How do we learn in a negative mood? Effects of a negative mood on transfer and learning

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Abstract

Findings show that both positive and negative mood may hinder or promote information processing. In two experiments, we show that negative mood impairs transfer effects and learning. In the first experiment, N = 54 participants drawn from a training course for the Swiss Corps of Fortification Guards first learned to solve the three- and four-disk Tower of Hanoi (ToH) problem to mastery level. After mood induction, they were asked to solve one proximal (five-disk ToH) and two distal transfer tasks (the Missionary and Cannibal Problem and the Katona Card Problem). Participants in a negative mood solved the transfer tasks less efficiently. In the second experiment, this result was replicated with a sample of N = 80 participants drawn from a training course for nurses. Additionally, mood affected performance if it was induced before the learning phase; participants in a negative mood needed more repetitions to reach the mastery level and also performed worse in the transfer tasks, although there were no greater mood differences in this problem-solving phase. The implications for the design of learning settings are discussed.

Keywords: Negative mood; Transfer; Problem solving; Tower of Hanoi; Mastery level

Article Outline

1. Mood effects on cognitive tasks
2. Transfer
3. Experiment 1
   3.1. Method
      3.1.1. Participants and design
      3.1.2. Material
         3.1.2.1. Mood induction
         3.1.2.2. Learning task: three-disk and four-disk Tower of Hanoi (ToH)
      3.1.2.3. Transfer tasks
      3.1.3. Measures
         3.1.3.1. Mood
         3.1.3.2. Dependent variables
      3.1.4. Procedure
4. Results
4.1. Mood
4.2. Learning task
4.3. Transfer task
4.3.1. Proximal task: five-disk ToH
4.3.2. Distal task: MC problem
4.3.3. Distal task: KC problem
4.4. Discussion
5. Experiment 2
5.1. Sample, design, and materials
6. Results
6.1. Mood
6.2. Learning phase
6.3. Transfer phase
6.3.1. Proximal task: five-disk ToH
6.3.2. Distal task: Missionary and Cannibal Problem (MC)
6.3.3. Distal task: Katona Card Problem (KC)
6.4. Discussion
7. General discussion
References

The aim of learning is to acquire new skills and new knowledge on the basis of repeated personal experience (Bower & Hilgard, 1981), while transfer is the application of acquired knowledge to a new situation that has not previously been experienced (Larkin, 1989, VanLehn, 1991 and VanLehn, 1996). Transfer is therefore important for learning because it can speed up and optimize the acquisition of knowledge and skills. Yet, both everyday educational and clinical experience and research indicate that strong negative emotions such as anxiety and fear of examinations (cf. Pekrun & Jerusalem, 1996) or depression (Baker and Shannon, 1995 and Brown et al., 1994) can have potent adverse effects on cognitive processing and can impair learning performance as well as performance on transfer tasks. The issue of how these effects can be reduced has been widely discussed in the educational and clinical literature. Given the detrimental influence upon students of strong negative affect, classroom management seeks to avoid its occurrence (cf. Boekaerts, 1993, Seipp, 1990 and Wahl et al., 2001). But what about the impact of mood on cognitive processes? It is quite obvious that students are continuously learning and acquiring cognitive skills in various moods and that it is impossible not to learn while being in this diffuse background state of mind. Therefore, it is important to know more about potential effects of mood in learning settings. There is a great deal of research indicating that mood can affect performance on cognitive tasks (Abele, 1995, Abele, 1996 and Kleine and Schmitz, 1994). Our studies aimed at extending this research to a learning context by testing if mood also has an influence on transfer performance and learning. In contrast to the adverse effects of strong negative affect, it is not at all clear which mood quality impairs or improves transfer or knowledge of how to solve a complex problem. But given the relevance of transfer for learning, it is important to understand if and how this may occur as a function of mood quality.

1. Mood effects on cognitive tasks
According to Schwarz (1987, p. 2), mood, in contrast to affect, is understood as a “momentary, subjectively experienced state of mind…. that can be described in terms of feeling good – feeling bad”. Mood is a diffuse background state of mind, the cause of which is generally disregarded. In contrast to affect, the low-grade intensity of mood does not interrupt actions (Morris, 1989). One major function of mood is to inform the subject about the general quality of his or her momentary emotional state (cf. Bless, 2001, Nowlis and Nowlis, 1956, Pribram, 1970, Schwarz, 1990, Schwarz and Bless, 1991 and Schwarz and Clore, 1983).


However, with regard to the specific direction of the relation between mood and performance, there does not seem to be one general rule. There is empirical evidence that cognitive performance may be reduced in the presence of a positive, as opposed to a neutral or negative mood. These findings tally with models assuming that a positive mood leads to a simplification of cognitive processes (Chaiken, 1980, Chaiken, 1987, Petty and Cacioppo, 1986a and Petty and Cacioppo, 1986b), a reduction in processing capacity (Mackie and Worth, 1989 and Oaksford et al., 1996), and a decline in motivation (cf. Bodenhausen et al., 1994 and Wegener et al., 1995). In particular, Oaksford et al. (1996) argue that positive mood suppresses convergent, analytic thinking by depleting central executive resources while solving, for instance, the Tower of London problem. Additionally, with respect to social perception, people in a positive mood are more prone to rely on stereotypes (Bodenhausen et al., 1994 and Bodenhausen and Lichtenstein, 1987) and more vulnerable to halo effects (Sinclair & Mark, 1992). These observations accord with the claim that a positive mood impairs performance. In a similar vein, a number of studies demonstrate that a negative mood can result in more systematic, elaborate and analytical cognitive processing (cf. Clore et al., 1994, Weary and Jacobsen, 1997 and Weary et al., 1993), and can significantly reduce halo effects (Sinclair & Mark, 1992). People in a negative mood, compared to those in neutral or positive mood, seem to be especially likely to engage in systematic processing, to adhere more consistently to the data provided (Gasper, 2003 and Sinclair, 1988) and to show less confidence in their assumptions. Correspondingly, judgements of people in a negative mood are less influenced by stereotypes (Bodenhausen, Sheppard, et al., 1994), and more specifically by negative stereotypes, whereas the use of positive stereotypes seemed not to be affected (Lambert, Khan, Lickel, & Fricke, 1997). Yet the observation that a negative mood may improve performance is at odds with the conclusion that a bad mood is associated with a reduction in cognitive processing (Ellis & Ashbrook, 1988; see also Oaksford et al., 1996) as well as with findings that it neither improves nor damages problem-solving performance and therefore has no effect on creativity (Isen et al., 1987b). At least four reasons have been offered for why a negative mood is associated with a reduction in cognitive performance, all of them focussing on the reduction of information processing capacity. The resource allocation model (Ellis & Ashbrook, 1988) points out that people in a sad mood are concerned with extra-task processing (e.g., thinking about their own bad mood) or with task-irrelevant processing; Oaksford et al. (1996) argue for depletion of central executive processes, whereas Bohner, Bless, Schwarz, and Strack (1988) suggest a capacity reduction, since subjects in a
bad mood are more concerned with finding out why they are in this specific mood. Last, Isen, 1984 and Isen, 1987 proposed that a person in a negative mood tries to regain a better mood ("mood repair"). As a consequence, the focus of cognitive capacity is both on the task and on mood correction.

