Mood Effects on Memory and Executive Control in a Real-Life Situation

Prune Lagner[1], Matthias Kliegel[1], Louise H. Phillips[2], Andreas Ihle[1], Alexandra Hering[1], Nicola Ballhausen[1]& Katharina M. Schnitzspahn[1]

[1]University of Geneva

[2]University of Aberdeen

- Brief Report -

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Correspondence concerning this article should be addressed to Katharina Schnitzspahn, Faculté de psychologie et des sciences de l'éducation, Université de Genève, Boulevard du Pont d'Arve 40, CH-1211 Genève. E-Mail: Katharina.Schnitzspahn@unige.ch

Abstract

In the laboratory, studies have shown an inconsistent pattern of whether and how mood may affect cognitive functions indicating both mood-related enhancement as well as decline. Surprisingly, little is known on whether there are similar effects in everyday life. Hence, the present study aimed to investigate possible mood effects on memory and executive control in a real-life situation. Mood effects were examined in the context of winning in a sports competition. Sixty-one male handball players were tested with an extensive cognitive test battery (comprising memory and executive control) both after winning a match and after training as neutral baseline. Mood differed significantly between the two testing situations, while physiological arousal and motivation were comparable. Results showed lowered performance after the win compared with training in selected cognitive measures. Specifically, short term and episodic memory performance was poorer following a win, whereas executive control performance was unaffected by condition. Differences in memory disappeared when emotional states after the match were entered as covariates into the initial analyses. Thus, findings suggest mood-related impairments in memory, but not executive control processes after a positive real-life event.

Keywords: mood, emotion, memory, executive control

Mood Effects on Memory and Executive Control in a Real-Life Situation

Mood is a relatively long lasting affective state which occurs in response to many everyday experiences such as success or failure in the pursuit of personal goals (Lazarus, 1991). Although one might easily say “I was in such a bad mood that I forgot your birthday”, the effects of emotional states on cognitive performance such as on memory or executive control processes are still unclear; especially in everyday life.

To study mood effects on cognition in non-clinical populations, so far, most studies have experimentally induced mood states in the laboratory and afterwards assessed cognitive performance (Mitchell & Phillips, 2007). The findings differ substantially depending on the mood induced and the cognitive tasks applied. When considering episodic memory and learning, results mainly suggest that mood appears to impair performance. If the mood induction occurred before the learning phase, participants showed reduced encoding or needed more repetitions for reaching a criterion level (Brand, Reimer, & Opwis, 2007). In general, episodic memory tasks using neutral stimuli material showed worse recall performance when participants were in a sad or happy compared to a neutral mood (Seibert & Ellis, 1991).

While these results suggest a general deficit in basic memory processes under experimentally induced sad and happy mood in non-clinical samples, studies targeting executive control processes revealed a more mixed pattern. For instance, studies conducted on planning showed impaired performance under positive mood compared to neutral mood (Oaksford, Morris, Grainger, & Williams, 1996; Phillips, Smith, & Gilhooly, 2002), but no sad mood effects in young adults (Phillips et al., 2002). In contrast studies examining mood effects on verbal fluency generally show greater word production in happy mood states. For example Bartolic, Basso, Schefft, Glauser, and Titanic-Schefft(1999) showed that positive mood coincided with better verbal than figural fluency. Phillips, Bull, Adams, and Fraser (2002) found that positive mood was related to better performance on a letter fluency task (though there was no overall effect of happy mood compared to neutral on this task). A similar association between positive mood and verbal fluency was reported by Carvalho and Ready (2010).

The effects of mood on prospective memory, a cognitive task requiring memory but mainly depending on executive control processes (Schnitzspahn, Stahl, Zeintl, Kaller, & Kliegel, 2013), has also recently been addressed. Kliegel et al. (2005) found that performance on a time-based prospective memory task (i.e., remembering to do something at a certain time) was impaired under sad mood compared to neutral mood. However, Rummel, Hepp, Klein and Silberleitner (2012) observed that participants showed better performance in an event-based prospective memory task (i.e., remembering to do something after the recognition of an external cue in the environment) under sad mood. Yet, prospective memory was found to be impaired under positive mood.

