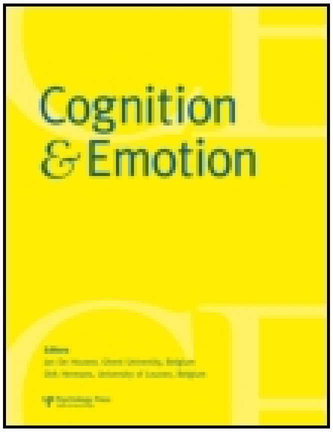

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Positive feelings facilitate working memory and complex decision making among older adults

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BRIEF REPORT

Positive feelings facilitate working memory and complex decision making among older adults

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The impact of induced mild positive feelings on working memory and complex decision making among older adults (aged 63–85) was examined. Participants completed a computer administered card task in which participants could win money if they chose from "gain" decks and lose money if they chose from "loss" decks. Individuals in the positive-feeling condition chose better than neutral-feeling participants and earned more money overall. Participants in the positive-feeling condition also demonstrated improved working-memory capacity. These effects of positive-feeling induction have implications for affect theory, as well as, potentially, practical implications for people of all ages dealing with complex decisions.

Keywords: Positive affect; Mood; Decision making; Aging; Working memory.

A large and growing body of evidence demonstrates that mild, everyday positive feelings (often called positive affect, e.g., Isen, 1993, 2008, or positive mood, e.g., Nadler, Rabi, & Minda, 2010; Peters, 2006) have a marked facilitative influence on cognitive processes that may be related to decision making and problem solving (e.g., Aspinwall, 1998; Estrada, Isen, & Young, 1997; Fredrickson, 2001; Isen, 2008; Nadler et al., 2010). Numerous studies suggest that mild

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It is dedicated to the memory of Alice Isen, a friend and collaborator, who unfortunately passed away the same day that this paper was accepted. She will be missed.

improvements in positive feelings increase cognitive flexibility and enable individuals to entertain multiple perspectives or goals and shift attention among them, as needed (e.g., Bodenhausen, Mussweiler, Gabriel, & Moreno, 2001; Isen, 1993, 2008). This is particularly the case when participants find the task meaningful and engaging.[1] For example, doctors in whom positive feelings were induced were more open to new information, and better integrated information, about hypothetical patients than did controls (e.g., Estrada et al., 1997). In a series of studies, participants in a positive-feeling condition demonstrated superior incidental learning and ability to divide attention successfully than did participants in the neutral condition, while maintaining excellent performance on their assigned focal task (Isen & Shmidt, 2007). In another example, people in a positive condition performed better on a categorization task than did those exposed to either a neutral or a negative feeling-state induction (Nadler et al., 2010).

In the present study, we hypothesised that a positive-feeling induction would improve both working-memory capacity and complex decisions involving contingencies about rewards and punishments. Such behavioural effects are hypothesised based on Ashby, Isen, and Turken's (1999) dopamine hypothesis. In this hypothesis, they theorised that positive mood leads to dopamine release into prefrontal brain regions involved in working memory (dorsolateral prefrontal cortex; dlPFC) and decision-making processes (rostral areas of the anterior cingulate, which are densely interconnected with orbitofrontal cortex). The increased dopamine to dlPFC should lead to particular improvements in working memory. This hypothesis has received some attention recently in studies conducted with college-student samples (Yang & Isen, 2006).

Although we focused on working memory based on Ashby et al.'s dlPFC predictions, it is possible that other cognitive-performance tasks may benefit from mild improvements in positive feelings for two reasons. First, dopamine release is predicted to the nucleus accumbens and anterior cingulate cortex (Ashby et al., 1999), areas which may be associated with creative reasoning. Second, performance on some tasks may rely more on working-memory ability (matrix reasoning and speed of processing, in particular; Salthouse, 1993). We assessed performance on four cognitive measures: working memory, matrix reasoning, speed of processing, and vocabulary. Based on Ashby et al.'s (1999) predictions, however, and the lack of strong evidence linking performance on any other cognitive measure to specific brain areas, we expected the strongest effects of the positive-feeling induction on working memory.