In contrast, improved performance has been observed in subjects in a positive mood when a task requires either elaboration of the given data (Abele, Gendolla, & Petzold, 1998), decision-making (cf. Isen & Labroo, 2003), logical thinking (Abele, 1995), problem solving (Isen, Rosenzweig, & Young, 1991), or broadening the scope of attention (Fredrickson & Branigan, 2005). Furthermore, Estrada et al. (1997) showed that people in a positive mood were more likely to adhere to data that did not fit with a preconceived idea that they were entertaining. In addition, an increased flexibility in thinking has been found to co-occur with positive mood (Greene and Noice, 1988 and Isen et al., 1987b): subjects in a positive mood solved insight problems (the candle problem; cf. Duncker, 1945) or word association problems (Remote Associates Test; cf. Mednick, Mednick, & Mednick, 1964) faster and more accurately than subjects in a negative mood. The underlying theoretical framework is based on the idea that subjects in a positive mood may have more varied information. Consequently, there is a tendency to see relationships between types of information that are normally not associated (cf. Isen, Daubman, & Gorgoglione, 1987a). This suggests that a good mood influences the breadth of attention, thus resulting in a larger and more varied range of information (cf. Derryberry and Tucker, 1994 and Fredrickson and Branigan, 2005). Accordingly, Ashby, Isen, and Turken (1999) and Isen (2002) proposed a neurobiological theory of positive affect, pointing out that a positive mood may be directly associated with increased dopamine levels in the brain. Furthermore, subjects in a positive mood show flexible thinking even when they are not required to do so (Gasper, 2003). Some recent research has emphasized the concept of affect-as-information (the AAI-model; cf. Bless, 2001, Gasper, 2003, Isbell, 2003, Schwarz, 1990, Schwarz and Clore, 1983 and Schwarz and Clore, 1988) according to which the assessment and significance of the momentary situation and hence also the associated processing style changes as a function of mood. If situations are interpreted as being unproblematic and not requiring caution, it can be assumed that the already existing knowledge structures can be used successfully and repeatedly. On the other hand, unknown or problematic situations require a more information-driven procedure. Thus, people in a positive mood should have confidence in their available cognitive concepts, whereas those in a negative mood tend to take the existing data into account and engage in more systematic information processing.

In sum, the empirical findings are controversial; a positive mood can be associated with reduced cognitive performance but also with more flexible thinking; a negative mood can result in more systematic and data-oriented information processing but can also impair performance.

2. Transfer

Transfer is a behavioral change occurring in a specific situation as a result of repeated previous experience made in another situation (Campione, Brown, & Ferrara, 1982). Thus, generally, transfer improves performance if problem solvers are able to apply their knowledge acquired in previous problem-solving tasks (the learning or exercise tasks) to new contexts (the transfer task) (cf. Larkin, 1989, VanLehn, 1991 and VanLehn, 1996).
The development and transfer of knowledge structures are central components of learning (cf. for instance Hasselhorn, 1995 and Steiner, 1999), by virtue of four practical consequences. First, the application of established knowledge structures such as schemata and scripts implies rapid and more economical information processing, since the encoding has already been processed in accordance with established algorithms (cf. Fiske and Taylor, 1991 and Taylor and Crocker, 1981). Second, more complex information configurations can be condensed into more compact information units (chunks) by means of schema-driven information processing. Third, conclusions can be speeded up, because information is assumed to be given and implicit. And, fourth, the use of heuristics makes cognitive resources available for further additional information processing.

However, transfer tends not to occur spontaneously (Hasselhorn & Mähler, 2000), which explains why, notably in the educational context, transfer between different disciplines or to new contexts is seldom observed (Andrade & Perkins, 1998), or else it requires a substantial effort of instruction (Fogarty, Perkins, & Barell, 1992).

But on what does the quality of transfer depend? First, the similarity of the learning and the transfer task is one important determinant of transfer performance (Detterman and Sternberg, 1993 and Hasselhorn and Mähler, 2000). In general, achieving transfer is easier when similarity of surface features of the learning and transfer tasks is high (proximal transfer) than when similarity is low (distal transfer) (VanLehn, 1996). Second, transfer performance is to be expected if the knowledge units acquired during the learning phase, i.e., the productions (Gray & Orasanu, 1987) and problem-solving rules (Kotovsky, Hayes, & Simon, 1985), can be re-used in the transfer phase (cf. Bovair et al., 1990 and Singley and Anderson, 1989). Finally, there is a direct relation between transferability and the difficulty of the learning task (cf. Kotovsky & Fallside, 1989); moreover, metacognitive strategies are also able to improve transfer performance (Brand et al., 2003 and Berardi-Coletta et al., 1995).

The minimum cognitive prerequisite for transfer is the level of complete acquisition, or mastery level (Steiner, 1996). Thus, a high level of mastering must precede successful transfer. This observation tallies with the studies conducted by Kotovsky and Fallside (1989), which concluded that complete mental representation of the problem is the main factor in the success of transfer processes.

