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Author(s)	Madeline L. Pe, Ai-Girl Tan and Kurt A. Heller
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Affect and Successful Performance: A Study on the Tower of Hanoi and Nine-dot

Madeline L. Pe
National Institute of Education, Singapore

Ai-Girl Tan
Nanyang Technological University, Singapore

Kurt A. Heller
University of Munich, Germany

A study was conducted to investigate the relation between positive affect, feeling, task interest and performance. The participants of the study were 109 post secondary students from the business school in Singapore. The age range was between 17 and 20 years old (M = 18.13, SD = .70). The students of the study solved two problems, the Tower of Hanoi task (paper and pen format, well-defined task) and nine dot problem (insight task). Before problem solving, the participants rated their mood using the Positive and Negative Affect Schedule (PANAS, Watson, Clark, & Tellegen, 1988) and pleasantness rating of unfamiliar words (Isen, Daubman, & Nowicki, 1987). After the tasks, they rated the PANAS and task interest. The findings supported the hypotheses that there is a positive relation between positive affect and successful task completion (Fredrickson, 1998), between task interest and successful performance (Amabile, 1983). The findings suggest a change in negative affect (lower than the initial state) as an indicator of the presence of successful performance, particularly in solving a well-defined task (Schwarz, 1990). The study expands the paradigm of inclusion of emotions in regulating performance, including positive and negative affect, task interest and general feeling.

A person's emotional state can influence his/her cognition (see Forgas, 2001) and performance. Often reported is that positive affect has a constructive role in cognition (Fiedler, 2001; Isen & Daubman, 1984; Schwarz, 1990). Positive affect is defined as feelings that reveal a level of pleasure with its environment. This includes happiness, joy, excitement, enthusiasm and contentment, which could last either for a short or long period of time (Pressman & Cohen, 2005). Happy people and those in pleasant moods have a high chance of becoming efficient or creative problem solvers (Fredrickson, 2001; Grawitch, Munz, & Kramer, 2003; Isen, Daubman, & Nowicki, 1987; Isen, Johnson, Mertz, & Robinson, 1985; Lyubomirsky, King, & Diener, 2005). Positive emotions not only broaden momentary cognition, but also build personal resources to be transient and durable (Fredrickson, 1998). The broaden-and-build theory fo-

Correspondence concerning this paper should be addressed to Ai-Girl Tan, University of Munich, Martiusstrasse 4, 80802 Munich, Germany. E-mail: aigirl.tan@nie.edu.sg

cuses on five discrete positive emotions – joy, interest, contentment, pride and love, which have the ability to broaden our momentary thought-action repertoires and build our enduring personal resources (i.e., intellectual, social and psychological) (Fredrickson, 2001). During broadening state of mind, actions emerged can lead to building of personal resources (Cohn & Fredrickson, 2006; Fredrickson, 1998). Joy encourages the individual to play more, push the limits, and be creative. In play, a person's intellectual resources increase. Experiencing positive affect allows a person to have diverse thoughts and actions. Negative emotions shrink or narrow thoughts and actions (Fredrickson & Branigan, 2005). In build-and broaden theory, interest is a positive emotion (Fredrickson, 1998). Task interest is an indicator of intrinsic motivation, an essential component of creative performance (Amabile, 1983).

Neuropsychological View

From the neuropsychological perspective, integration of the left and right hemispheres is reported as essential for creative attainment (Atchley, Keeney, & Burgess, 1999). A relationship was seen between the boost in dopamine level and performance on a variety of cognitive tasks (Ashby, Isen, & Turken, 1999). There is an increased release in dopamine levels during periods of mild positive affect. An increase in the dopamine level leads to elevated feelings (Beatty, 1995). After receiving an unanticipated reward, dopamine cells in the ventral tegmental area (VTA) that are projected into the nucleus acumbens can increase positive affect (Ashby, Isen, & Turken, 1999; Floresco, Yang, & Phillips, 1998). Nicely wrapped tokens, for instance, induce positive affect (e.g., Erez & Isen, 2002; Isen & Reeve, 2005). Mild stress causes the release of dopamine from the VTA to the prefrontal cortex, but not to the nucleus accumbens (Ashby et. al., 1999). This may be the reason for mixed findings on the influences of positive and negative affect on creativity (Lyubomirsky et al, 2005).