Ashby et al. (1999) also concluded that positive feelings are associated with dopamine release to areas of the prefrontal cortex that have been associated with better decision making (Bechara, Damasio, Damasio, & Anderson, 1994). The beneficial effects of induced positive feelings among younger adults are robust, and research has suggested that induced positive feeling increases early learning of advantageous decks on the Iowa Gambling Task (IGT) when compensation is based on performance (de Vries, Holland, & Witteman, 2008). Its effects in older adults, however, have been studied less. Older adults, on average, demonstrate less flexible information processing than younger adults and show declines in deliberative capacity that may be critical to good decision making and other cognitive processes (Peters, Hess, Västfjäll, & Auman, 2007). These behavioural and brain-ageing findings could mean that older adults' cognitive processes are not malleable to improvement strategies or environmental influences, including mild feeling inductions. Growing evidence, however, suggests that environmental factors often help to preserve cognitive abilities. Emotional processes also appear to have at least an

[1] Research also has demonstrated that positive-feeling inductions can impair task performance (Forgas, 1995) and lead to more heuristic styles of information processing (i.e., Bless, Bohner, Schwarz, & Strack, 1990) when the task at hand is less meaningful, engaging, and relevant to participants (see Isen, 2008, for a review). In the present study, we used a task that participants tend to find engaging.

equal influence on older adults as on younger adults (e.g., Peters et al., 2007; Peters & Bruine de Bruin, 2012). Thus, one might expect older adults to show beneficial influences of positive feelings that are similar to those observed among younger adults.

In the present study, we explored the induction of positive feelings and its facilitative influence on complex decision making and working memory in older adults. We tested the influence of induced positive feelings on older adults' performance on two tasks—a complex choice task similar to the IGT (it also required learning about gains and losses) and a test of working-memory capacity. Our primary hypotheses were: (1) that older-adult participants exposed to a positive-feeling induction would make better decisions compared to those in a neutral-feeling condition; and (2) that the positive-feeling induction would improve working-memory processes.

METHOD

Forty-six older-adult participants ($M_{\text{age}} = 73.9$ years, range = 63–85) were recruited from a Pacific Northwest community. Participants were pre-screened via a phone interview to be of good health and to have normal or corrected-to-normal vision and hearing. In order to have a diverse age range among participants, approximately equal numbers from two age groups, 63–74 and 75–85 years, were randomly assigned to a neutral-feeling condition ($n = 26$) or a positive-feeling condition ($n = 20$). We had no hypotheses concerning expected task performance differences between older adult age groups, and no significant differences existed between the feeling conditions in age, gender, self-reported health, or education. Participants completed a computer card task followed by a vocabulary test (Ekstrom, French, Harman, & Derman, 1976), measures of working memory, speed-of-processing, reasoning (i.e., WAIS-III Letter-Number Sequencing, Digit-Symbol Coding, and Matrix Reasoning; Wechsler, 1997), and demographic items. Participants took part in the study individually, with an experimenter present.

Feeling-state manipulation

In the positive-feeling condition, participants first received a positive-feeling induction similar to one that has been used previously in research on the topic. Participants were given a thank-you card and two small bags of candy—one containing sugar candy and one containing sugar-free candy—tied with a red ribbon. They were told to take the candy with them and not eat it during the session. In the neutral-control condition, participants received neither candy nor card. As a check of this initial induction, we asked participants to write down the first five words they thought of beginning with the letter H. Previous work demonstrates that individuals in a positive-feeling condition produce more positive word associations, on average, than those in neutral-control conditions. This implicit manipulation check offers several advantages over explicit self-reports of feelings (see Isen & Erez, 2007, for a discussion).

To maintain the positive-feeling state throughout the duration of the experiment ($M = 80$ minutes, range = 63–120 minutes), a second, continuous, feeling manipulation was added. In both conditions, the computer card task was presented on a background that appeared to be the computer "desktop". In the positive-feeling condition, a sky-blue background, with smiling "suns" framed the actual card task. In the neutral-feeling condition, participants viewed the experiment with the same sky-blue background, but each "sun" was replaced with a neutral round image comprised of the same colours, but no face. Pilot tests indicated that exposure to the smiling suns induced more positive feeling than the "no-face" images; neither aroused participant suspicion. Upon completion of the computer task, participants self-reported their current feelings using the Positive Affect Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988).