We took this into account in our studies by having all subjects reach mastery level with the three-disk and four-disk Tower of Hanoi (ToH) problem in the learning phase. The ToH problem is suitable for investigating proximal and distal transfer tasks because the recursive structure to be applied is fundamental to the solution of many cognitive tasks (cf. Schmid et al., 1998, Schmid and Wysotzki, 1997 and Schmid and Wysotzki, 1998).

So far, the extent to which positive or negative mood may lead to improved or reduced transfer performance has not been studied. A single finding showed favorable effects of a positive mood for grasping metaphors (Roehm & Sternthal, 2001). Furthermore, if a positive mood, as highlighted by Isen et al. (1987b) leads to more flexible thinking, this should be particularly favorable for detecting analogies between different transfer tasks with similar or dissimilar surface features but with identical substructure. However, the contrary may also be the case; given the evidence that a negative mood leads to more systematic and analytical cognitive processing (cf. Clore et al., 1994, Weary and Jacobsen, 1997 and Weary et al., 1993), people in a sad mood may be more aware of the data available and therefore more
easily detect a problem-solving algorithm underlying the different transfer tasks. In sum, the issue of how mood influences transfer performance remains controversial.

3. Experiment 1

To date, the impact of mood on transfer effects is unclear, i.e., it remains unanswered to what extent mood promotes the transfer of a previously acquired problem solving strategy to tasks with very similar (proximal transfer task: five-disk ToH) and dissimilar surface features (distal problems such as the Missionary and Cannibal Problem and the Katona Card Problem). The main aim of the first study was therefore to test the hypothesis that mood has an effect on the transfer of knowledge from a learning task to transfer tasks, which have in common that they can be solved by means of the same recursive strategy.

3.1. Method

3.1.1. Participants and design

Fifty-four male students from the Swiss Corps of Fortification Guards (FWK) took part in the study. The average age was 24.07 years (SD = 3.38). The admission procedure used by this corps is such that persons studied could be assumed to form a homogeneous subject pool in respect of their professional, cognitive and social background. First of all, the students had to develop a schema for solving the ToH problem. After acquiring the schema, participants’ mood was manipulated so as to create a positive or a negative mood (mood factor). In the subsequent transfer phase, all students solved one proximal and two distal transfer tasks, and the impact of mood on transfer performance was evaluated.

3.1.2. Material

3.1.2.1. Mood induction

Mood was manipulated by having students recall a particularly “happy and positive” or “sad and negative” life event and then having them write about it for 15 min (Abele, 1995 and Westermann et al., 1996). Earlier research (cf. Schwarz and Clore, 1983 and Schwarz and Clore, 1988) had revealed that mood induction is only successful if participants are not aware that their mood is being manipulated and hence do not focus on it. Following Schwarz (1990), mood induction was therefore introduced as an independent mock study aimed at “creating a life event inventory”. Thus, the students were told that several separate investigations were being conducted at the same time as part of a large-scale survey.

3.1.2.2. Learning task: three-disk and four-disk Tower of Hanoi (ToH)

In the learning phase, participants were confronted with a ToH with three and four disks (see, for instance, Simon, 1975). The goal was to learn to solve the tower problem so efficiently that they achieved mastery level, i.e., a high level of skill. To do so, they had to move a pyramid of variously sized disks from one peg to another. Only one disk could be transferred per move and it had to be smaller than the disk underneath it. In the instructions, it was explained that they had to solve the ToH repeatedly until they had achieved mastery level. This level was achieved if, regardless of the number of repetitions, both ToH problems were solved twice with the minimum of moves (three-disk ToH: seven moves; four-disk ToH: 15 moves).
3.1.2.3. Transfer tasks

The subsequent test phase consisted of the following three transfer tasks: a five-disk ToH, the Missionary and Cannibal Problem (MC), and the Katona Card Problem (KC).

Five-disk ToH: compared with the learning tasks, this ToH problem has just one more disk and can be solved within 31 moves. In contrast to the learning phase, the goal now was to solve the ToH problem only once in as few moves as possible. Participants were allowed to correct their moves by moving one and the same disk several times. However, they were not allowed to go back to the beginning and start the problem all over again.

In the Missionary and Cannibal Problem (MC), the goal is to get three cannibals and three missionaries across a river in a boat. The boat, however, has room for only two people and there must never be more cannibals than missionaries on either side of the river (for a more detailed description of the Missionary and Cannibal Problem, see Anderson, 1989).

The goal of the Katona Card Problem (KC, Katona, 1940) is to arrange a stack of six playing cards so that when they are dealt they appear in ascending order. When the cards are being dealt, every second card is returned to the bottom of the stack. The challenge posed by this problem is to define the sequence of the cards in the stack.

In contrast to the ToH problem, the MC and KC problems allow only one correct solution and require a specific sequence of submoves (cf. Mayer, 1992 and Opwis, 1996). The problems were considered to be correctly solved if the best solution was demonstrated without reversing any of the moves made. If the solution proposed did not lead to the prescribed goal, the participant was required to start all over again.

All three transfer tasks have in common that they can be solved by a recursive strategy in which the problems are successively broken down into smaller subproblems and hence simplified (cf. Kotovsky and Fallside, 1989 and Kotovsky et al., 1985). However, the three transfer problems differ in their surface features. With its very similar surface features, the five-disk ToH can still be described as a proximal transfer task. The Missionary and Cannibal Problem (MC) and the Katona Card Problem (KC), however, do not have any surface features in common with the ToH tasks and can therefore be described as distal transfer tasks (Andrade and Perkins, 1998, Brand et al., 2003 and Hasselhorn and Mähler, 2000).

3.1.3. Measures

3.1.3.1. Mood

The mood check consisted of asking participants to rate “How I feel right now” on four scales (“tense vs. relaxed”; “good vs. bad”; “sad vs. cheerful”; “depressed vs. happy”) ranging from 1 to 7. Afterwards, the four scales were averaged. Thus, the higher the value of the averaged scale the more positive was the mood.

3.1.3.2. Dependent variables

For the learning task, the number of attempts required for achieving mastery level was registered. For the transfer tasks, the number of moves required for the ToH problem and the number of solution attempts proposed for the MC and KC problems were recorded as dependent variables. The reason for this last variable is that both the MC and KC problems...
are what is known as well-structured problems that permit only one possible solution and require a specific sequence of submoves (Opwis, 1996). In addition, the time taken to solve the problems was recorded by the computer (ToH) or using a stopwatch (MC and KC).