Change in affect caused by the unanticipated reward can last for 30 minutes or longer (Ashby et al, 1999). Stimulating the basolateral amygdale with the possible mediator of reward will increase dopamine release in the nucleus accumbens for about 30 minutes (Floresco et al, 1998). It can be expected that change caused by induced positive affect, especially by giving a reward, can last long after the stimulus is presented. Dopamine has a substantial influence on one's cognition. Reducing dopamine levels in the pre-frontal cortex can weaken one's working memory. Moderate levels of positive affect may improve working memory, but extreme levels may disrupt it (Ashby et. al., 1999). Dopamine and positive affect facilitate the selection of, or the switching among, alternative cognitive responses. The release of dopamine seems to suggest a characteristic in creative processes that increases cognitive flexibility (Isen, Daubman, & Nowicki, 1987). People in positive affect states showed an increase in creativity and intrinsic task motivation (Erez & Isen, 2002; Isen & Reeve, 2005), but not at the expense of neglecting the uninteresting task they needed to do (Isen & Reeve, 2005).

The Information Approach

It is inconclusive, if affect precedes thinking or feeling emerges after cognitive engagement (Ashby, Isen, & Turken, 1999). Some researcher claims that positive affect can act as precedent to cognitive processes (Zajonc, 1980). Emotions are regarded as initiators of thinking, not only as results of stimuli or bodily expression as once believed by Charles Darwin and William James (Garrison, 2003).

The affect as information approach focuses on the role of affect as a signal of a psychological situation (Schwarz, 1990). Given any task, happy people likely look at the situation as safe, while sad people likely find it problematic. Being in a perceived safe environment, a person is likely to be playful with his/her cognition, and come up with novel responses. Feeling that a situation is problematic, a person is likely to take few risks, and be careful with his/her responses. His/her cognitive strategy is likely focused, detail-oriented. Positive and negative affect can be seen as appetitive and aversive situations, respectively (Fiedler, 2001). In the aversive situation, a person employs avoidance behavior, making sure that everything is working reliably and error-free. The person then believes that performance on this task has to be perfect and stimulus-driven, making it essential to avoid mistakes and not to overlook significant environmental stimuli. In the appetitive set during positive situations, the person likely put more weight on curiosity than to safety and avoidance of mistakes.

Problem Solving and Affect

Our study examines the relation between positive affect, feeling, task interest and performance in solving well-defined and insightful problems. A well-defined problem has all the components of its problem space presented to the solver and there is an algorithmic path towards the solution (Dunbar, 1998; Ormerod, 2005). Problems having an algorithmic solution are usually associated with analytical processing (Schwarz, 1990). For this study, the Tower of Hanoi will be used as the task for the well-defined problem (Ormerod, 2005). In an insight problem, there are parts of the problem which are not clearly specified or are missing, making its structure similar to ill-defined problems. Resembling well-defined tasks, insight problems usually have a ready-made solution to the problem (Dunbar, 1998; Ormerod, 2005). Researchers might consider insight problems to be creative tasks (e.g., Isen et al., 1987). The cognitive processing strategy likely is similar with ill-defined than with well-defined problems. The *nine dot problem* represents the insight problem (Finke, Ward, & Smith, 1992).

We hypothesize that there is a positive relationship between positive mood and successful problem solving. This hypothesis is supported a review confirming that people in pleasant moods are efficient problem solvers or creative (Lyubomirsky et al., 2005). The hypothesis is supported by Brand and Opwis's (2007) study on the role of positive affect on the tower of Hanoi task (n = 64). The study showed that the participants in the positive mood condition (induced by recalling a happy or positive event) were able to solve the problem and transfer this learning to a similar problem more efficiently than those in a negative mood.

We hypothesize that there is a positive relationship between task interest and successful performance. Affect is then related to the interest on the task. If the person foresees a possibility to be successful in an incomplete outcome, he/she will continue the cycle of creative process. The successful outcome can increase the person's motivation or interest to engage in a similar task. The creative cycle continues, and in time to build his/her personal resources (cognitive skill) (Fredrickson, 1998). The person ends the creative process, when a failed outcome emerged (Amabile, 1983).

METHOD

Participants

A total of 109 post secondary students from the business school in Singapore participated in our study. Their age ranged between 17 and 20 years old (M = 18.13, SD

= .70). Of the total, 67 (61.5%) were females, and 42 (38.5%) were males. Nearly all were Singaporean (n = 105, 96.3%), and four were international students (3.7%). The ethnicity of the participants varied; sixty-nine (63.3%) were Chinese, thirty-five (32.1%) Malays, two (1.8%) Indians, two (1.8%) others and one did not indicate his/her ethnicity. They self-reported their religions: Buddhist (n = 39, 35.8%), Catholic or Christian (n = 13, 11.9%), Daoist (n = 4, 3.7%), Hindu (n = 1, .9%), Muslim and others (n = 46, 42.2%), and six did not indicate their spirituality.

