Mood states determine the degree of task shielding in dual-task performance

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BRIEF REPORT

Mood states determine the degree of task shielding in dual-task performance

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Current models of multitasking assume that dual-task performance and the degree of multitasking are affected by cognitive control strategies. In particular, cognitive control is assumed to regulate the amount of shielding of the prioritised task from crosstalk from the secondary task. We investigated whether and how task shielding is influenced by mood states. Participants were exposed to two short film clips, one inducing high and one inducing low arousal, of either negative or positive content. Negative mood led to stronger shielding of the prioritised task (i.e., less crosstalk) than positive mood, irrespective of arousal. These findings support the assumption that emotional states determine the parameters of cognitive control and play an important role in regulating dual-task performance.

Keywords: Cognitive control; PRP; Crosstalk; Task shielding; Mood; Valence.

When people perform two tasks simultaneously performance is worse than if the same tasks are performed separately (Logan & Gordon, 2001). Given the substantially greater co-ordination demands posed by dual-task conditions (Schubert, 1999), this is not particularly surprising. Among other things, adding a secondary task creates additional processing noise and uncertainties in stimulus and response selection and decision making in general, which calls for some kind of shielding of the primary task from crosstalk with the secondary task (Goschke, 2000). Given the constantly increasing dual-task demands in modern industrial life and work environments, research has set out to identify characteristics of "perfect" dual-tasking by studying, for example, the role of task difficulty, optimised task combinations (Allport, Antonis, & Reynolds, 1972) and by developing learning schedules to improve the strategic control of dual-task co-ordination and performance (Schumacher et al., 2001).

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Theoretical models of dual-tasking have assumed that multiple tasks are scheduled and co-ordinated through mechanisms of cognitive control (Logan & Gordon, 2001; Meyer & Kieras, 1997)—a claim that has also received increasing support from neuroimaging studies on dual-tasks demonstrating the involvement of brain regions associated with executive control functions (e.g., Dux, Ivanoff, Asplund, & Marois, 2006; Stelzel, Brandt, & Schubert, 2009). According to the strategic response deferment model (Meyer & Kieras, 1997), for example, dual-task co-ordination may strategically delay secondary task processing so to more optimally shield primary task processing and to avoid confusion between the task sets. The notion that shielding of the prioritised task processing is realised by *strategic* control regulations raises the question of how the degree of task shielding is adaptively adjusted to the current situational demands (i.e., when task shielding is chosen to be weaker or stronger).

Recent studies demonstrated that an acute stress experience (Plessow, Schade, Kirschbaum, & Fischer, 2012) or the induction of different cognitive control styles by means of priming with convergent and divergent creativity tasks determine the amount of primary task shielding in dual-tasks (Fischer & Hommel, 2012). The engagement in a convergent thinking task, for example, primed a systematic, focused processing mode and, consequently, led to stronger shielding during a subsequent dual-task as compared to a prior divergent thinking task, which is associated with a more holistic, flexible task processing mode (Fischer & Hommel, 2012). One possible mechanism for this finding might be phasic dopamine release, which is known to affect cognitive control by modulating the balance between cognitive flexibility and stability (Cools & D'Esposito, 2011; Dreisbach et al., 2005). Indeed, it was found that performance in creativity tasks was related to participants' eye blink rate, an indicator of dopaminergic activity (Chermahini & Hommel, 2010).

Phasic dopamine release is also strongly coupled to mood. A close relationship between the valence of mood states and cognitive flexibility has been attributed to dopamine release in the prefrontal cortex (Ashby, Isen, & Turken, 1999). Accordingly, higher positivity of mood was found to relate to increased performance in tasks associated with divergent creativity (Phillips, Bull, Adams, & Fraser, 2002). This raises the possibility that affective mood states are associated with particular control styles or parameters that systematically mediate the way a given task is being processed. Whereas this assumption has been successfully pursued in single-task studies (Rowe, Hirsh, & Anderson, 2007; van Steenbergen, Band, & Hommel, 2010), comparably little is known about the influences of mood states on cognitive control processes that are required to minimise interference between two simultaneously running, task-relevant S–R translation processes in dual-tasks. Furthermore, in many previous studies the valence of the manipulated mood states was also likely to be confounded with the respective arousal levels.