Computer card task

Rather than using the IGT (which confounds gains, losses, and expected values; see Peters & Slovic, 2000), we adapted Zinbarg and

Mohlman's (1998) card task. This choice allowed us to examine the effects of our feeling manipulation separately on gain and loss choices and, thus, to test critical alternative mood-congruency and positivity effects (see discussion). In the task, participants were presented with virtual card decks on a computer screen. After a short practice block, participants were provided with \$3 in quarters (i.e., 25-cent coins) and told they could keep any money they won above this original amount. They were instructed that the goal of the task was to win as much money as possible and to avoid losing money. Eight different decks were used in the experiment; each was uniquely identifiable by a geometric pattern. Choices from the four "Gain" decks won 25 cents 75% of the time, and 25% of the time did not win or lose, whereas choices from the four "Loss" decks lost 25 cents 75% of the time and neither won nor lost 25% of the time. Card decks were presented one at a time, and participants could accept or reject the top card. The presentation order of these eight card decks was block-randomised across eight blocks, with each deck appearing once per block, for a total of 64 trials. On every trial, participants received feedback via the computer monitor. Those who chose the offered card were shown how much they had won or lost on that trial. An experimenter transferred 25 cents to their pile if they won or removed 25 cents from their pile if they lost. When a participant rejected a card, he or she was told what amount *would have been* won or lost. At the end of the session, participants were compensated \$20 plus any amount they had won above the starter amount (\$3). The experiment was designed to be easy enough so that all participants won some money, so as not to inadvertently induce negative feeling states.

The present task was nonetheless similar to the Iowa Gambling Task (IGT; Bechara et al., 1994) in that participants originally knew nothing about the decks and learned from post-choice feedback. We expected participants to find the present task difficult, as they often find the IGT difficult. For example, college-student participants typically choose poorly 30–40% of the time in the final 30% of the experiment (Peters, 1998). In the IGT, participants win and lose hypothetical money with choices from each of four decks; in the present task, participants either won or lost smaller amounts of real money from each of eight decks.

Cognitive-performance tasks

In the working-memory task, the experimenter read aloud a group of intermixed letters and numbers. The participant was to repeat each group back in numeric and then alphabetic order (e.g., "T9A3" would be "39AT"). The participant received groups with increasingly more letters and numbers until he or she missed all three groups in a set. Three other general measures of cognitive performance were also assessed. In the digit-symbol coding (speed of processing) measure, the participant saw a key of special symbols at the top of the page, each of which corresponded to a digit. Below this key, digits appeared randomly in rows with a blank box below each one. The participant had two minutes to fill in as many blank boxes as possible with the symbol corresponding to its digit. In the matrix-reasoning task (designed to tap into abstract problem solving and spatial reasoning), the participant saw a geometric picture that was missing one key section. Five patterns were shown at the bottom of the page, and the participant was asked to choose the pattern that best completed the geometric picture. In the vocabulary task, the participant was shown words, each of which was followed by a list of five possible synonyms. The participant was asked to circle the correct synonym for each word.

RESULTS

Manipulation check

Analyses were conducted to assess the effectiveness of the candy manipulation. Two independent coders, blind to participant condition, rated the valence of the H-words generated by each participant as positive (+ 1), neutral (0), or negative (− 1). The first author resolved any differences, without awareness of the participant's experimental condition. Average valence was calculated for each participant. Results of an independent-samples t-test indicated that positive-feeling participants produced more positive words than did neutral-feeling participants (mean valence = 0.21 and 0.08, respectively), $t(44) = 1.71$, $p < .05$, one-tailed.