3.1.4. Procedure

First, participants were asked to learn to solve the ToH problem. After this learning phase, a positive or negative mood was induced (mood factor). In the test or transfer phase, all the participants solved three transfer tasks in the same sequence, i.e., a more difficult ToH, and two structurally isomorphic tasks (MC and KC) that had different surface features from the ToH problem. All participants went through the three phases (learning phase, mood induction and transfer phase) in the same sequence. After each phase, a questionnaire in which mood was measured had to be filled out.

4. Results

4.1. Mood

Table 1 shows mood at three assessments: after the learning phase, after mood induction and after the transfer phase.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Mood induction</th>
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<tbody>
<tr>
<td></td>
<td>Positive induction</td>
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<tr>
<td></td>
<td>M</td>
</tr>
<tr>
<td>After learning phase</td>
<td>5.66</td>
</tr>
<tr>
<td>After mood induction</td>
<td>5.85</td>
</tr>
<tr>
<td>After transfer phase</td>
<td>5.98</td>
</tr>
<tr>
<td>N</td>
<td>27</td>
</tr>
</tbody>
</table>

Note. M = mean; SD = standard deviation; N = number of participants.

As expected, there were no differences before mood induction (t(52) = −0.32, ns). It should be noted that all participants showed quite a positive mood at the beginning of the experiment and that further enhancement of mood in this direction was probably difficult. Consequently, mood induction itself was only partly successful; students recalling and writing about a sad life event exhibited a more negative mood than those describing a happy event (t(52) = 5.56, p < 0.01). Thus, comparing the mood after the learning phase with that after mood induction
shows that mood deteriorated significantly in the “negative mood” experimental condition ($t(26) = 6.38, p < 0.01$), whereas the positive mood induction was found to have no significant effect ($t(26) = -1.38$, ns). After the transfer phase no further mood differences were observed ($t(52) = 1.59$, ns). To sum up, mood induction led above all to a deterioration of mood in the “negative mood” condition. Intercorrelations showed high consistencies (positive mood induction – learning to induction: $r = 0.64$; induction to transfer: $r = 0.41$; learning to transfer: $r = 0.73$; negative mood induction – learning to induction: $r = 0.41$; induction to transfer: $r = 0.20 (p > 0.1)$; learning to transfer: $r = 0.70$; all $p$ values < 0.05), confirming that mood induction was a reliable method.

### 4.2. Learning task

As expected, the two experimental conditions to which participants were randomly assigned exhibited no significant differences in performance during the learning phase (all $p$ values > 0.1). On average, participants required 6.24 (SD = 1.84) attempts before solving the three- and four-disk ToH problems with the minimum of moves (Table 2).

<table>
<thead>
<tr>
<th>Table 2. First experiment. Performance during learning and transfer phase</th>
</tr>
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<tbody>
<tr>
<td><strong>Mood induction</strong></td>
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<td><strong>M</strong></td>
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<tr>
<td>Learning phase</td>
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<tr>
<td>Attempts</td>
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<td>Moves</td>
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<td>Time to solution (s)</td>
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<td>Transfer phase</td>
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<tr>
<td>Moves to solution</td>
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<tr>
<td>Time to solution (s)</td>
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<tr>
<td>MC</td>
</tr>
<tr>
<td>Attempts at solution</td>
</tr>
<tr>
<td>Time to solution (s)</td>
</tr>
</tbody>
</table>
### 4.3. Transfer task

Table 2 gives an overview of the number of moves (ToH) and attempts (KC, CM) needed and the times required.

#### 4.3.1. Proximal task: five-disk ToH

Participants in a negative mood required significantly more disk moves to solve the five-disk ToH ($M = 67.81; SD = 23.38$) than those who had described positive life events ($M = 51.81; SD = 21.25; t(52) = −2.63, p < 0.05$). However, no significant differences in the solution time were observed ($M = 226.30; SD = 105.26$ vs. $M = 189.39; SD = 129.16; t(52) = −0.15, ns$).

#### 4.3.2. Distal task: MC problem

As Table 2 also shows, participants in a negative mood needed significantly more attempts ($t(52) = 2.09; p < 0.05$) and significantly more time to solve the MC problem ($t(52) = 2.49, p < 0.05$).

#### 4.3.3. Distal task: KC problem

Participants in a bad mood required a significantly higher number of attempts to solve the third transfer task ($t(52) = 2.21, p < 0.05$) and also required more time ($t(52) = 1.97, p < 0.1$).
When the two distal transfer tasks are aggregated, participants in a negative mood again needed significantly more attempts \((t(52) = 2.76, p < 0.01)\) and significantly more time to find the solutions \((t(52) = 2.64, p < 0.05)\).

4.4. Discussion

The method used for mood induction in this experiment, i.e., requiring participants to recall and write about a very pleasant or very unpleasant life event, was partly successful (cf. Westermann et al., 1996), and there is reason to assume that it was difficult to enhance participants’ mood, since they already displayed a fairly happy mood at the beginning of the investigation. Thus, in line with previous findings (Gasper, 2003; fourth experiment), the life event inventory method primarily brought about a deterioration of mood in the “negative mood” condition while, on the evidence of the self-reports, the description of a positive event did not significantly improve mood. As a consequence, results should be interpreted in terms of a negative compared to a more positive mood.