Therefore, in the present study we aimed at testing for the impact of different mood states on the effective primary task shielding from crosstalk resulting from simultaneous secondary task processing while separating effects of valence and arousal. To do so, we tested two groups of participants—one receiving a positive and one receiving a negative mood induction, which was achieved by means of short film clips. Each group received two film clips, one inducing a low level and one inducing a high level of arousal. To test for the impact of mood states on the effective primary task shielding, we implemented the dual-task paradigm of Fischer and Hommel (2012; see also Fischer, Miller, & Schubert, 2007; Logan & Schulkind, 2000) and focused on performance in Task 1. The same stimulus–response rules and similar input–output modalities were used for the two tasks (T1 and T2) to increase the likelihood of large crosstalk effects on Task 1 performance (Logan & Schulkind, 2000). Participants performed two number-size categorisations (i.e., smaller/larger than five), first on the digit presented above fixation (S1) and then on the digit presented below fixation (S2). To the degree that participants carried out both stimulus–response translations concurrently, the categorisation of S1 was expected to be affected by the categorisation

of S2 (e.g., response-category compatibility; Hommel, 1998). These cross-task interactions should be particularly problematic if the categorisation of S2 (e.g., smaller than five) mismatches the categorisation of S1 (e.g., larger than five), that is, if the implied response categories are different (i.e., response-category incompatible). This response-category compatibility effect can be considered as an indicator of crosstalk between the two tasks and, by implication, as a measure of task shielding (which implies little or no crosstalk). Hence, a small size of the response-category compatibility effect would indicate strong task shielding while a large size of the effect would indicate weak task shielding (Fischer & Hommel, 2012). We hypothesised that the extent of task shielding would be modulated by the valence dimension of mood states. Given that positive mood states compared to more negative mood states induce increased flexibility, more distractibility, a less focused attentional orientation (Dreisbach & Goschke, 2004), and weaker top-down control (van Steenbergen et al., 2010), weaker shielding of the primary task should be found in the positive valence group than in the negative valence group. As this should be indicated by stronger response-category compatibility effects (i.e., more crosstalk from T2 on T1 performance) we predicted positive and negative valence groups to differ in the amount of between-task interactions (i.e., smaller between-task interactions for the negative valence group).

METHOD

Participants

Sixty students of the Technische Universität Dresden (49 female; $M_{age} = 23.6$ years, $SD = 5.6$) participated in the study. They had normal or corrected-to-normal vision. Participants were paid 7€ or received course credit. The experiment lasted for about 75 minutes.

Stimuli and apparatus

Stimuli were presented on a 17″ monitor in a white font on a black background. The stimuli were preceded by a fixation field, which consisted of four horizontal dashes about 4 mm in width. Two of them appeared 10 mm above the screen centre indicating the position of the first stimulus and two of them were located 10 mm beneath the centre where the second stimulus appeared. S1 was either the digit 3 or 7 (12×5 mm) presented between the upper dashes. The digits 2, 4, 6 or 8 served as S2 appearing between the lower dashes. Reactions were made on a QWERTZ keyboard, to S1 with the right hand, pressing the key "." (middle finger) for a digit >5 and "," (index finger) for digits <5. Reactions to S2 were made with the left hand pressing "X" (index finger) for digits >5 and "Y" (middle finger) for digits <5.

Each trial started with the fixation field (500 ms) followed by S1. After a delay (stimulus onset asynchrony, SOA) of 40, 130, 300 or 900 ms the second stimulus appeared. Both stimuli disappeared after another 1,000 ms. Subsequently the display turned black for 3,500 ms, after which the feedback "correct" appeared, or "wrong" if at least one of the responses was incorrect or missing. After a random interval between 100 and 1,000 ms the next trial started. Participants were instructed to react as fast and accurately as possible first to the upper stimulus and then to the lower one. They were further told to refrain from grouping responses by prioritising Task 1. Each task block consisted of 64 trials. The experiment stopped after 32 trials to allow for a short break and could be resumed by pressing the space bar.

