective in inducing reliably different moods, with the negative induction having a particularly marked effect when compared to the relatively positive pretest mood of our participants. There is also a clear tendency, particularly for the negative mood, to persist, although somewhat weakened, during the word evaluation session, suggesting that it is reasonable to include evaluations for the whole of the sequence of words judged.

Our word evaluation scale was clearly effective in separating out the words rated as positive from those rated as neutral or negative, even though these did not reflect items from the extreme end of the scale. Crucially, our mood induction procedures were able to significantly influence the ratings of words at all three levels, indicating an influence that operated throughout the range sampled, and was not limited to relatively neutral items. Although reliable, the mood induction effects are small compared to the magnitude of difference between the positive and negatively selected items, raising the question of its reliability. The obvious test of this issue is by replication.

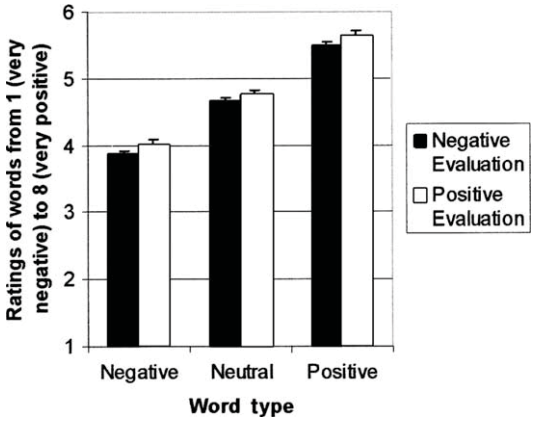

Figure 2. Mean hedonic ratings of negative, neutral, and positive words following negative or positive mood induction. Both mood induction methods are combined.

Although Experiment 1 showed a clear effect of induced mood on subsequent word judgement, it has a major limitation. We detected a difference between a positive and negative mood, but in the absence of a neutral baseline we are unable to detect whether this is principally a result of the negative mood, of the positive mood or of both. The second experiment aimed to control for this by including a third, neutral condition. This presented a problem in the case of induction by music, since it is suggested that music is never emotionally neutral (Krumhansl, 1997). We therefore chose to use the Velten method of mood induction. In order to further increase the generality of our results, we extended the judgement process to three types of material: words as in Experiment 1, together with pictures and faces. In order to reduce complexity, in each case we chose test items that were rated as neutral. Hence, the design was equivalent to Experiment 1, except that only one method of mood induction was used, and combined with three types of stimulus material, rather than with three levels of rated emotionality.

EXPERIMENT 2

Method

Participants

Eighteen participants (14 female) participated in this study. All participants were students at the University of York.

Design

This experiment used a 3×3 repeated measures design. The first within-subject factor was the mood induced (positive, neutral, and or negative). The order of mood induction was counterbalanced between participants. The

second within-subject factor was the type of stimulus evaluated (word, picture, or face). The participants evaluated all three types of stimuli during different evaluation blocks with the order counterbalanced between participants.

Procedure

The participants filled out the Beck Depression Inventory followed by 18 practice trials on the pleasantness evaluation task. The item to be evaluated was presented at the centre of the screen for 1000 ms. Participants were asked to evaluate the pleasantness of the item on a 1–8 scale. Their response was following by a 500 ms interval before the next item was presented. Participants then filled out the mood check questionnaire before the first mood induction procedure, using the Velten mood induction technique (Velten, 1968). After the first mood induction session, participants rated their current mood states followed by the first pleasantness evaluation block. There were 18 items in each evaluation block composed of 10 neutral, four slightly positive and four slightly negative filler items. The item to be evaluated could be a word, a picture, or a face depending on the counterbalanced order.

After the pleasantness evaluation task, participants were given a boost in the induced mood state by reading 20 further sentences from the Velten induction material from the same mood category. This was followed by the second hedonic evaluation block. Another boost in the mood state was given after the participants finished this block, followed by the third block of the hedonic evaluation task. Participants were asked to rate their mood state again after completing this third block. This was then followed by a break. Participants then performed a word generation task for 2 min, requiring them to produce as many words as possible from one of two target town names, Constantinople and Weston-Super-Mare, so as to neutralise the mood previously induced before the next mood induction session started. The entire procedure was then repeated with each of the other moods to complete the counterbalanced design.