This first experiment showed that mood influenced the use of a previously learned problem solving strategy. This led to differences in transfer performance: a negative as opposed to a more positive mood reduced the ease with which participants grasped the logical structures inherent in the acquired skill and their application to a proximal transfer task but also to two distal transfer tasks with completely different surface features (cf. Bovair et al., 1990, Kotovsky et al., 1985, Singley and Anderson, 1989 and VanLehn, 1996). Moreover, we were able to add to the evidence of previous investigations by showing that mood not only has an effect on one-off and spontaneous decision-making, reaction times, person judgements and attitude judgements, but also on the use of a complex problem-solving strategy. Furthermore, since there was no systematic bias of knowledge acquisition prior to mood induction, differences in transfer performance could be attributed to the impact of mood. These findings therefore did not confirm theories that postulate more systematic information processing in a negative mood (cf. Clore et al., 1994, Gasper, 2003, Weary and Jacobsen, 1997 and Weary et al., 1993). If that were the case, participants in a negative mood would have been expected to need longer solution times but to require fewer disk moves and fewer solution attempts. But this was not observed and consequently, the possibility of a speed-for-accuracy trade-off is unlikely. Thus, in effect the results showed that a negative mood impaired information processing (cf. Bohner et al., 1988, Ellis and Ashbrook, 1988, Isen, 1984, Isen, 1987 and Oaksford et al., 1996). Furthermore, these results are contrary to findings which have shown that a negative mood neither speeds up nor reduces problem-solving performance (Isen et al., 1987b).

As a further important result, even though a positive mood was not entirely achieved, a less negative mood did not seem to impair cognitive processes as suggested by models such as those proposing process simplification (Chaiken, 1980, Chaiken, 1987, Petty and Cacioppo, 1986a and Petty and Cacioppo, 1986b), reduction in processing capacity (Mackie and Worth, 1989 and Oaksford et al., 1996), decline in motivation (cf. Bodenhausen et al., 1994, Bodenhausen et al., 1994 and Wegener et al., 1995), or depletion of central executive resources (Oaksford et al., 1996).

However, a great deal of research suggests that information processing when in a negative mood may occur more systematically, i.e., adhering more consistently to the data provided (cf. Clore et al., 1994 and Gasper, 2003). Therefore, it is also conceivable that individuals in a negative mood are better at actually learning how to solve a problem such as the ToH.
problem. So, what happens if learning takes place in a negative as compared with a positive mood, and if the acquired knowledge then has to be applied to transfer tasks?

5. Experiment 2

The first goal of the second experiment was to check with a sample from a new population whether, in contrast to experiment 1, mood induction for positive mood could also be successful, and what consequences might flow from a successful induction of this kind. The second aim was to check by means of a modified experimental design whether mood affected the acquisition of how to solve the ToH problem to mastery level and its subsequent application to transfer tasks.

With respect to this second aim the following assumptions were made. As shown in other studies (cf. Greene and Noice, 1988, Isen and Daubman, 1984 and Isen et al., 1987b), people in a good mood are likely to show creative and flexible thinking together with a broadening of attention (cf. Fredrickson & Branigan, 2005) and to elaborate the information presented (Abele et al., 1998). Furthermore, subjects in a positive mood exhibit flexible thinking even when they are not required to do so (Gasper, 2003). In addition, compared to controls, people in a happy mood are more able to integrate new information and to use it in subsequent decision-making (Estrada et al., 1997); they are also able to solve problems more efficiently (Isen et al., 1991). Therefore, the experiment was based on the premise that subjects in a more positive compared to a more negative mood would need less time to acquire the recursive algorithm for solving the three-disk Tower problem and would consolidate and apply it to solving the four-disk Tower problem with which they were to be immediately confronted. In short, positive mood was expected to have a favorable impact on learning.

But a contrary hypothesis is also possible. First, positive mood may suppress convergent, analytical thinking by depleting central executive resources, as has been shown for instance while solving the Tower of London problem (Oaksford et al., 1996). Second, studies (cf. Clore et al., 1994 and Gasper, 2003) have shown that subjects in a negative mood select a more elaborate, systematic and analytical approach. This is true not only of observations in the field of persuasive communication, which indicate that subjects in a sad mood are more likely than those in a good mood to agree with strong rather than weak arguments in a message (cf. Bless, Bohner, & Schwarz, 1992). It has also been observed in the context of person judgements that a negative mood is associated both with a reduction of halo effects (Sinclair & Mark, 1992) and an increase in the use of diagnostic information (cf. Weary et al., 1993), which can be understood as more systematic processing and thus a stronger focus on the details of the available data. Therefore, it is indeed conceivable that the processing of information occurs more systematically in a negative mood, and this would be expected to be very important during acquisition of a problem solving strategy. Applied to our experimental context, it was therefore also possible that participants in a negative mood would proceed more systematically, resulting in fewer repetitions to reach mastery level, and better performance to solve the transfer tasks.

Thus, by repeating the previous experiment, the aim of the second experiment was first to check whether, following the findings of experiment 1, further insights could be provided by sampling from a new population and with successful positive mood induction. The second goal was to check by means of a modified experimental design whether mood had an impact on the acquisition and transfer of a problem solving skill.
5.1. Sample, design, and materials

The study was performed with 84 subjects (45 females and 39 males) recruited from the School of Nursing (Basel). Average age was 25.53 years (SD = 6.50). The participants were randomly assigned to one of four experimental conditions (21 subjects for each condition). In a 2 × 2 design, they were subjected to induction of either a positive or a negative mood (mood factor), with the induction occurring either before or after the learning phase (position of mood induction factor). In all other respects, the tasks and procedures were identical to those in experiment 1. In the learning phase, subjects were required to learn to solve the three- and four-disk Tower of Hanoi to mastery level. In the subsequent test phase, they all had to solve the three transfer tasks described in experiment 1 in the same sequence. One male and three female subjects were excluded from the evaluation because, despite several attempts, they were unable to achieve mastery level. Consequently, the distribution of participants providing complete data was as follows: positive mood induction after learning phase and negative mood induction before learning phase: both conditions n = 20; positive mood induction before learning phase: n = 21; negative mood induction after learning phase: n = 19.

6. Results

6.1. Mood

As in experiment 1, mood induction was partially successful (see Table 3). All subjects describing a negative experience (M = 4.43; SD = 1.12) were in a more negative mood than those describing a positive experience (M = 5.60; SD = 0.91; t(78) = −5.15; p < 0.01), regardless of whether their mood had been induced before (t(39) = 3.93; p < 0.01) or after the learning phase (t(37) = 3.28; p < 0.01). Subjects whose mood had been induced before the learning phase no longer differed within the transfer phase in terms of mood (t(39) = 0.36, ns).

Table 3.