While the studies reported above focused on the effect of mood on one or two single cognitive abilities per study, Chepenik, Cornew and Farah (2007) tested the effect of sad mood on an array of tests within the same participants (i.e., working memory, cognitive control, recognition of emotional facial expressions and memory for emotional words). Sad mood did not affect performance on any of the executive function tasks or overall word recognition or recall. However, sad mood caused better recognition of negative words and poorer facial emotion recognition. The authors conclude that mood was significantly more influential on some tasks than others.

Thus, taken together, the pattern of results tends to be inconsistent and appears to be partly dependent on the cognitive construct that is being measured and the valence of the experienced mood. Specifically, sad mood seems to impair memory, but not executive functioning. Studies on positive mood effects suggest that memory and some kinds of executive functions like planning are impaired, while performance in other tasks like fluency improves under positive mood.

Most of these studies rely on lab-based mood manipulations and measurement. Few previous studies investigate mood-related effects on cognition in everyday life in non-clinical samples. Riediger, Wrzus, Schmiedek, Wagner, and Lindenberger (2011) assessed the correlations between positive and negative affect and working memory performance over six occasions per day on nine days with the help of mobile phones. Low intensity positive and negative affect was associated with enhanced working memory, while high intensity positive and negative affect was associated with impaired working memory. Another study, focusing on negative affect only (Brose, Schmiedek, Lövdén, & Lindenberger, 2012), confirmed that daily levels of negative affect predicted less accurate working memory performance.

While these studies nicely show initial evidence of a relation between everyday mood and working memory they only test a single cognitive ability and are correlative in nature focusing on the effects of relatively mild daily fluctuations in mood. It is important to also investigate the effects on cognition of strong mood changes after an emotionally meaningful event, particularly given that emotional intensity may influence the direction of these cognition-emotion relationships (Riediger et al., 2011). It was therefore the aim of the present study to test how intense mood states following an emotionally meaningful event in everyday life influence cognition and memory using a quasi-experimental design. Such an approach allows a closer comparison of the findings in an everyday environment with the results of lab-based studies, as both examine the effects of acute mood states directly after an emotional situation was experienced. The present approach has the advantage of a higher ecological validity, because the mood changes are caused by a real life situation and not by experimenter chosen mood induction material.

As a real-life situation provoking emotions we chose sports competitions. The sport context appears to be an attractive setting for present purposes because sport competitions involve intense emotional states related to a success (positive mood) or a defeat (negative mood) in a real-life situation. Male amateur handball players were tested twice, once after training and once after a match. The testing after the training was considered as the neutral baseline condition with comparable physical characteristics but lacking the competitive element and therefore the related emotions of the match condition.

While former everyday mood and cognition studies generally addressed a single cognitive ability as dependent variable, the present study assessed performance in a range of tasks measuring memory and executive control processes. Thus, the present study is also of conceptual importance as it can determine the specificity of the effect the same everyday mood event has on cognitive performance. A further aim was to determine the extent to which any effects of testing condition (training versus match) was related to differences in measured mood, physiological arousal, or motivational factors.

Method

Participants and Design

80 male handball players (*M age* = 31.63 years, *SD* = 8.63) who belonged to the first handball district league of Dresden (Germany) were tested twice. Players came from seven out of the ten listed teams hence covering the entire spectrum of the league. Inclusion criteria were German as a native language, no psychiatric disorders or recent alcohol or drug consumption. Each participating team received 50 € monetary compensation. As it happened, five out of the seven tested teams won their competitive match, while only one team lost (*n* =

9) and one team played for a draw (*n* = 10). Thus, we decided to compare only positive (winning) and neutral (training) mood effects in the present study. Accordingly, all following analyses are based on the within-person comparisons with players from the winning teams (*N* = 61; *M age* = 30.46 years, *SD* = 8.29).

The study followed a repeated measures design. All participants were tested twice, once after a training (neutral control condition) and once after a winning match (positive mood condition), in counterbalanced order. As dependant variables served measures of episodic memory, short-term memory, prospective memory, verbal fluency, and cognitive flexibility. All cognitive constructs were measured at both testing sessions using parallel test versions of comparable difficulty.[1]The same parallel versions were always used in the match as compared to the training condition in a fixed task order.

Materials

Mood assessment. To measure the affective state of the participants, the affective state subscale of the Self-assessment manikin scale (SAM; Bradley & Lang, 1994) was used. The SAM is a non-verbal pictorial assessment using a 9-point-Likert scale to directly measure a person's affective state at a particular point in time. Low values on the affective state scale represent a positive mood, while high values stand for a negative mood.