Card-task performance

We conducted a mixed analysis of variance (ANOVA) on the number of correct choices (choosing a gain deck or rejecting a loss deck) minus the number of incorrect choices, in a 2 (Deck Type: gain, loss) × 2 (Feeling Condition: positive, neutral) design. Positive-feeling participants chose significantly better than those in the neutral-feeling condition (mean overall performance = 8.0 and 3.5 for positive-condition and neutral-condition participants, respectively), $F(1, 44) = 4.30$, $p < .05$, $f = 0.31$, p-rep = .88. See Figure 1. Choice accuracy for gain decks was higher than that for loss decks across participant condition, $F(1, 44) = 40.2$, $p < .0001$, but no significant difference emerged between the feeling conditions in their influence on choice accuracy from gain versus loss decks, interaction $F(1, 44) = 0.3$, *ns*. See Figure 2. This result is important because the absence of a mood-congruent effect suggests that the facilitative effects of positive mood were relevant to both gain and loss decks. The mean number of choices from gain decks was higher among positive-feeling than among neutral-feeling participants (22.7 and 20.9 selections, respectively), and the mean number of choices from loss decks was lower for the positive group than for the neutral-feeling participants (14.7 and 17.5, respectively).

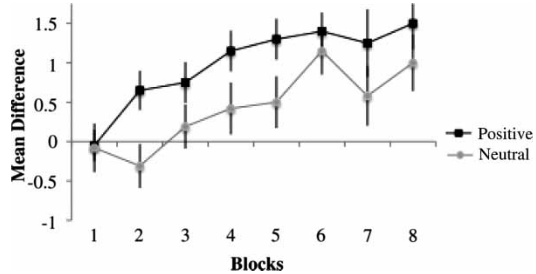

Figure 1. *Number of correct minus incorrect choices by block in the positive-feeling and neutral-feeling conditions (N = 46). Error bars represent plus or minus one standard error of the mean calculated separately for each block. Note: An analysis examining differences between feeling conditions at each block indicated that a significant difference in performance emerged at the second block, F(1, 44) = 6.0, p = .018, d = 0.74. A difference was maintained throughout the task, but did not attain conventional significance in any subsequent block.*

Working-memory and other cognitive-performance measures

Based on the theorising described (i.e., Ashby et al., 1999), we hypothesised that induced positive feelings would facilitate working-memory processes as well. Our results supported this working-memory prediction. The positive-feeling manipulation had a greater influence on working-memory capacity than on the other cognitive measures when scores on each measure were standardised separately, and submitted to a 2 (Feeling Condition: positive, neutral) × 4 (Task Type: working memory, processing speed, reasoning, vocabulary) mixed ANOVA, with Feeling Condition as the between-participants factor, and Task Type as the within-participants factor. Positive-feeling participants scored higher than those in the neutral condition across the cognitive performance measures, $F(1, 44) = 5.8$, $p = .02$; the interaction was marginally significant, $F(1, 44) = 2.9$, $p = .09$.[2] To examine this

[2] A follow-up study was also conducted where we attempted to recruit all original participants to return to the lab approximately four months later to complete the cognitive performance measures a second time. Results ($n = 19$, response rate = 41.3%) were consistent with our interpretation that the mild positive-feeling induction increased working-memory capacity. Within this subset of participants, as in the full sample, working-memory scores of the two conditions originally differed in response to the feeling manipulation (means = 9.5 and 11.3, respectively) for this subset in the neutral- and positive-feeling conditions, $t(17) = 1.85$, $p = 0.04$, one-tailed. In the follow-up study, however, working-memory scores of these same neutral- and positive-feeling participants did not differ significantly (means = 10.7 and 9.8, respectively, $t<1$, *ns*). Results for the other three measures did not differ between conditions in the original or follow-up study.