Second experiment. Mood states with mood induction after and before learning phase; the sequence of measurement time-points reflects the respective study designs

<table>
<thead>
<tr>
<th>Position of mood induction and mood</th>
<th>Mood induction</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive induction</td>
<td>Negative induction</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Mood induction after learning phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>After learning phase</td>
<td>5.26</td>
<td>1.00</td>
</tr>
<tr>
<td>After mood induction</td>
<td>5.51</td>
<td>1.08</td>
</tr>
<tr>
<td>After transfer phase</td>
<td>5.26</td>
<td>1.06</td>
</tr>
<tr>
<td>N</td>
<td>20</td>
<td>19</td>
</tr>
</tbody>
</table>
Again, however, mood induction brought about a deterioration of mood in subjects describing a negative experience ($t(19) = 5.05; p < 0.01$), while the description of a positive experience did not significantly improve mood ($t(19) = -1.48$, ns). As before, a possible reason may be the fact that participants started the investigation in a good mood which was probably difficult to improve any further. The basis of these findings is the “Mood induction after learning phase” condition, in which mood was measured immediately before and after being induced. As in experiment 1, significant differences in mood were no longer found after the transfer phase ($t(78) = 0.57$, ns). Intercorrelations showed high consistencies (positive mood induction – learning to induction: $r = 0.70$; induction to transfer: $r = 0.73$; learning to transfer: $r = 0.81$; negative mood induction – learning to induction: $r = 0.53$; induction to transfer: $r = 0.38$; learning to transfer: $r = 0.63$; all $p$ values < 0.05), underlining again that the mood induction was a reliable method.

### 6.2. Learning phase

Table 4 presents the performance data of the four experimental groups in the learning phase. As was to be expected, having been randomly assigned to the groups, the subjects in whom mood had been induced after the learning phase did not differ systematically in their baseline level, i.e., their performance in the learning phase (number of attempts, time to perform the attempts, number of moves per attempt; all $t$ values ns).

<table>
<thead>
<tr>
<th>Learning tasks</th>
<th>Mood induction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive induction</td>
</tr>
<tr>
<td>Learning tasks</td>
<td></td>
</tr>
</tbody>
</table>
Mood induction after learning phase
ToH with three and four disks
<table>
<thead>
<tr>
<th></th>
<th>$M$</th>
<th>SD</th>
<th>$M$</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attempts</td>
<td>5.35</td>
<td>2.08</td>
<td>6.21</td>
<td>1.48</td>
</tr>
<tr>
<td>Moves</td>
<td>96.96</td>
<td>55.69</td>
<td>118.19</td>
<td>38.19</td>
</tr>
<tr>
<td>Time to solution (s)</td>
<td>357.29</td>
<td>251.32</td>
<td>477.98</td>
<td>281.10</td>
</tr>
</tbody>
</table>

Mood induction before learning phase
ToH with three and four disks
<table>
<thead>
<tr>
<th></th>
<th>$M$</th>
<th>SD</th>
<th>$M$</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attempts</td>
<td>5.48</td>
<td>1.47</td>
<td>7.30</td>
<td>1.72</td>
</tr>
<tr>
<td>Moves</td>
<td>102.20</td>
<td>40.10</td>
<td>157.52</td>
<td>65.88</td>
</tr>
<tr>
<td>Time to solution (s)</td>
<td>373.32</td>
<td>191.40</td>
<td>662.53</td>
<td>371.58</td>
</tr>
<tr>
<td>$N$</td>
<td>21</td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. $M$ = mean; SD = standard deviation; $N$ = number of participants.

ToH = Tower of Hanoi.

Information on the effects of mood during the learning phase is provided by the experimental condition in which mood was induced before the learning phase. This group exhibited significant mood-dependent differences in performance: subjects in a more negative mood required more attempts to reach mastery level ($t(39) = 3.66, p < 0.01$) than those in a more positive mood. Their solutions required more moves ($t(39) = 3.26, p < 0.01$) and they needed more time to reach mastery level ($t(39) = 3.16, p < 0.01$).

6.3. Transfer phase

In a further step, the question of whether the mood induced (mood induction factor) or the timing of mood induction (position factor) had an effect on the three transfer tasks was also investigated (see mean values in Table 5).

Table 5.

Second experiment. Performance during transfer phase with mood induction after and before learning phase

<table>
<thead>
<tr>
<th>Position of mood induction and transfer tasks</th>
<th>Mood induction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive induction</td>
</tr>
<tr>
<td></td>
<td>$M$</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----</td>
</tr>
<tr>
<td><strong>Mood induction after learning phase</strong></td>
<td></td>
</tr>
<tr>
<td><strong>ToH</strong></td>
<td></td>
</tr>
<tr>
<td>Moves to solution</td>
<td>52.75</td>
</tr>
<tr>
<td>Time to solution (s)</td>
<td>162.31</td>
</tr>
<tr>
<td><strong>MC</strong></td>
<td></td>
</tr>
<tr>
<td>Attempts at solution</td>
<td>1.30</td>
</tr>
<tr>
<td>Time to solution (s)</td>
<td>304.80</td>
</tr>
<tr>
<td><strong>KC</strong></td>
<td></td>
</tr>
<tr>
<td>Attempts at solution</td>
<td>1.65</td>
</tr>
<tr>
<td>Time to solution (s)</td>
<td>334.90</td>
</tr>
<tr>
<td><strong>MC + KC</strong></td>
<td></td>
</tr>
<tr>
<td>Attempts at solution</td>
<td>2.95</td>
</tr>
<tr>
<td>Time to solution (s)</td>
<td>639.70</td>
</tr>
<tr>
<td><strong>Mood induction before learning phase</strong></td>
<td></td>
</tr>
<tr>
<td><strong>ToH</strong></td>
<td></td>
</tr>
<tr>
<td>Moves to solution</td>
<td>54.71</td>
</tr>
<tr>
<td>Time to solution (s)</td>
<td>182.07</td>
</tr>
<tr>
<td><strong>MC</strong></td>
<td></td>
</tr>
<tr>
<td>Attempts at solution</td>
<td>1.43</td>
</tr>
<tr>
<td>Time to solution (s)</td>
<td>315.95</td>
</tr>
<tr>
<td><strong>KC</strong></td>
<td></td>
</tr>
<tr>
<td>Attempts at solution</td>
<td>1.62</td>
</tr>
<tr>
<td>Time to solution (s)</td>
<td>270.00</td>
</tr>
<tr>
<td><strong>MC + KC</strong></td>
<td></td>
</tr>
<tr>
<td>Attempts at solution</td>
<td>3.04</td>
</tr>
<tr>
<td>Time to solution (s)</td>
<td>585.95</td>
</tr>
<tr>
<td>$N$</td>
<td>21</td>
</tr>
</tbody>
</table>
To make this comparison, two-way ANOVAs with the corresponding measurement parameters of the tasks were calculated as dependent variables.