Physiological arousal assessment. To control for possible differences in physiological arousal between the testing situations (i.e., match vs. training), systolic blood pressure was assessed with a monitor watch (Sanitas). This measurement was always taken while answering a SAM, so that the subjective mood ratings and arousal measures were performed at the same time points.

Cognitive test battery

Episodic memory (short delay). A face-to-face version of the verbal episodic memory task from the Cognitive Telephone Screening Instrument (COGTEL; Kliegel, Martin, & Jäger, 2007) was used in two versions (A and B). In both versions, eight word pairs were presented for one minute. Participants were asked to memorize all word pairs for later recall. After 20 minutes, participants were shown the first words of all pairs in random order and they were asked to recall the corresponding word which they had learned previously. The minimum score was zero (no correct recall) and the maximum score was eight (for eight words recalled correctly).

Episodic memory task (long delay). The same task but with different material was administered using a longer delay. Here, the word pairs were presented before training/match and recall occurred after the training/match. Thus, the delay varied from 75 to 105 minutes.

Numerical short-term memory task. An adapted version from the digit backward-span test from the Wechsler Adult Intelligence Scale-Revised (WAIS-R) was used to assess short-term memory storage. The experimenter read out loud lists of digits and the participants' task was to immediately repeat the digits in the reverse order. Lists of two to seven digits were presented. Each list length was presented twice. Participants received one point for each correctly recalled list (maximum: 12).

Visuo-spatial short-term memory task. Visuo-spatial short-term memory was assessed with a revised task from the Wechsler Memory Scale-Revised (WMS-R). Specifically, participants had to learn particular patterns and to recognize them among distractors after a short delay. Participants received one point for each correctly identified pattern (maximum score: 10).

Prospective memory task (short delay). This task was adapted from Chasteen, Park and Schwarz (2001). At the beginning of cognitive testing, participants were asked to remember to add either the page number or the date on each page of the booklet while working on the cognitive test battery. Participants received one point for each correctly fulfilled intention (maximum score: 23).

Prospective memory task (long delay). This task was adapted from the COGTEL. Here participants were asked before the match/ training to remember to write down their place or date of birth underneath the instruction for flexibility specific task. Participants received two points for correctly performing the task at the right moment, one point for being late (i.e., writing down the right information on a wrong page) and zero points in case of non-fulfilment.

Verbal fluency task. The task used to measure verbal fluency was again based on the COGTEL. Participants had to write down as many words as possible beginning with a given letter during one minute with one of two letters, either “A” or “K”. Participants received one point for each correct answer and were informed that they would not receive any points for repetitions and names.

Cognitive flexibility task. To assess cognitive flexibility, participants were asked to perform an adapted version of the fluency task described above. Specifically, they were asked to write down two words from one category (job titles or plants) in turn with two words from another category (furniture or body parts) for one minute. Participants received one point for each correct answer and were informed that they would not receive any points for repetitions and names.

Procedure

The testing took place in the locker room. The first part was done 30 minutes before the training / match and lasted 15 minutes. After filling out the consent forms and a socio-demographic questionnaire, the testing booklets were distributed and general instructions were provided (e.g., it was forbidden to turn back pages). In addition, the monitor watches were handed out with instructions how to use them. The affective state was measured for the first time with the SAM and participants assessed their blood pressure. Participants learned the first list of word-pairs for the episodic memory task (long delay). Finally, instructions regarding the first prospective memory task (long delay) were given. This part was followed by the match or the training session. Immediately after the training / match the testing continued with a second mood and blood pressure assessment. Then, instructions for the second prospective memory task (short delay) were provided. Participants were subsequently asked to recall the words belonging to the list learned before the training / match, before the verbal fluency task was administered. After that the second list of word pairs had to be memorized, followed by the third mood measurement (i.e., SAM and blood pressure measures). Participants then performed the numerical and the visual-spatial short-term memory tasks, followed by the cognitive flexibility task. Finally, they were asked to recall the second list of word pairs, followed by the last mood assessment. After the cognitive testing, the participants were asked to fill in a brief questionnaire assessing their motivation to work on the cognitive tasks, their interest in the study and perceived task difficulty with the help of 4-point-Likert scales. Finally, they were asked to evaluate their own performance during match/ training measured against their personal best performance (equals 100 %) in percentage terms from 0-100 %.