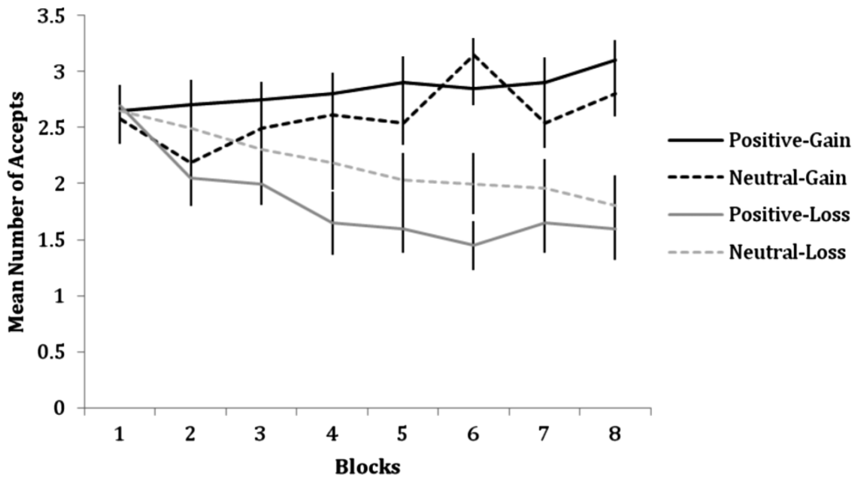

Figure 2. *Number of correct accept choices in gain and loss blocks in the positive-feeling and neutral-feeling conditions (N = 46). Error bars represent plus or minus one standard error of the mean calculated separately for each block.*

interaction in more detail, four one-way ANOVAs were conducted with feeling condition as the independent variable and the standardised scores for working memory, processing speed, reasoning, and vocabulary as the respective dependent variables. Results indicated a significant difference between the positive and neutral feeling conditions for performance on the working-memory task (means = 0.41 and −0.31, respectively), model $R^2 = .13$, feeling-condition $F(1, 44) = 6.6$, $p = .01$,[3] $f = 0.39$, p-rep = .93), but not for speed of processing (means = 0.03 and −0.03), $F(1, 44) = 0.041$, $p = .840$, matrix reasoning (means = 0.26 and −0.20), $F(1, 44) = 2.32$, $p = .13$, or vocabulary (means = 0.21 and −0.16), $F(1, 44) = 1.59$, $p = .21$.

Mediation analysis

Hinson, Jameson, and Whitney (2002) suggested that performance on the similar Iowa Gambling Task is dependent on working-memory processes. Regression analyses were conducted to examine whether the observed increases in working-memory scores mediated the effect of feeling condition on decision performance. This analysis revealed that higher working-memory scores were associated with better choices in the card task, $R^2 = .28$, $b = 1.74$, $t(44) = 4.13$, $p < .001$. Positive-feeling participants also made better choices than those in the neutral condition, model $R^2 = .09$, feeling-condition $b = 4.49$, $t(44) = 2.08$, $p = .04$. A final regression analysis was conducted on overall performance, with working memory and feeling condition used as predictors (model $R^2 = .29$). Feeling condition was no longer a significant predictor, $b = 1.87$, $t(43) = 0.91$, $p = .37$, whereas working memory (the proposed mediator) was, $b = 1.59$, $t(43) = 3.51$, $p = .001$. Increases in working memory resulting from the positive-feeling induction appeared to mediate the effect of positive feeling on choice performance (Sobel = 2.1, $p < .05$).

DISCUSSION

Our results indicate that induced positive feelings facilitated working-memory capacity and improved performance on a complex decision task among older adults. Participants in the positive condition made better choices than controls; this was true for both "winning" and "losing" decks

[3] This effect remains significant with a conservative Bonferroni correction.

and emerged early in the task. These results are consistent with the substantial body of empirical evidence showing that mild positive feelings improve people's ability to think carefully, flexibly, and efficiently about multiple factors in a situation, integrating the needed information (e.g., see Isen, 2008, for a discussion). They are also compatible with existing evidence that people in a positive state are quite sensitive to negative as well as positive information (e.g., Reed & Aspinwall, 1998). The present results importantly extend such findings to include an older adult population.

The effect of positive feelings on choices appeared to be mediated by working memory. Because these results are correlational, however, we do not know whether improved working-memory ability enhanced choice performance (i.e., the mediation) or if these effects are independent. Theorising by Ashby et al. (1999) concerning dopamine release to multiple brain areas, such as the dorsolateral prefrontal cortex (dlPFC; associated with working-memory processes), and the orbitofrontal cortex (associated with decision making), suggests two independent effects. Using the similar IGT paradigm, Bechara and colleagues (1994) have also suggested that working-memory and experiential decision processes may be independent. In support of the mediation hypothesis, however, Hinson et al. (2002) demonstrated that IGT performance is dependent on working memory. Further research is needed to disentangle the relationship between working memory and decision-making performance.