Material

The mood checklist was that used in Experiment 1, as was the Velten mood induction technique, except that the sentences were presented on a computer screen rather than on cards.

Rating items. The words used were again taken from the ANEW (Bradley & Lang, 1999). Thirty neutral words comprised the target set (mean valence = 5.24, $SD = 0.05$; the smaller the value the more negative the stimulus; mean arousal = 3.74, $SD = 0.36$, the smaller the value, the less arousing the stimulus). To broaden the range, a further 12 positive and 12 negative words served as fillers that were included but not scored. Another six words (two from each valence category) were selected to be used during the practice session.

The pictures used were taken from the International Affective Picture System (IAPS; Lang et al., 2005). Thirty neutral pictures (mean valence = 4.41, $SD = 0.46$; (mean arousal = 3.93, $SD = 0.89$), formed the target set, with 12 positive and 12 negative filler pictures. Another six pictures (two from each valence category) were selected to be used during the practice session.

The faces used were taken from the AR Face Database (Martinez & Benavente, 1998). All 44 faces chosen were those categorised as neutral. However, we selected 12 of the faces that we judged as posing a slightly positive expression as positive fillers and 12 of the faces that posed a slightly negative expression as negative fillers. Within each valence category, half were female and half were male faces.

Results

Mood check

As Figure 3 indicates, the mood induction procedure was successful; a one-way analysis of variance (ANOVA) was conducted with the valence of mood induction as the factor (negative, neutral, or positive). The data to be analysed were the mood index after the first mood induction in each mood condition.

The effect of the valence of mood induction reached statistical significance, $F(2, 34) = 14.463$, $p < .001$. Tukey's post hoc analysis revealed that participants rated themselves as less positive after negative mood induction compared to their mood after neutral or positive induction. No difference between the ratings after neutral and positive mood induction was observed.

Evaluation task

Only the data for the neutral items were analysed. Our principal measure involved the

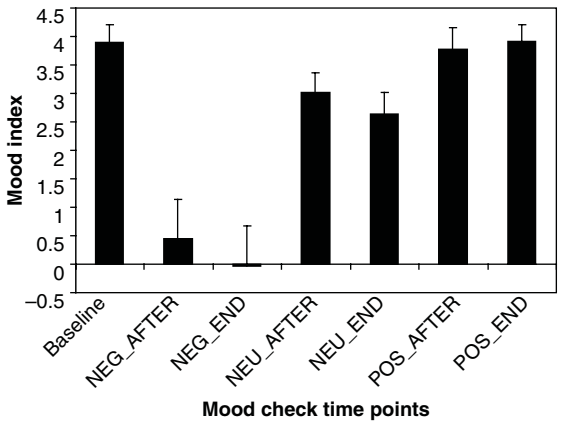

Figure 3. Mean mood ratings across the various phases of Experiment 2.

mean pleasantness ratings for different types of items under different mood manipulations. The data are shown in Table 2. Data were analysed using ANOVA, with the mood state (negative, neutral, or positive) and type of stimuli (face, picture, or word) entered as separate within-subject factors.

The effect of different mood states was significant, $F(2, 34) = 8.237$, $p < .001$, $\eta^2_G = .055$. Tukey's post hoc analysis revealed that participants evaluated the items as less pleasant when induced into a negative mood compared to when induced into neutral or positive mood. However, no difference was observed whether participants were induced into neutral or positive mood. The effect of the type of stimulus (words, faces, or pictures) also reached statistical significance, $F(2, 34) = 30.717$, $p < .001$. Tukey's post hoc analysis revealed that participants evaluated the faces as less pleasant than the pictures or the words. No difference in pleasantness evaluation was observed between pictures and words. The interaction between the two factors did not reach statistical significance, $F < 1$.