Results

Mood effects

The subjective mood ratings were submitted to a 2 x 4 ANOVA with condition (match vs. training) and mood measurement time-point as within-subject factors. There were main effects of condition, $F(1,180) = 30.48$, $p < .001$, $\eta^2 = .34$, mood measurement time-point,

$F(3,180) = 13.20$, $p < .001$, $\eta^2 = .18$, as well as a significant interaction, $F(3,180) = 11.86$, $p < .001$, $\eta^2 = .17$. As expected, the reported mood was more positive after the won match than after the training (see Figure 1). Under both conditions, mood worsened during the cognitive testing. However, the mood remained significantly more positive after the match than after the training at all measurement time-points, all *p*s<001.

Cognitive performance

Performance in all cognitive tasks after the match and after the training was compared with separate repeated-measures ANOVAs. While performance in the memory tasks was significantly impaired after the match compared with performance after the training, performance in tasks requiring executive control processes (prospective memory and fluency tasks) was comparable under both conditions (see Table 1 for all results).

To further explore if the effects of condition were related to positive mood levels, mood was entered as a covariate in the analyses. Specifically, the second mood measurement at the beginning of cognitive testing was entered as a covariate for tasks performed first (i.e., prospective memory short delay, episodic memory long delay, fluency), while the third mood measurement during the testing session was used for the analyses on subsequent tasks (i.e., both short-term memory tasks, cognitive flexibility, prospective memory long delay and episodic memory short delay). The ANCOVAs showed that covarying mood markedly reduced the condition effect by 84 % for episodic memory long delay, 63 % in the numerical short-term memory task and by 85 % in episodic memory short delay, no longer reaching significance in all three cases (for the *F* values and effect sizes, see Table 1) suggesting that group differences could be explained by mood (cf. Baron & Kenny, 1986).

Control measures

To ensure that the match and the training condition were generally comparable regarding physical arousal (systolic blood pressure), motivational variables and well-being, several control measures were assessed during the testing. A repeated-measures ANOVA showed that systolic blood pressure was not significantly affected by the testing condition (i.e. match vs. training), $F(1,60) = 3.17$, $p > .05$. Furthermore, there was no significant interaction between condition and measurement time-point, $F(3,180) = 1.51$, $p > .05$. However, there was a significant effect of measurement time-point, $F(3,180) = 4.61$, $p = .004$, $\eta^2 = .07$, as systolic blood pressure was higher after physical activity (whether match or training) than before.

Training and match duration did not differ significantly (t (61) = .25, $p > .05$) and the players reported comparable subjective health before both testing sessions, t (61) = .17, $p > .05$. The players reported that they put up similar percentages of their personal best performance during match and training, t (61) = -1.13, $p > .05$. Furthermore, they were equally motivated, t (61) = .22, $p > .05$ and interested, t (61) = .77, $p > .05$ to work on the cognitive tasks and assessed the tasks as similarly difficult, t (61) = .00, $p > .05$ and similarly important, t (61) = 1.10, $p > .05$.

Discussion

The aim of the present study was to investigate the impact of an acute real-life mood state on cognitive functioning. Findings suggest task-dependent mood effects. Specifically, performance in tasks assessing basic memory processes was impaired after the match compared to the training condition, whereas performance in tasks measuring cognitive control processes remained stable. When mood was entered as a covariate, condition effects were no longer significant. Thus, cognitive performance differences between the two testing conditions (i.e., training versus match) seem to be mediated by the more positive mood states reported after a winning match compared with training.

Our findings have several important implications. They corroborate studies which were conducted in the laboratory reporting impaired performance in memory under positive mood (Seibert & Ellis, 1991). Executive control processes were not influenced by positive mood, which is in contrast with laboratory studies showing that positive mood may impair executive functioning (Mitchell & Phillips, 2007). However, on closer inspection, results in this research area are very heterogeneous. It has also been reported that positive mood did not influence or even enhanced fluency in some tasks (Phillips, Bull, et al., 2002) which is in accordance with the stable fluency performance observed in the current field study. Furthermore, it has been shown that positive mood can facilitate task switching in tasks where novelty in stimulus or response is a major feature (Dreisbach & Goschke, 2004). This was the case in the task measuring cognitive flexibility in the present study (i.e., generating new words). For prospective memory, Rummel et al. (2012) only found impaired execution of delayed intentions under positive compared to negative mood, but not compared to neutral mood. Thus, this effect was partly caused by improved performance under negative mood and might explain why we did not find mood effects on prospective remembering in the current study as we only compared neutral and positive mood effects.