6.3.1. Proximal task: five-disk ToH

As can be seen in Table 5, a negative as opposed to a more positive mood increased the number of disk moves (mood induction factor: $F(1, 76) = 13.39, p < 0.01$; position factor: $F(1, 76) = 0.33, ns$; interaction: $F(1, 76) = 0.02, ns$). As the lack of interaction suggests, these effects of mood were independent of whether mood had been induced before ($t(39) = 2.57, p < 0.05$) or after the learning phase ($t(37) = 2.63, p < 0.05$). Likewise, subjects in a negative as opposed to a more positive mood also took significantly more time to solve the problem (mood induction factor: $F(1, 76) = 12.30, p < 0.001$; position factor: $F(1, 76) = 1.54, ns$; interaction: $F(1, 76) = 0.21, ns$). This was also the case when mood induction effects were examined separately in terms of timing; mood induction after the learning phase: $t(37) = 2.60, p < 0.05$; mood induction before the learning phase: $t(39) = 2.57, p < 0.05$.

6.3.2. Distal task: Missionary and Cannibal Problem (MC)

A similar pattern of differences was found in the first distal transfer task: subjects in a negative mood required significantly more attempts to solve the Missionary and Cannibal Problem (mood factor: $F(1, 76) = 14.83, p < 0.001$; position factor: $F(1, 76) = 0.04, ns$; interaction: $F(1, 76) = 0.25, ns$). Again, this effect was independent of whether mood had been induced before or after the learning phase (mood induction after the learning phase: $t(37) = 3.82, p < 0.001$; mood induction before the learning phase: $t(39) = 2.07, p = 0.05$). These differences were also found in the required time. Subjects in a negative mood took more time to solve the Missionary and Cannibal Problem (mood factor: $F(1, 76) = 10.73, p < 0.01$; position factor: $F(1, 76) = 0.006, ns$; interaction: $F(1, 76) = 0.03, ns$). This was also the case when mood induction effects were examined separately by timing (mood induction after the learning phase: $t(37) = 2.57, p < 0.05$; mood induction before the learning phase: $t(39) = 2.10, p = 0.05$).

6.3.3. Distal task: Katona Card Problem (KC)

Subjects recalling sad life events needed more attempts than those recalling happy ones at solving the Katona Card Problem (mood factor: $F(1, 76) = 23.97, p < 0.001$; position factor: $F(1, 76) = 0.24, ns$; interaction: $F(1, 76) = 0.38, ns$). This was also the case when the mood induction effect was examined separately by timing (mood induction after the learning phase: $t(37) = 3.16, p < 0.01$; mood induction before the learning phase: $t(39) = 3.77, p < 0.001$). As can be seen in Table 5, subjects in a negative mood took more time to solve the Katona Card Problem (mood factor: $F(1, 76) = 8.24, p < 0.001$; position factor: $F(1, 76) = 0.003, ns$; interaction: $F(1, 76) = 2.27, ns$). While sad subjects with mood induction after the learning phase had a higher mean than those with mood induction before the learning phase this difference was not statistically significant ($M = 380.47$ (SD = 189.58) vs. $M = 334.90$ (SD = 156.86); $t(37) = 0.82, ns$). However, subjects in a negative mood with induction...
before the learning phase did require significantly more time to solve the card problem ($M = 441.10$ (SD = 195.37) vs. $M = 270.00$ (SD = 126.80); $t(39) = −3.34, p < 0.01$).

When the findings for the two distal transfer tasks are aggregated, participants describing negative life events needed more attempts at solving the two distal transfer tasks (mood induction factor: $F(1, 76) = 33.06, p < 0.001$; position factor: $F(1, 76) = 0.22$, ns; interaction: $F(1, 76) = 0.03$, ns), independently of the timing of mood induction (mood induction after the learning phase: $t(37) = −4.84, p < 0.001$; mood induction before the learning phase: $t(39) = −4.67, p < 0.001$). The identical picture was found for solution time: mood factor: $F(1, 76) = 16.02, p < 0.001$; position factor: $F(1, 76) = 0.00$, ns; interaction: $F(1, 76) = 0.75$, ns; mood induction after the learning phase: $t(37) = −2.36, p < 0.05$; mood induction before the learning phase: $t(39) = −3.28, p < 0.01$.

6.4. Discussion

The results of experiment 1 were confirmed in two ways. First, again the life event inventory method primarily produced a deterioration of mood in the “negative mood” condition; the description of a positive event did not significantly improve mood (cf. Gasper, 2003; fourth experiment). Second, negative mood significantly reduced transfer effects.

The results from this second study are generally clear. They indicate that a sad as opposed to a happy mood reduces transfer performance, regardless of the population sampled and regardless of when mood is induced. The latter findings are in line with Isbell (2003) who found differences in information processing as a function of specific mood, but regardless of the time of presentation.

Additionally, and consistent with Ellis and Ashbrook (1988) and others but in contrast to some previous findings (cf. Bless et al., 1992, Clore et al., 1994, Gasper, 2003, Sinclair and Mark, 1992 and Weary et al., 1993), we found that subjects in a negative mood did not show more systematic and analytical information processing though they did require more attempts, more disk moves and more time to achieve mastery level in solving the learning tasks. These differences also had implications for the subsequent transfer phase, where differences in mood were no longer observed; a negative mood impaired the solution of the subsequent proximal and distal transfer tasks. Although once again positive mood induction was not successful, there is reason to suggest that a more positive mood does not impair information processing, contrary to the findings of other studies (cf. Bodenhausen et al., 1994, Bodenhausen et al., 1994, Chaiken, 1980, Chaiken, 1987, Mackie and Worth, 1989, Oaksford et al., 1996, Petty and Cacioppo, 1986a, Petty and Cacioppo, 1986b and Wegener et al., 1995).