Measures of Positive Affect

In this study, positive affect will be measured using the Positive and Negative Affect Schedule (PANAS, Watson, Clark, & Tellegen, 1988) and participants' pleasantness rating of unfamiliar words (Isen, Daubman, & Nowicki, 1987; Isen, Johnson, Mertz, & Robinson, 1985).

Positive Affect and Negative Affect Schedule (PANAS). The PANAS (Watson, Clark, & Tellegen, 1988) is a 20-item mood scale measuring both the positive (10 items) and negative (10 items) affect of individuals. The PA measure consists of the following adjectives: *attentive, interested, alert, excited, enthusiastic, inspired, proud, determined, strong* and *active.* The NA measure has the following adjectives: *distressed, upset, hostile, irritable, scared, afraid, ashamed, guilty* and *nervous.* Each mood adjective has to be rated in a 5 point scale labeled with the following descriptors, *very slightly or not at all, a little, moderately, quite a bit* and *very much,* respecttively. The PANAS is flexible. Researchers can ask participants to rate their mood in various points in time, *moment, today, past few days, past few weeks, year,* and *general.* Undergraduate students' results of the PANAS across different points in time show a relatively high reliability, ranging from .86 to .90 for the PA scale, and .84 to .87 for the NA scale. The correlation between the PA and the NA remains low, ranging from -.12 to -.23, showing that these two scales are relatively independent from each other (e.g., Crawford & Henry, 2004; Pressman & Cohen, 2005). For the present study, alpha reliabilities for PA (pretask), NA (pretask), PA (posttask) and NA (posttask) were .89, .69, .91, and .77, respectively. Inter-item correlation between PA and NA for pretask, r = .17, and post task, r = .23 remained low.

Pleasantness Rating of Unfamiliar Words. Research showed that pleasantness rating of unfamiliar words can tell us something about an individual's affect. People experiencing positive mood tend to rate unfamiliar words higher than those under neutral mood (Isen et al., 1987; Isen et al., 1985). According to Isen, Johnson, Mertz and Robison (1985), pleasantness ratings of unfamiliar words is another way of measuring positive affect. Positive affect tend to be "associated with significantly more positive ratings of unfamiliar words and a nonsignificant tendency toward more negative ratings of familiar items" (Isen et al., 1985, p. 1416). Similar results were reported in other studies using the same method of investigation (e.g., Isen, Daubman, & Nowicki, 1987; Mikulincer & Sheffi, 2000).

However, since the original unfamiliar words by Isen et al. (1985) are not available, the Turkish words used by Zajonc (1968) for his research on *Attitudal Effects of Mere Exposure* are used instead. Zajonc have shown to participants a series of Turkish words (unfamiliar words to the participants), *afworbu, enanwal, iktitaf, cividra, lokanta, dilikli, zabulon* and *nansoma*, in varying frequencies. It is hypothesized that unfamiliar words shown more frequently will be rated more positively by participants

in a 7-point "good-bad" scale. His scale is quite similar with Isen et al. (1985) and Mikulincer and Sheffi (2000), since they also use a 7-point scale to rate their set of unfamiliar words.

Task Specific Mood Measure/Post Task Interest. Task specific mood measure was termed the post task interest. Adopting the measure by Amabile, Barsade and Mueller (2005), participants were asked to rate on a 7-point scale, the extent of how they felt each of the following emotion while doing the problem solving task: happy, enjoyment of task, and satisfied with myself. For the present study, the alpha reliability of this measure for Tower of Hanoi was .81 and nine-dot .85, respectively. Alpha reliabilities of the post task interest measure with two additional items: frustration and frustration of myself for Tower of Hanoi was .72 and nine-dot .66, respectively.

Procedure

All participants were asked to respond individually to the PANAS (pre task), pleasantness ratings of unfamiliar words, tower of Hanoi task (paper and pen format) and nine dot problem, PANAS (post task) and post task interest measures. They were told to answer the survey in that order. Participants were reminded not to discuss their answers with others. On average the participants took 50minutes to complete the survey.

RESULTS

Mean and standard deviation of positive affect (PA) and negative affect (NA) before the participants attended to the tasks (pre-task) and after the tasks (post task), feeling toward unfamiliar words, and post-task interest were computed. Table 1 summarizes the results.

Correlations between Pre-task Mood/Post-task Interest and Performance

There were no significant correlations between performance in the Tower of Hanoi task and positive affect ($r = .128$, $p = .185$); and positive affect balance ($r = .175$, $p = .077$), as well as for performance in the nine dot problem and positive affect ($r = .121$, $p = .216$); and positive affect balance ($r = .066$, $p = .510$). Taking the three positive emotions (happy, enjoy and satisfied) as an indicator, post task interest was significantly correlated with Tower of Hanoi performance, $r = .520$, $p < .01$; and nine dot performance, $r = .334$, $p < .01$.