Mood induction procedure and mood rating

Four film clips (adopted from Gomez, Zimmermann, Guttormsen Schär, & Danuser, 2009) served to elicit positive and negative mood. For negative mood an excerpt from the film *The Deer Hunter* (high arousal) and from *Les Enfants du Borinage* (low arousal) were used. For the induction of positive mood a collection of sport (high arousal) and nature (low arousal) clips were used. Each clip lasted about ten minutes except for the nature clip which took only six minutes (see Gomez et al., 2009). Participants were instructed

to empathise with the mood conveyed while they watched the films. For mood assessment the Affect Grid (Russel, Weiss, & Mendelsohn, 1989) was used, which measures affective valence and arousal each on a 1-item 9-point scale.

Procedure

Participants were randomly assigned to a positive or negative valence group. Within each group participants watched a high and a low arousal mood clip, respectively. The order of high and low arousal conditions was balanced across participants.

The experiment started with 32 dual-task practice trials, followed by a five-minute break in which participants read an affectively neutral newspaper article. The experiment continued with a first mood assessment ("Pre") and the first mood induction procedure after which mood was assessed ("Post 1") and the first dual-task block took place. In order to maintain the induced mood effect, participants were then presented with the last two minutes of the film clip again after which the second dual-task block was conducted, again followed by a mood assessment ("Post 2"). The whole procedure was repeated for the other arousal condition, again starting with a five-minute break (see also Figure 1B). Each participant completed 256 trials (128 trials in each arousal state).

RESULTS

Mood ratings

For valence and arousal ratings two separate analyses of variance (ANOVAs) were conducted with Valence Group (positive vs. negative) as a between-subject factor and Arousal Condition (high vs. low) as well as Time of Measurement (Pre, Post 1, Post 2) as within-subject factors.

Valence ratings. Valence ratings were more positive in the positive than in the negative group, $F(1, 58) = 60.85$, $p < .001$, $\eta_p^2 = .51$. Furthermore, there was a significant main effect of Time of Measurement, $F(2, 116) = 34.88$, $p < .001$,

$\eta_p^2 = .38$. Importantly, changes in valence ratings were dependent on valence group as indicated by the significant interaction between Valence Group and Time of Measurement, $F(2, 116) = 49.75$, $p < .001$, $\eta_p^2 = .46$. Arousal Conditions affected valence ratings differently for each Valence Group, $F(1, 58) = 4.28$, $p = .043$, $\eta_p^2 = .07$, depending on Time of Measurement, $F(2, 116) = 3.50$, $p = .033$, $\eta_p^2 = .06$. In the low arousal condition (but not in the high arousal condition), positive mood induction was successful to increase valence ratings toward positive mood (see Figure 1A, left panel). This resulted in an overall main effect of Arousal Condition, $F(1, 58) = 9.11$, $p = .004$, $\eta_p^2 = .14$, that depended on the Time of Measurement, $F(2, 116) = 5.80$, $p = .004$, $\eta_p^2 = .09$. Importantly, valence ratings did not differ between the two groups before the mood induction ($ts < 1$, for high and low arousal conditions). Both groups, however, differed in their ratings at measurements after mood induction. This was valid for Post 1, $t(58) = 4.96$, $p < .001$ and $t(58) = 12.84$, $p < .001$ (for high and low arousal condition, respectively) and for Post 2, $t(58) = 3.25$, $p = .002$ and $t(58) = 4.20$, $p < .001$ (for high and low arousal condition, respectively).