Several conceptual approaches have been developed to explain how mood influences cognitive processing. For example, it could be argued that physiological arousal could be an important factor in explaining mood effects – however the current evidence does not support this argument as the neutral and positive mood groups did not differ in arousal. Capacity theories (Seibert & Ellis, 1991) propose that positive and negative mood states lead to mood relevant but task-irrelevant thoughts resulting in decreased cognitive capacity to work on any highly resource-intensive cognitive tasks. On the contrary, Isen (1999) argues that positive mood mostly facilitates efficient and careful thinking and problem solving by promoting flexibility and innovation. These theories cannot explain the dissociation between positive mood effects on memory and executive control obtained in the present study. More suitable to explain differential effects of positive mood on cognitive performance may be motivational approaches. For example, it has been argued that positive mood tends to result in a more heuristic processing style compared to neutral mood (Park & Banaji, 2000). Related theories suggest that positive mood tends to result in a broader range of thought-action repertoires, while negative mood narrows the available action tendencies (Frederickson & Branigan, 2005). According to these approaches, mood states might have enhancing as well as impairing effects on cognitive performance depending on the specific task requirements. Thus, the impairing effects of positive mood on episodic and short-term memory found in the present study could be caused by failure to sufficiently focus on encoding and retrieval. On the contrary, the current fluency and cognitive flexibility tasks both required flexible problem solving for which a heuristic processing style is probably helpful. Furthermore, while tasks measuring basic memory processes are mostly mediated by the medial temporal lobes (Nyberg, McIntosh, Houle, Nilsson, & Tulving, 1996), executive control processes are mostly supported by the prefrontal cortex (Lezak, 1995). Thus, the differential mood effects found in the two cognitive domains tested in the present study (i.e., memory and executive control) can maybe also be explained by the different underlying brain structures and their responsiveness towards positive mood. Further studies are needed to directly test this hypothesis.

One possible limitation of the present study is that the tasks assessing executive control processes and prospective memory were relatively easy paper and pencil tests. Other tasks assessing more specific cognitive constructs (e.g., inhibition, updating) or being more resource-intensive might influence the nature of mood effects.

Another methodological limitation concerns the counterbalancing of materials used in the different cognitive tasks. All participants performed the tasks on the same materials in the match condition, with parallel materials in the training condition. Therefore we cannot completely rule out the possibility that differences between our task materials could have affected the present findings. However, it seems unlikely that the two conditions were systematically associated with more or less difficult task versions assessing the same cognitive construct, as established parallel tests of comparable difficulty were used. In addition, the finding that performance differences between the two testing situations found in the memory tasks were no longer significant when mood was entered as a covariate in the analyses speaks further against the assumption that performance differences were caused by task and not mood effects. Another possible issue related to the counterbalancing concerns order effects within the cognitive test battery as the tasks were always presented in the same order. We acknowledge that a fully counterbalanced design would have been desirable. However, importantly, the cognitive tasks measuring memory and cognitive control were presented in an alternating order. Thus, missing mood effects in the tasks measuring executive functioning cannot be explained by the fact that they were performed at the end of the testing session when the positive mood already decreased. Similarly, detrimental mood effects on memory performance were not limited to the tasks that had to be performed first.

Given that the large majority of teams included in the current study won the match after which the testing took place, we could only compare neutral and positive mood effects with each other. Further studies are needed to explore possible effects of negative real-life events on subsequent cognitive performance in order to examine whether results found in the laboratory also hold true for negative mood effects on cognitive functioning in everyday life. The field situation makes it difficult to ensure that change in mood is the major difference between the training and the match condition. However, the ANCOVA results suggest that differences found in the memory tasks after the match compared with the training condition were mediated by measured mood in the two conditions. Furthermore, possible influencing factors like physiological arousal, subjective effort, motivation, evaluation of the cognitive testing and general well-being were assessed during both testing sessions and did not differ between training and match. Thus, we conclude that both conditions were comparable regarding important situational and individual factors which might be associated with cognitive performance.