It should also be noted that the effect of the positive-feeling induction on matrix reasoning approached significance ($p = .13$). The chosen reasoning task was relatively abstract, and performance on it is related to working-memory performance (Salthouse, 1993). Thus, the demonstrated improvements were likely due to increased working-memory scores in the positive-feeling condition. Alternatively, although our particular reasoning task is not generally considered creative, dopamine release is also expected to the nucleus accumbens and anterior cingulate cortex, areas proposed to be associated with creative reasoning (Ashby et al., 1999).

The demonstration that positive feelings improve working memory extends, to this older-adult population, the recent comparable finding that positive feelings facilitate controlled processes among young adults (rule-based categorization, Nadler et al., 2010; working memory, Yang & Isen, 2006). Together, these findings suggest that positive feelings may particularly improve monitoring and learning from feedback, among both younger and older adults. Thus, these findings hold important implications for understanding how positive feelings influence cognition.

Decision performance also improved following this simple feeling induction. The results underscore the potential use of positive-feeling inductions to improve complex decision making and the psychological processes that underlie it. Although the effect size was modest, even smaller effects can have important implications in practice (Rosenthal, 1990). It is particularly noteworthy that these results also demonstrate that inducing mild positive feelings facilitates learning new information, as success on the card task required each participant to learn card decks about which they initially knew nothing. Significant differences in good choices emerged in the second block, when participants had experienced feedback from each deck only once before. Thus, positive-feeling participants appeared to learn at a faster rate than neutral-feeling participants. This result is consistent with previous studies indicating that positive-feeling inductions lead to more efficient and thorough decision-making processes in complex decisions (Isen, 1993).

Furthermore, it is of interest that the positive-feeling induction in our study improved choices among both positive (gain) decks and negative (loss) decks. Some existing literature suggests that older adults tend to orient toward positive material and exhibit a positivity bias, and that this effect occurs primarily among older adults with greater executive functioning capacity (e.g., Mather & Knight, 2005). Thus, one might have expected the older adults to have shown such a bias in their performance on our task.

In particular, it might have been expected that those who had greater working-memory capacity as a result of the positive-feeling manipulation would have learned better about the gain decks but not about the loss decks. We found, however, improved choices among both positive gains and negative losses.

Because decision performance in this task depends on learning from feedback, the present findings also indicate that easily induced, mild, positive feelings facilitate learning of new information, both positive and negative in tone. Combined with previous findings (e.g., incidental learning, creative problem solving, and other tasks), it appears that positive-feeling inductions may have a fundamental, beneficial influence on learning, problem solving and decision making, both with and without feedback. Thus, continued exploration of the topic seems promising and important.

One potential issue that might be raised about this study is that task order (the card task vs. the cognitive-performance measures) was not counterbalanced, and older adults in the positive-feeling condition earned more money in the task. Thus, it is possible that participants in the positive-feeling condition may have been more motivated to perform well on all subsequent tasks. All participants, however, won some money in the task, and no participant had any knowledge about his or her relative performance. In addition, positive-feeling participants did not perform better on all subsequent tasks; their superior performance (relative to the neutral group) was evident only on the working-memory task. We also did not counterbalance the order of the cognitive-performance tasks, and the working-memory measure was completed first. It is plausible, therefore, that the positive-feeling induction (completed before and throughout the card task) may have been "used up" by the working-memory measure. Although some evidence exists for this possibility outside of the present study, other positive-feeling studies support a more enduring role for positive-feeling inductions (Isen, 1993). In addition, the only measure that approached significance (aside from working memory) was matrix reasoning, the measure completed third, making this interpretation that working memory used up the positive feeling state less likely.

These results are the first to show, among older adults, some of the facilitating cognitive effects that follow from the same kind of positive-feeling inductions shown to improve thinking and performance among middle-aged, college-aged, and adolescent participants. Given current concern about cognitive declines among the aged (a fast-growing population segment), our findings are potentially important for their indication that simple positive inductions can improve cognitive functioning and decision performance among older adults, as other work has shown they do for younger populations (see Isen, 2008, for a summary).

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