Arousal ratings. The significant main effect of Arousal Condition, $F(1, 58) = 63.48$, $p < .001$, $\eta_p^2 = .52$, depended on the Time of Measurement, $F(2, 116) = 32.57$, $p < .001$, $\eta_p^2 = .36$. That is, before mood induction, high and low arousal conditions did not differ in the negative valence group, $t(29) = 0.98$, $p = .333$, but differed significantly in the positive valence group, $t(29) = 2.39$, $p = .023$. After the mood induction, high and low arousal conditions differed at Post 1, $t(29) = 5.59$, $p < .001$ and $t(29) = 8.39$, $p < .001$, as well as at Post 2, $t(29) = 3.16$, $p = .004$ and $t(29) = 4.04$, $p < .001$, for negative and positive valence groups, respectively (see Figure 1A, right panel). The difference between arousal conditions was larger for the positive group than the negative group, resulting in an interaction between Arousal Condition and Valence Group, $F(1, 58) = 10.93$, $p = .002$, $\eta_p^2 = .16$. Finally, we found a main
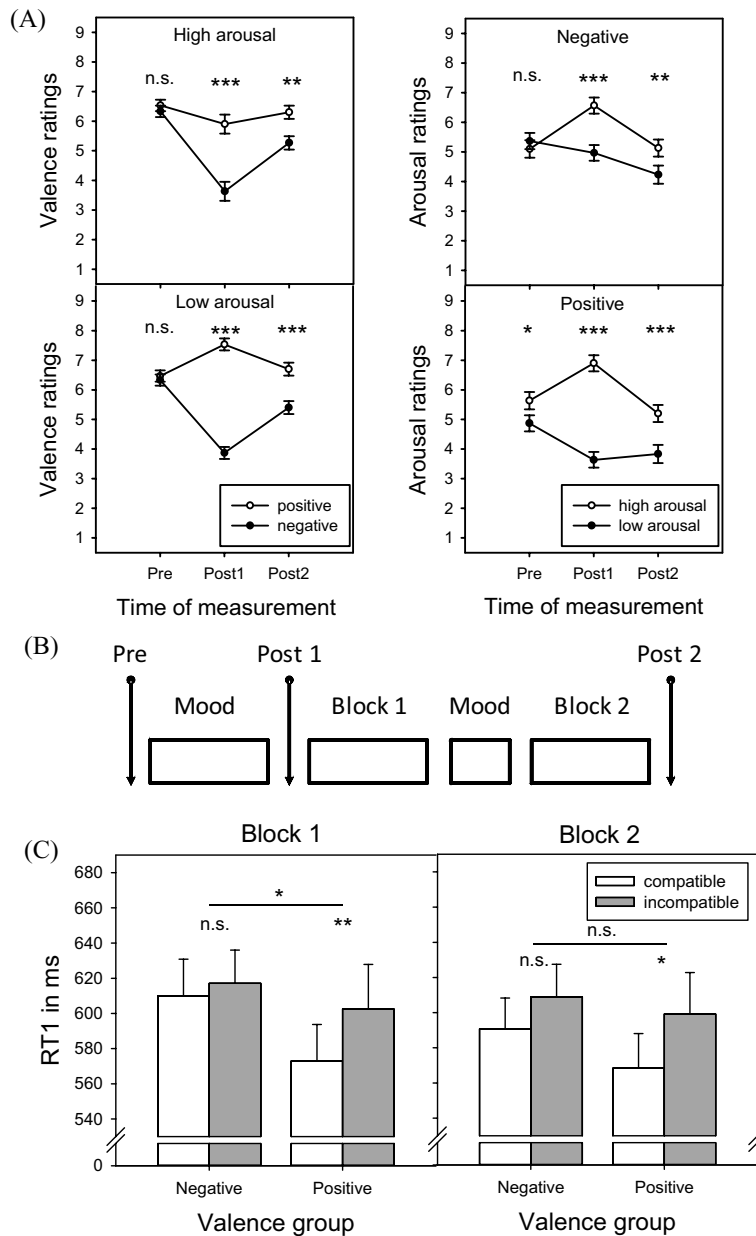
Figure 1. *(A) Left panel: Valence ratings displayed separately for high and low arousal conditions, respectively. Right panel: Arousal ratings separately for the positive and negative valence group. (B) Experimental procedure for each valence group including mood induction at the beginning and a shorter mood actualisation in between cognitive testing (i.e., Block 1 and Block 2, respectively). Pre, Post 1 and Post 2 illustrate the time point of mood/arousal assessment. For each valence group this procedure was conducted twice, for high arousal and low arousal mood inductions, respectively (see method section for further details). (C) Task 1 response times (RT1) for response–category compatibility and valence group in Block 1 (immediately after mood induction) and Block 2 (after mood actualisation). Note: ns = not significant; *p <.05; **p <.01; ***p <.001.*