In sum, the present results suggest that a sports match with the emotional states related to a win or a loss offers an appropriate environment to test how naturally occurring mood influences cognitive performance in a real-life setting. Our results validate and extend former findings reported in lab-based studies suggesting that positive mood impairs basic memory performance, but not performance in executive control tasks.

Footnotes

[1]Reanalyzing the data set from Kliegel et al. (2007) confirmed equal difficulty of the two test versions A and B used in the present study. Specifically, face-to-face performance from 81 young adults performing either version A or version B did not differ for any of the tasks (all ps> .147).

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Table 1.

Mean performance scores for each cognitive task as a function of testing condition (training vs. match) as well as ANOVA results concerning the condition effect (first row for each cognitive test), and ANCOVA results covarying for mood (second row for each cognitive test).

	Condition					
	Training	Match				
Cognitive Test	*M(SD)*	*M(SD)*	Covariate	*F*(1, 60)	*p*	η_p^2
Episodic memory short delay	4.20 (1.79)	3.56 (1.47)	None	8.60	.01	.13
			Mood	0.86	.36	.02
Episodic memory long delay	4.52 (1.56)	3.72 (1.80)	None	14.26	<.001	.19
			Mood	1.99	.16	.03
Numerical short-term memory	6.72 (1.69)	6.26 (2.11)	None	5.31	.03	.08
			Mood	1.53	.22	.03
Visuo-spatial short-term memory	8.23 (1.35)	7.80 (1.22)	None	7.16	.01	.11
			Mood	4.62	.04	.07
Prospective memory short delay	18.69 (5.28)	17.39 (6.91)	None	2.75	.10	.04
			Mood	2.37	.13	.04
Prospective memory long delay	2.16 (0.86)	1.98 (0.87)	None	2.09	.15	.03
			Mood	0.08	.78	.00
Verbal fluency	9.84 (2.66)	9.38 (3.15)	None	1.81	.18	.03
			Mood	2.56	.12	.04
Cognitive flexibility	11.26 (2.73)	11.79 (3.10)	None	2.16	.15	.04
			Mood	1.13	.29	.02

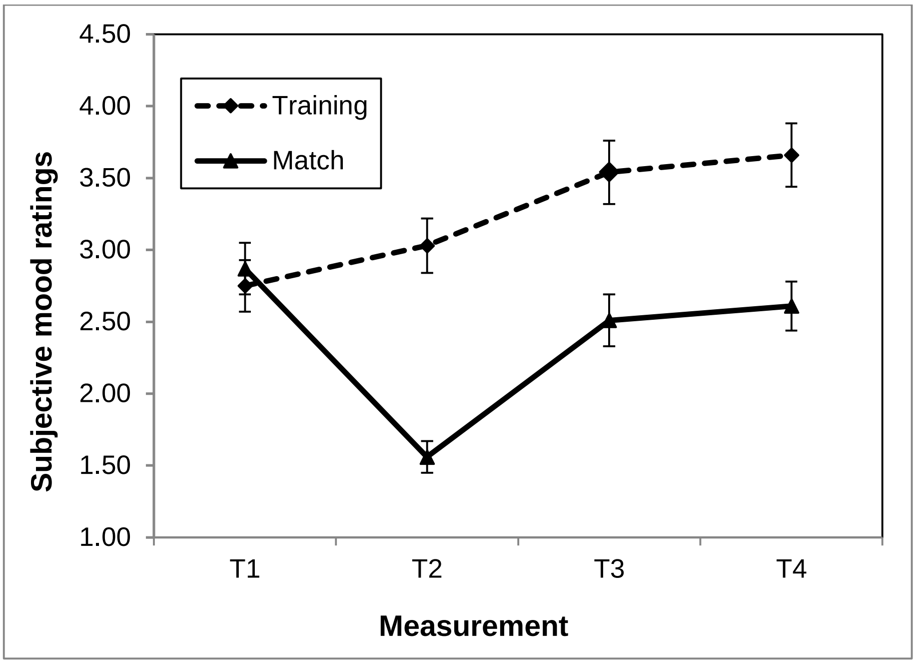

Figure 1.

Subjective mood assessed with the affective state subscale of the SAM (Bradley & Lang, 1994) before (T1) and directly after (T2) match or training as well as during (T3) and after (T4) the cognitive testing. Low values on the affective state scale represent a positive mood, while high values stand for a negative mood. Error bars represent standard errors.