7. General discussion

A great deal of research suggests that cognitions, just like judgements and memory retrieval, may be influenced by mood. With our two experiments we were able to show that a negative as compared to a more positive mood significantly reduces transfer performance as well the acquisition of a problem solving algorithm.

As observed in previous studies (cf. Gasper, 2003), however, mood induction for positive mood was difficult to achieve, which led us to focus on the impact of a negative mood compared to a more positive mood.
Findings from the first experiment showed that a negative in contrast to a more positive mood impaired transfer performance not only for problems with very similar surface features, but also in those with completely dissimilar surface features (cf. Bovair et al., 1990, Singley and Anderson, 1989 and VanLehn, 1996). Thus, a negative mood clearly reduced transfer effects; i.e., subjects remembering sad life events were less able to use the recursive strategy inherent in all three transfer tasks and thus to exploit the compatibility of operators and algorithms (cf. Kotovsky and Fallside, 1989 and Kotovsky et al., 1985).

These effects were also observed in the second study in which we sampled from a completely new population. Furthermore, a negative mood was associated with greater difficulty in acquiring a solution of the ToH problem, while this also resulted in an unfavorable impact on transfer tasks.

It could, however, be objected that in the second study the participants, depending on the mood induced, did not acquire the mastery level at all but just learned to solve the ToH tasks superficially. Effectively, the study design and the results did not allow for insight into participants' cognitive processes; i.e. it remains unclear whether participants really developed a long-term problem-solving strategy. Nevertheless, participants in a happier mood needed fewer repetitions and less time to achieve the mastery level; i.e., learning how to solve the ToH problem, which in turn also had a positive impact on transfer tasks. These findings tally with the assumption that positive mood facilitates integration of new information (Estrada et al., 1997), and more elaboration of information available (Abele et al., 1998), probably due to a broadening of attention (cf. Fredrickson & Branigan, 2005). In addition, results were in line with findings indicating that a positive mood generally leads to enhanced performance with respect to different kind of tasks (for overview, see Abele, 1995). Furthermore, the poor knowledge transfer performance observed under negative mood conditions in both studies did, in our opinion, not confirm the hypothesis that a negative mood enables a more systematic and more analytical procedure (cf. Bless et al., 1992, Clore et al., 1994, Gasper, 2003, Sinclair and Mark, 1992 and Weary et al., 1993), nor were the findings consistent with the affect-as-information model (cf. Bless, 2001, Gasper, 2003, Isbell, 2003, Schwarz, 1990, Schwarz and Clore, 1983 and Schwarz and Clore, 1988). In the same vein, results were not congruent with concepts that associate a positive mood with a simplification of cognitive processes (Chaiken, 1980, Chaiken, 1987, Petty and Cacioppo, 1986a and Petty and Cacioppo, 1986b), a reduction in processing capacity (Mackie & Worth, 1989), a decline in motivation (cf. Bodenhausen et al., 1994, Bodenhausen et al., 1994 and Wegener et al., 1995) or a depletion of central executive resources (Oaksford et al., 1996).

How can we explain impaired cognitive performance consequent upon negative mood? Since subjects in a negative mood were less able to grasp the logical structures inherent in all transfer tasks, did they just have less confidence that the strategy they had learned would work, or are there grounds for thinking that these subjects perceived the transfer tasks as completely new and disconnected tasks? Assuming that, as a rule, problem solving can be broken down into four structural steps (cf. Davidson, Deuser, & Sternberg, 1994) – first, identification of the problem (Newell & Simon, 1972), second, mental representation of the problem (Hayes, 1981), third, procedural planning in terms of algorithms and heuristics, and fourth, continuous evaluation of the procedure being used (Chi, Bassok, Lewis, Reimann, & Glaser, 1989) – then it may be stated that cognitive capacities should be used for task-relevant processes. Therefore, the unfavorable impact of a negative mood may be explained in terms of a decrease in cognitive resources as proposed in the resource allocation model (Ellis & Ashbrook, 1988), or depletion of central executive processes (Oaksford et al., 1996), or
because subjects in a bad mood are more concerned with finding out why they are in this
specific mood state (Bohner et al., 1988). In this last case, trying to regain a better mood
(“mood repair”; Isen, 1984 and Isen, 1987) would lead to cognitive capacity being divided
between the task and mood correction. The study design and the results are not able to shed
light on which of these four hypotheses offers the most appropriate explanation. However,
since subjects in a bad mood after the transfer phase had remained in a mood similar to the
mood they were in at the beginning of the investigation, there is reason to suppose that
cognitive resources were redirected to “mood repair” and to task-irrelevant cognition,
respectively. But why change a bad mood? Simply because it is inherently unpleasant.

What implication has this for learning contexts? We can conclude that, in addition to the
influence of strong emotions such as fear, anxiety, and severe dejection on cognitive
performance, mood also has an impact on the success of learning and transfer. In our opinion,
this is particularly important because, although for instance a reasonable classroom
management tries to avoid the occurrence of negative feelings, learners cannot avoid being
and working continuously in a diffuse background state of mind. Thus, even subtle negative
feedback or, in some circumstances the mere expectation of disappointment, can reduce
development and transfer of knowledge. Our findings suggest that a negative mood has
effects not only in terms of transfer of knowledge to new contexts, but also in terms of
learning and performance when knowledge needs first to be acquired and then applied to new
situations.

By way of qualification, it should be emphasized that determining the complex interaction
between mood and cognitive performance continues to be a methodological and theoretical
challenge. But, our experiments suggest that a negative mood does necessarily not lead to
more systematic information processing, and a more positive mood does not seem to impair
cognitive performance.

Future studies might consider whether the measurement of mood can avoid possible ceiling
effects with appropriately constructed mood assessment scales and also whether mood
triggers knowledge transfer in problem-solving contexts different from the context we have
considered here. It would also be particularly interesting to determine whether mood
influences the dyadic learning and problem-solving contexts frequently encountered in
educational settings.

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