effect of Time of Measurement on arousal ratings, $F(2, 116) = 20.52$, $p < .001$, $\eta_p^2 = .26$.

RT1

Data analysis. For the RT analyses, erroneous trials (4.0%, including 0.3% missing) and trials with RTs <150 ms or $>2,000$ ms (0.5%) were excluded. Because the size of the response-category compatibility effect is not only dependent on the SOA between both tasks but also on the duration of T1 processing (i.e., the larger the temporal overlap between tasks the larger the possibility of between-task interactions), we correlated the individual RT1 with the size of the response-category compatibility effect. Overall, the response-category compatibility effect increased with increasing RT1, $r = .297$, $p = .021$. Thus, in order to control for influences of processing duration, the individual mean RT1 was entered as covariate into an analysis of covariance (ANCOVA) with SOA (40, 130, 300 and 900 ms), Block (1 – mood induction vs. 2 – mood actualisation), Arousal (high vs. low), and Response-category Compatibility (compatible vs. incompatible) as within-subject variables and Valence Group (positive vs. negative) as between-subject variable on RT1 and RT2. Greenhouse–Geisser adjustments were applied wherever appropriate.

Dual-task: Practice. In order to exclude differences between the valence groups before mood induction the aforementioned ANCOVA was performed on the practice trials with Response-category Compatibility as a within-subject and Valence Group as between-subject variable. This analysis resulted in no significant difference between the groups concerning response-category compatibility, $F < 1$.

Dual-task: Experiment. RT1 gradually decreased with increasing SOA, $F(3, 171) = 5.88$, $p = .007$, $\eta_p^2 = .09$. Elevated RT1 at short SOA, however, were due to large RT1 in response-category incompatible trials whereas RT1 for response-category compatible trials remained virtually un-

affected across SOAs (see Table 1). This resulted in decreasing response-category compatibility effects with increasing SOA (47, 34, 7, and -3 ms for SOAs 40, 130, 300, and 900 ms, respectively), $F(3, 171) = 2.48$, $p = .063$, $\eta_p^2 = .04$. Response-category compatibility interacted with the covariate individual mean RT1, $F(1, 57) = 5.73$, $p = .020$, $\eta_p^2 = .09$, which proves its strong dependence on Task 1 processing speed. This explains why the overall compatibility effect (22 ms) fell short of significance when controlling for RT1, $F(1, 57) = 2.09$, $p = .154$, $\eta_p^2 = .04$, but was highly significant without controlling for Task 1 processing duration, $F(1, 57) = 23.13$, $p < .001$. $\eta_p^2 = .29$. Although RTs were 11 ms faster for the high than for the low arousal condition, $F(1, 57) = 5.62$, $p = .021$, $\eta_p^2 = .09$, arousal did not interact with any other factor (all $ps > .144$). Positive and negative valence group did not differ in RT1, $F(1, 57) = 2.02$, $p = .161$, $\eta_p^2 = .03$.

