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Compatibility between approach/avoidance stimulation and valenced information determines residual attention during the process of encoding

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Abstract

We tested the hypothesis that the activation of the motivational systems of approach or avoidance by body postures and taste influences residual attention during the process of encoding differentially valenced words. In Experiment 1, participants were asked to stand upright or kneel while learning either positive or negative adjectives. To measure participants' differential cognitive capacities, a dual task paradigm was used, including a finger-dexterity test as a secondary task. We were able to show that participants performed worse on the secondary task compared to a baseline assessed before if there was incompatibility between postures and the valence of the information. In Experiment 2, we replicated the results with bitter and sweet taste instead of body positions. It is our contention that the activation of approach or avoidance systems by bodily states prepares the organism for information of differential valence. Copyright © 2000 John Wiley & Sons, Ltd.

The possibility that the valence of information can automatically activate approach or avoidance behavior has been entertained in the literature for a long time (e.g. Bargh & Gollwitzer, 1994; Bargh & Barndollar, 1996; James, 1890; Lewin, 1935). Recently it has been argued that the brain deals with two distinct motivational systems — an approach system and a withdrawal system — which can be activated by a valenced stimulus (Lang, Bradley, & Cuthbert, 1990). Activation of one or the other system by like-valenced stimuli is said to produce an 'action disposition' which immediately and spontaneously follows from stimulus input (for a similar point of view see, e.g. Bargh, 1997; Prinz, 1990). Consistent with this model, it has been shown

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that basic reflex behaviors, such as the startle reflex in reaction to noise, is stronger when participants are in a compatible emotional state, for instance, while looking at unpleasant slides (Lang, Bradley, & Cuthbert, 1990).

In a recent paper, Chen and Bargh (1999) demonstrated that even behaviors more complex than simple reflexes can be automatically influenced by valenced stimuli. Using a paradigm devised by Solarz (1960), they showed that it was easier for participants to pull positive words toward themselves and easier to push away negative words when they were asked to evaluate the words as 'good' or 'bad' in meaning. In a second experiment, this pattern held even when evaluation of the stimuli was irrelevant to the participants' conscious task. These experiments highlight the effects of valenced characteristics of the information on the elicitation of approach (pulling) versus avoidance (pushing) tendencies. Moreover, they point to two distinct systems, an approach and an avoidance system, which can be automatically activated by valenced cues and lead to the facilitation or inhibition of behavior.

Research on facial feedback, however then could provide considerable evidence for the other causal direction: the direct influence of behavior on cognition (for reviews see Adelman & Zajonc, 1989; Izard, 1990). Here a direct route of how behavior can affect cognition was proposed (see Zajonc, 1980) which works beyond conscious or self-perception mechanisms (Bem, 1967). And tests did in fact show that unobtrusively induced expression patterns influenced participants' reported feelings (e.g. Stepper & Strack, 1993; Larsen, Kasimatis, & Frey, 1992; Zajonc, Murphy, & Inglehart, 1989), their subsequent judgments (e.g. Strack, Martin, & Stepper, 1988), their preferences for objects and products (e.g. Cacioppo, Priester, & Berntson, 1993; Tom, Patterson, Lau, Burton, & Cook, 1991), their evaluation of strangers (Förster, 1998), their susceptibility to counterattitudinal messages (e.g. Cacioppo & Petty, 1979; Petty, Wells, Heesacker, & Cacioppo, 1983; Wells & Petty, 1980), and their memories of positive versus negative events (Förster & Strack, 1996, 1997, 1998; Riskind, 1983). Here is one example. Participants who held a pen with their teeth to facilitate smiling rated cartoons as funnier than participants who held a pen with their protruding lips, which inhibited a smiling expression (Strack *et al.*, 1988). Smiling as a component of approach presumably activated an approach system which then affected the evaluation of information. Importantly, the facial expressions were unobtrusively induced, so that the effect appeared outside of participants' awareness. Thus, more conscious inference mechanisms ('I am smiling, therefore the cartoons must be funny') were ruled out for producing this effect, indicating a more direct connection between proprioceptive cues and cognition.

In a recent study, body feedback also influenced more basic information processing (Förster & Strack, 1996). Using a paradigm from Wells & Petty (1980), it could be shown that participants performing vertical head movements during encoding of positive and negative information were better at recalling positive than negative words in a subsequent yes/no recognition test, whereas the reverse was true for participants performing horizontal head movements (Förster & Strack, 1996; Experiments 1 and 2). To unobtrusively induce the head movements (i.e. to show a direct influence of the movements on encoding and exclude interpretations based on self-perception mechanisms), participants were told that they were taking part in a study on 'marketing research'. Supposedly in order to test whether headphones were comfortable while dancing or walking, they were asked to perform either horizontal or vertical head movements in a standardized fashion while listening to positive and negative words presented via headphones. Analyses of the subsequent recognition test revealed better memory for positive than for negative information in the vertical condition, while the reverse was true for the horizontal condition. Using methods that can distinguish between participants' discrimination between targets and distractors and their indiscriminate tendencies to answer affirmatively (see Snodgrass & Corwin, 1988), it could be shown that the effect was due to participants' enhanced abilities to discriminate between targets and distractors rather than to bias at the time of retrieval. Because this 'compatibility' affected the discrimination between stimuli which had actually been presented and stimuli which had not, and because the head movements occurred only in the learning phase, the interactive influence between expressions and the valence of the stimuli was assumed to occur during encoding rather than during retrieval. Note that the influence of body feedback in this case was an interaction with the valence of the incoming information rather than a simple main effect of expression patterns, indicating *selective* encoding due to proprioceptive cues.