Differences between the Successful and Not-Successful Groups

About half the participants ($n = 48$, 44%) solved the Tower of Hanoi, and 61 (56%) of them did not. Nearly two-thirds ($n = 65$, 59.6%) solved the nine-dot and 43 (39.4%) did not, and one of them did not attended to the task. The affect and interest of the successful and non-successful groups were computed for comparison. The independent two samples t-test was computed to find out if there were significant differences between the affect of individuals who succeeded and did not succeed in the problem solving tasks. The participants who solved the Tower of Hanoi report-ed higher post task interest, $t(101) = - 6.122$, $p = .000$, $d = 1.20$ than those who failed to solve it. In contrast, those who did not solve the Tower of Hanoi reported higher post task NA, $t(104) = -2.87$, $p = .005$, $d = .56$, and lower post task PA-NA balance, $t(104) = 3.70$, $p = 000$, $d = .73$. Results for the nine-dot problem were the same. The participants who solved the nine-dot problem reported higher post task interest, $t(99) = -3.529$, $p = .001$, $d = .73$ as compared to those who were unable to complete it. To investigate change in affect between those who solved and who did not solve the tasks, a paired sample t-

Table 1
Mean and Standard Deviation for Pre-task and Post task of Affect, Feeling, and Interest

	n	M	SD	Skewness	Kurtosis
Pre-task					
PA	108	2.64	.81	.44	.36
NA	106	1.77	.52	.83	.69
PA-NA_bal	103	.88	.90	.46	.44
Post-task					
PA	106	2.60	.90	.67	.17
NA	106	1.68	.55	1.35	2.46
PA-NA_bal	106	.91	.94	.61	.41
Turkish words	105	3.85	.83	-.77	2.91
Post task interest					
TOH_3	103	3.74	1.66	.25	-.62
TOH_all	103	4.22	1.29	.19	-.36
Nine-dot_3	101	3.56	1.73	.23	-.90
Nine-dot_all	101	3.30	1.25	-.14	-.62

Note: PA = positive affect, NA = negative affect, PA-NA_bal = Affect balance,
TOH_3 (Tower of Hanoi, happy, enjoy and interest),
TOH_all (Tower of Hanoi, happy, enjoy, interest, frustration, frustration self),
Nine-dot_3 (Nine dot, happy, enjoy, and interest),
and Nine-dot_all (Nine-dot, happy, enjoy, interest, frustration, frustration self).

test was performed. Negative affect after performance was significantly lower for the participants who were able to solve the tower of Hanoi, $t(45) = 3.36$, $p = .002$, $d = .46$, and nine dot problems, $t(60) = 2.59$, $p = .012$, $d = .27$, than that before performance.

DISCUSSION

Our study explored the relation between affect and cognition in the context of solving the well-defined and insight tasks. Affect of the participants before and after performance were measured using the PANAS. The pleasantness rating of unfamiliar words was included as a comparison. The task interest scale was meant to discover emotions of the participants after completing a task. The reliabilities of the scales PANAS, the PA subscale and NA subscale, and the task interest scale (three emotions, happy, enjoy and satisfied) indicated the presence of internal consistency. The task interest with three positive emotions were employed for subsequent analysis due to it high internal consistency. Skewness and kurtosis of the scales, PA and task interest (happy, enjoy and satisfied) were within 1.64, and hence the data were subjected for further analysis (Table 1).

We examined the pre-task mood (measured by the PANAS) and performance and learned that there was no significant correlation between it and performance of the well-defined (Tower of Hanoi) or insight (Nine dots) tasks. To explore further, we examined affect of the participants who succeeded and who did not succeed in task performance. The participants who succeeded in task performance reported a high

value in positive affect and in balanced affect but a low value in negative affect (Table 2). The finding supports our hypothesis that there is a positive relationship between mood and successful performance. It is also in line with the broaden-and-build theory (Fredrickson, 1998) that people who self-report high positive affect likely perform satisfactory, as they might possess cognitive flexibility and broad repertoire of skills.