Most importantly, however, the response-category compatibility effect was significantly larger for the positive than for the negative valence group, $F(1, 57) = 5.13$, $p = .027$, $\eta_p^2 = .08$. Subsequent analyses for each valence group separately, revealed a significant response-category compatibility effect in the positive valence group (30 ms), $F(1, 28) = 15.19$, $p = .001$, $\eta_p^2 = .35$, but not in the negative valence group (13 ms), $F(1, 28) = 1.11$, $p = .301$, $\eta_p^2 = .04$. Even though, we did not find an interaction between Valence Group, Response-category Compatibility, and Block ($F < 1$), visual inspection of Figure 1C suggests that the difference in the response-category compatibility effect between positive (30 ms) and negative (7 ms) valence group was especially pronounced in Block 1 immediately after mood induction, $F(1, 57) = 5.91$, $p = .018$, $\eta_p^2 = .09$. In Block 2 (after mood actualisation), however, this difference between positive (32 ms) and negative valence group (17 ms) was not significant anymore, $F(1, 57) = 2.09$, $p = .157$, $\eta_p^2 = .04$.

RT2

RT2 decreased with larger SOAs, $F(3, 171) = 9.66$, $p < .001$, $\eta_p^2 = .15$, which was neither

Table 1. *Task 1 and Task 2 response times (RT1 and RT2 in ms) and percent error (PE) depending on valence group (positive vs. negative), block (1 – mood induction vs. 2 – mood actualisation), response-category compatibility (C – compatible vs. I – incompatible), and SOA*

| | Arousal | SOA | Positive | | | | Negative | | | |
| | | | Block 1 | | Block 2 | | Block 1 | | Block 2 | |
			C	I	C	I	C	I	C	I
RT1	High	40	565 (16)	620 (26)	573 (19)	639 (26)	606 (21)	639 (19)	595 (17)	644 (20)
		130	572 (20)	626 (32)	554 (18)	586 (24)	600 (18)	628 (21)	586 (18)	612 (20)
		300	564 (25)	585 (28)	547 (22)	584 (24)	602 (22)	588 (19)	576 (20)	577 (20)
		900	571 (29)	573 (31)	582 (30)	566 (29)	616 (32)	614 (23)	553 (17)	564 (19)
	Low	40	581 (21)	633 (29)	584 (18)	639 (31)	611 (20)	634 (20)	606 (20)	652 (22)
		130	585 (24)	617 (29)	573 (22)	626 (29)	604 (20)	601 (22)	593 (23)	643 (31)
		300	577 (28)	581 (28)	573 (26)	582 (29)	609 (23)	611 (30)	605 (26)	598 (25)
		900	569 (23)	582 (29)	562 (24)	572 (28)	632 (37)	622 (32)	612 (30)	582 (24)
RT2	High	40	723 (22)	845 (28)	731 (27)	861 (29)	808 (36)	898 (30)	778 (31)	899 (33)
		130	658 (24)	779 (34)	644 (22)	715 (25)	722 (34)	804 (38)	715 (39)	775 (30)
		300	566 (22)	607 (25)	556 (19)	605 (24)	631 (29)	657 (34)	618 (36)	650 (34)
		900	502 (18)	488 (16)	477 (14)	469 (18)	543 (29)	531 (27)	516 (25)	523 (24)
	Low	40	762 (27)	889 (34)	750 (24)	872 (32)	823 (37)	923 (34)	803 (37)	920 (36)
		130	696 (26)	778 (33)	674 (24)	775 (31)	749 (41)	788 (37)	716 (36)	830 (46)
		300	597 (24)	626 (25)	578 (24)	617 (24)	663 (41)	694 (41)	629 (35)	655 (31)
		900	500 (15)	511 (22)	497 (16)	495 (18)	552 (30)	560 (33)	543 (21)	531 (25)
PE	High	40	3.3 (1.0)	6.7 (1.8)	2.1 (0.9)	4.6 (1.4)	1.4 (1.0)	5.0 (1.7)	1.3 (0.9)	6.7 (1.4)
		130	1.3 (0.7)	4.6 (1.4)	1.3 (0.7)	2.6 (1.0)	3.8 (1.4)	5.4 (2.0)	2.1 (0.9)	4.2 (1.6)
		300	5.8 (2.1)	2.9 (1.0)	3.3 (1.0)	4.2 (1.4)	3.8 (1.2)	4.6 (1.3)	5.8 (2.0)	3.8 (1.9)
		900	4.6 (1.5)	2.5 (0.9)	5.4 (1.3)	2.9 (1.0)	6.3 (2.0)	3.3 (1.5)	3.3 (1.0)	3.9 (1.1)
	Low	40	1.7 (0.8)	2.9 (1.0)	2.5 (0.9)	1.7 (1.0)	1.3 (0.9)	3.8 (1.2)	3.8 (1.2)	3.3 (1.2)
		130	2.1 (1.1)	5.0 (1.4)	2.5 (0.9)	4.7 (1.3)	2.5 (1.1)	3.1 (1.2)	2.5 (0.9)	5.9 (1.6)
		300	3.8 (1.5)	5.8 (1.6)	4.6 (1.7)	4.2 (1.8)	4.6 (1.5)	4.7 (1.5)	4.6 (1.1)	7.5 (1.5)
		900	3.8 (1.4)	4.6 (1.6)	4.6 (1.4)	2.5 (1.1)	3.3 (1.3)	1.7 (0.8)	4.3 (1.6)	3.3 (1.2)