Discussion

Experiment 2 replicated the difference between positive and negative induced mood on subsequent hedonic judgements, an effect that was found not only for words as in Experiment 1, but also with faces and neutral IAPS pictures. Our inclusion of a neutral mood induction condition suggested that our previous findings were probably attributable principally to the presence of negative mood, since we found no suggestion of an effect of positive mood. However, the lack of a positive mood effect should be viewed with caution, given that the baseline mood of our participants was already high, and that the difference between the mood induced by neutral and positive stimuli was not as powerful as the negative mood induction, with only nine of the 18 subjects showing higher mood following positive then neutral induction. It would clearly be advisable to repeat this study with less cheerful participants.

TABLE 2
Data from Experiment 2. The mean pleasantness ratings for different types of stimuli under different moods (standard deviation are shown in parentheses)

	Type of stimulus		
Type of mood	*Faces*	*Pictures*	*Words*
Negative	3.31 (0.88)	4.19 (0.72)	4.46 (0.60)
Neutral	3.73 (0.91)	4.59 (0.85)	4.89 (0.64)
Positive	3.72 (0.75)	4.53 (1.00)	4.82 (0.76)

GENERAL DISCUSSION

Our two experiments both suggest that an emotionally toned mood is capable of influencing a subsequent hedonic judgement. The effect was found to occur with two different methods of mood induction, the Velten technique and a combination of pictures and music. The negative mood effect was found for judgements of words, pictures, and faces, and in the case of words was found to operate across different levels of stimulus valence. Although the effect was clearly demonstrated in the case of negative mood, we do not have strong evidence of an equivalent positive mood effect. This could be due to fundamental difference in the way in which positive and negative moods operate. Ashby, Isen, and Turken (1999) argue strongly for a distinction between the basic systems responsible for positive and negative affect, citing for example a study of the influence of affect on two problem-solving tasks. Positive affect enhanced performance, which was not influenced by either increased arousal through exercise or the induction of negative mood by a depressing film clip (Isen, Daubman, & Nowicki, 1987). It would, however, be premature to reject the possibility of a positive effect on judgement, given the fact that the baseline mood of our participants was high,

making it difficult to produce a substantial elevation in mood.

One possible criticism of both studies is that our participants were simply responding to the demand characteristics of the experimental situation, behaving in a way that was consistent with the perceived expectations of the experimenter, with a negative mood encouraging a negative subsequent hedonic judgement. If this were the case, however, we would expect the positive condition to be just as effective as the negative inducement, whereas we found no difference. This could not be attributed to a ceiling effect, since the three types of item in Experiment 2 were all emotionally relatively neutral, whereas in Experiment 1 the effect occurred for words of low medium and high affective value. However, it is clearly important as a next step, to establish the validity of the task in a less artificial and more ecologically valid context, using depressive patients, for example.

A second issue relates to the magnitude of the change detected. Is a small effect, however reliable, of potential importance? We suggest that it is, for two reasons; first, because small but reliable deviations can provide extremely valuable indicators of major underlying phenomena, as for example in the case of human body temperature, where a change of a few degrees may mark the difference between health and illness. It is worth noting that the level of mood change induced by either of our methods is probably quite minor compared for example to the chronic difference in mood between a healthy person and a patient suffering from a major depression; a greater deviation in mood could well result in more substantial changes in judgement.

Finally, although our study was prompted by an attempt to extend the multicomponent working memory model to the study of emotion, we do not wish to claim that our results favour the hypothesis of a hedonic detector over other approaches to the study of emotion. Our aim was methodological, to provide a tool that might potentially allow us to develop what is currently a theoretical speculation into an empirically fruitful model. The task proposed is simple, rapid to perform and produces reliable effects even with relatively small participant groups. We hope to use it to explore the mechanism underlying the proposed hedonic evaluation system, testing assumptions about its resting point in different chronic mood states, its sensitivity to change, its capacity to average across hedonically complex situation and to maintain and manipulate such information in working memory. If a coherent concept of a hedonic detection system were to emerge, it would then be important to relate it to the more developed existing models of the interaction of cognition and emotion.

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