Table 2
Affect, Feeling and Interest of Successful and Not-successful Groups

	Success		Not-success	
	M	SD	M	SD
TOH				
Pre-task				
PA	2.75	.91	2.56	.73
NA	1.70	.43	1.82	.59
PA-NA_bal	1.04	.98	.75	.82
Post-task				
PA	2.79	.94	2.44	.85
NA	1.51	.37	1.81	.63
PA-NA_bal	1.27	.91	.63	.87
Turkish words	3.81	.77	3.89	.88
Post task interest_3	4.71	1.56	2.98	1.30
Nine-dot				
Pre-task				
PA	2.71	.84	2.53	.77
NA	1.81	.52	1.70	.53
PA-NA_bal	.91	.98	.81	.78
Post-task				
PA	2.67	.94	2.48	.84
NA	1.67	.52	1.71	.60
PA-NA_bal	1.00	.94	.78	.93
Turkish words	3.78	.79	3.94	.89
Post task interest_3	4.01	1.67	2.82	1.57

Note: PA = positive affect, NA = negative affect, PA-NA_bal = affect balance, post task interest_3 (happy, enjoy and interest).

When the individual is experiencing mild positive affect, he/she will judge the present situation as safe (Schwarz, 1990) and appetitive (Fiedler, 2001). This evaluation will influence the person's behavior, allowing him/her to explore more and take risks. Since the situation is seen as safe, he/she will not be concerned so much about avoiding mistakes or having error-free moves (Fiedler, 2001; Schwarz, 1990). The individual will look at the general picture (Fredrickson, 1998). Details of the stimulus will be ignored. Given the stimulus, the individual will generate and explore ideas

(Finke, Smith, & Ward, 1992), not binding himself/herself to the details of the problem (Fredrickson, 1998).

Amabile's (1983) componential framework focuses on the role of task motivation on creativity. Task interest is an indicator of intrinsic motivation that is fueled by an individual's inherent joy of discovery (Finke et al, 1992) and interest, a positive emotion (Fredrickson, 2001). Significant correlation was observed between the post task interest scores and performance for the Tower of Hanoi ($p < .01$) or nine dot problem ($p < .01$). The finding supports our hypothesis that there is a positive relationship between task interest and successful performance. We might propose that success in completing a task is related to task specific interest and hence positive emotions. Across group comparison supports the claim that when a person is interested in a task, he/she will engage in problem representation; and when a person engage in a task, he/she has high positive emotions or task interest. Evidently, the participants who were able to solve the Tower of Hanoi reported higher post task interest as compared to those who were unable to solve it ($p < .01$). The same finding was observed for the insight problem. The participants who solved the nine dot problem reported higher post task interest as compared to those who weren't able to do so ($p < .01$).

Our findings point to further reflection on the interplay between emotion and cognition. When the individual is generating ideas, there is a need to retrieve various types of information, such as specific category exemplars, general conceptual knowledge, analogical transfers, association and combining of concepts and images (Finke et al., 1992). Positive affect will be able to increase the access to these types of information giving opportunities for the individual to create novel products or ideas. Since negative affect makes the individual focus on the product constraints, this will likely limit the information he/she can generate and combine, making him/her more accurate, but less creative. We examined further the self-reported affect of the participants, and the change in affect for those who solved the two problems. We noticed that the participants who solved the tower of Hanoi reported significantly lesser negative affect ($M = 1.51$, $SD = .37$, $t(45) = 3.36$, $p = .002$, $d = .46$) than did their counterpart who was unsuccessful in the task ($M = 1.70$, $SD = .43$). Similarly, solving the nine dot problem made the participants experience lesser negative affect ($M = 1.67$, $SD = .52$, $t(60) = 2.59$, $p = .012$, $d = .27$) as compared to when they started the task ($M = 1.81$, $SD = .52$). The findings support views of some of the researchers. Negative affect facilitates analytical and systematic processing (Fiedler, 2000; Mackie & Worth, 1989; Schwarz, 1990) and can shrink and narrow thinking (Fredrickson, 1998). Under negative affect, participant's reaction is to focus (Schwarz, 1990), to ensure that what he/she is doing is correct (Fiedler, 2001) as he/she likely wishes to alleviate himself/herself from the negative feeling. Upon completion of the task, he/she shall experience a decrease in negative affect.

CONCLUSION

Acknowledging the importance of positive and negative affect and mood, future studies shall explore ways to regulate both positive and negative affect for effective and creative performance. Evidently, people under positive mood seem to engage less in systematic processing that do those under neutral mood (Markie & Worth, 1989). Happy people use mental shortcuts when solving problems as compared to sad individuals (Lyubomirsky et al, 2005). Positive and negative mood groups outper-

formed participants in the neutral condition in idea generation (Davis, Kirby, & Curtis, 2007). The relationship of general mood and post task interest can be explained with reference to the information approach (Schwarz, 1990), i.e., an individual may use his/her affective state as relevant information when making evaluative judgments. It is likely that when a task is complex, an individual may ask himself/herself, "how do I feel about it?" instead of looking into the features of the target.

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