Note: $N = 60$. Values are given as means (standard errors of the mean).

affected by arousal nor valence ($Fs < 1$). The response-category compatibility effect did not statistically differ between positive (64 ms) and negative (52 ms) valence group, $F(1, 57) = 2.11$, $p = .152$, $\eta_p^2 = .04$, and was not affected by arousal, $F < 1$. As in Task 1, response-category compatibility interacted with the covariate individual mean RT1, $F(1, 57) = 6.31$, $p = .015$, $\eta_p^2 = .10$. The factor response-category compatibility was significant without the covariate, $F(1, 58) = 124.42$, $p < .001$, $\eta_p^2 = .68$. There was a small tendency for faster responses in the high than in the low arousal condition, $F(1, 57) = 2.99$, $p = .089$, $\eta_p^2 = .05$.

Error rates

Trials with incorrect responses were analysed for both tasks commonly (Logan & Schulkind, 2000). An ANOVA included Response-category Compatibility, Block, Arousal, and SOA as within-subject variables and Valence Group as between-subject factor. Error rates were affected by the factor SOA (3.2, 3.3, 4.6, and 3.8% for SOAs 40, 130, 300, and 900 ms, respectively), $F(3, 174) = 3.79$, $p = .011$, $\eta_p^2 = .06$. More errors were committed in response-category incompatible than in compatible conditions (4.1 vs. 3.3%), $F(1, 58) = 5.13$, $p = .027$, $\eta_p^2 = .08$, which depended on SOA, $F(3, 174) = 5.72$, $p = .002$, $\eta_p^2 = .09$, with larger differences at short than long SOAs. In addition, the response-category compatibility effect at short SOA was stronger in the high (3.74%) compared to the low (0.63%) arousal condition, which resulted in the interaction between SOA, Response-category Compatibility and Arousal, $F(3, 174) = 3.47$, $p = .017$, $\eta_p^2 = .06$, which was independent of valence, $F < 1$. Response-category Compatibility in general was also not affected by Valence Group, $F < 1$.

Overall dual-task efficiency

To address effects of valence and arousal on overall dual-task performance, we calculated efficiency of dual-task performance by adding RT1 + RT2 (total reaction time, TRT). Dual-task performance was faster in conditions of high (1,255 ms) compared to low arousal (1,289 ms), $F(1, 58) = 7.44$, $p = .008$, $\eta_p^2 = .11$. There was, however, no significant overall difference between positive (1,237 ms) compared to negative mood (1,307 ms), $F(1, 58) = 1.32$, $p = .256$, $\eta_p^2 = .02$. Even though the numerical difference in TRT was larger between positive and negative valence (70 ms) than between high and low arousal (34 ms), only the latter was significant, which might be due to the fact that arousal was manipulated within subjects while valence was a between-subject variable. Valence and arousal did not interact, $F < 1$.

DISCUSSION

The aim of this study was to determine whether the induction of different mood states primes cognitive control parameters responsible for task shielding in a subsequent dual-task situation. We hypothesised that participants primed with film clips of positive valence would differ in their control regulation of task shielding to participants primed with film clips of negative valence.

Results are straightforward. The induction of different mood states determined subsequent control regulations in dual-task performance by affecting between-task interactions as indexed by the size of the response-category compatibility effect. In other words, primary task shielding in dual-task performance, serving to reduce between-task interference, is more pronounced under the influence of negative mood states than under the influence of positive mood states (van Steenbergen et al., 2010), whereas positive mood states seem to increase the susceptibility to interference (Dreisbach & Goschke, 2004). These mood-dependent modulations of task shielding appeared most pronounced immediately after mood induction. At the same time, mood induction did not significantly affect overall dual-task performance. The present findings of reduced versus increased attentional scope under negative versus positive mood are thus in accordance with previous results reported in single-task studies

(Dreisbach & Goschke, 2004; van Steenbergen et al., 2010).

Arousal seemed to generally reduce response thresholds, as RT1 and total reaction time were smaller for high than for low arousal. High arousal was also associated with a larger response-category compatibility effect in error rates at short SOA only (i.e., increased errors for response-category incompatible trials, see Table 1). This might conform to the observation of reduced response thresholds as high arousal facilitates premature motor activation, resulting in errors especially in high conflicting conditions (e.g., short SOA). Thus, the effect of arousal seems to reflect a non-specific effect of motor activation. Most importantly, valence and arousal did not interact on dual-task performance. Therefore, it seems unlikely that the difference in task shielding between the two valence groups was caused by different arousal levels.

At present we hypothesise that the observed differences in primary task shielding are primarily driven by the negative mood induction. Valence ratings displayed in Figure 1A seem to suggest that mood induction revealed its strongest effect in the negative valence group. The non-significant between-task interference effect for the negative valence group further supports this assumption. Similar dual-task paradigms that also use identical stimulus-response categorisation in both tasks typically produce large between-task interference effects (e.g., Fischer et al., 2007; Logan & Schulkind, 2000). We therefore assume that negative relative to positive mood may increase primary task shielding to prevent between-task interactions. At the same time it should be noted that increased task shielding does not necessarily equal speeded processing. On the contrary, increased task-shielding also comes at a loss of beneficial information, which might slow down responses in response-category compatible trials (see Figure 1C). Therefore, we assume that both positive and negative moods facilitate different cognitive control styles that bias the balance between exploitation and exploration (Cohen, McClure, & Yu, 2007; Goschke, 2000) and are thus adaptive depending on situational contexts.

Negatively valenced stimuli may be more dangerous and hence demands for a stronger attentional focus and shielding towards competing stimuli and response tendencies while positive mood signalises freedom of danger and allows for exploration. In this respect, our results fit with Ashby et al.'s (1999) assumptions with positive mood being beneficial for performance in tasks requiring creativity and cognitive flexibility, which are connected to loosened attentional control.

The present findings also relate to dual-task research and the question of which situational conditions increase or decrease the likelihood of interference between two tasks. Our results showed that the amount of between-task interference is not only determined by characteristics of the dual-task situation but also by dual-task unrelated features such as the current mood or subjective state of the participant (see also Fischer & Hommel, 2012; Plessow et al., 2012), thus, suggesting the possibility of contextual bottom-up regulation of cognitive control in dual-tasks. By showing that mood states modulate the shielding of the prioritised task processing, further research is clearly needed to identify the specific mood-sensitive cognitive mechanism that enables task shielding, e.g., strengthened Task 1 processing (Stelzel et al., 2009) or temporary inhibition of Task 2 processing (Koch, Gade, Schuch, & Philipp, 2010).

The present study showed that mood states influence cognitive control regulations, not only in single-task contexts but also in dual-task situations, in which cognitive control processes are required to minimise interference between two simultaneously running, task-relevant S–R translation processes and thus, emphasise the importance of mood states as a hitherto neglected variable influencing the strategic control of dual-task performance.

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