To explain the findings, a 'conceptual-motor compatibility model' was developed which predicted processing advantages for valence-compatible information due to overlearned or wired-in associations between overt and covert responses (Förster, 1995; Förster & Strack, 1996). Based on research in the field of perceptual-motor compatibility (for a review see Alluisi and Warm, 1990), which showed, for example, that response selection is faster if the sense modalities of stimuli and responses are compatible (e.g. Greenwald, 1970), the conceptual-motor compatibility model predicted better encoding for behavior-compatible information than for behavior-incompatible information. It was argued that in natural situations, certain overt responses co-occur with covert responses. For example, nodding (vertical head movements) is an approach reaction to subjectively positive information, whereas head shaking (horizontal head movements) is an avoidance reaction to subjectively negative information. Such connections are overlearned and automatized over time, so that one may elicit the other. Those reactions can be considered compatible. On the other hand, individuals can 'overrule' associations. For example, people may nod when they happen to disagree. While it is therefore possible to perform the incompatible behavior, its execution (e.g. masking of an expressive display) requires more behavioral effort and/or more mental processing capacity. Because the participants in the experiments had to maintain the movement at a prescribed frequency (i.e., they were not allowed to change the pattern or slow it down in incompatible conditions), it was concluded that participants had to allocate more resources to the maintenance of the behavior in incompatible conditions. As a result, they devoted less attention to the encoding of incompatible words than of compatible words. Moreover, in case of compatibility it can be theorized that, because of such overlearned associations, the entry for a compatible stimulus might be prepared and is therefore easier to process (see Lang, 1995).

In order to test the hypothesis that learning information incompatible with an expressive motor pattern is possible but requires more cognitive capacity than learning compatible information, one study used a dual task paradigm to measure participants' cognitive effort while encoding valenced words and performing either compatible or incompatible head movements (Förster & Strack, 1996; Experiment 3). Specifically, participants were asked to complete a secondary task — the solution to which depended upon their 'residual attention' (e.g. Hasher & Zacks, 1979) — while they were learning either positive or negative words and simultaneously performing vertical or horizontal head movements. Contrary to the first experiments, a reward was given for the best memory performance. This was done to show that strong motivation can override the previously discovered memory impairment due to incompatibility. And in fact, participants' memory performances did not differ as a function of compatibility. However, participants in incompatible learning conditions did worse on the secondary task than those in compatible learning conditions, reflecting the fact that attentional resources were directly influenced by in/compatibility. As a result, we maintain that compatibility between expressive behaviors and valenced information determined the amount of available capacity during the process of encoding, which presumably led to the differential recollection of valenced information in the first studies. On a more general level, the activation of compatible motivational approach or avoidance systems and the valence of incoming information seems to facilitate information processing, whereas incompatibility impedes it.

However, two different processes may be responsible for this difference in resources. Drawing on the studies of automatic behavior activation by valenced goals, one could argue that the information *distracted* the participants from performing the behavior, producing load which then lead to inferior encoding. We shall call this the 'distraction hypothesis'. On the other hand, it is possible that the expression patterns *prepared* processing of certain information, thus freeing resources. We shall call this the 'preparedness hypothesis'. The present studies were designed to find out more about the underlying process that guides capacity deficits or advantages in case of compatibility.

There is already some evidence for the distraction hypothesis in the literature. In a study by Wells & Petty (1980), researchers were able to observe that participants who were led to perform either vertical head movements (nodding) or horizontal head movements (shaking the head) while listening to pro- or counter-attitudinal messages, performed head movements more frequently in compatible than in incompatible conditions. Consequently, a counter-attitudinal message might, for example, have distracted especially those participants who were led to perform the incompatible nodding movement. A similar process may have guided the differential encoding in the Förster & Strack (1996) study. For example, a person who has to nod when faced with a negative stimulus may be spontaneously motivated to engage in an avoidance reaction. If the person is not allowed to change the movement, the performance of the incompatible behavior may be more difficult, because the valenced stimuli repeatedly activate a behavior which must not be performed. This may actually distract a person from learning the word.

On the other hand, the preparedness hypothesis — that behavior prepares the organism to approach or avoid compatible information — is implicitly or explicitly implied in both Lang's (1995) and Förster & Strack's (1996) models, as well in other models of facial feedback (Adelman & Zajonc, 1989; Stepper, 1992). Here, to the best of our knowledge, direct evidence is still lacking, and obtaining more evidence for this hypothesis was therefore the main impetus behind the present paper. More specifically, we wanted to show that during the process of encoding, residual attention is limited in case of incompatibility between approach and avoidance activation and valenced information, even when a person's behavior is not distractive or effortful. In order to show some causal influence of behavior on cognition, we attempted to experimentally control for the possibility of distraction by incompatible movements. To that end, in Experiment 1 we manipulated body postures of approach or avoidance rather than movements. If residual attention is affected by easily maintained body positions, distraction by disruptive movements can not be the cause of the effects on residual attention, and such effects seem to be more likely based on preparedness.

In Experiment 2 we sought to generalize the findings on compatibility. Since the current models on facial feedback explain influences of behavior on cognition without inference processes, and because it is assumed that associations between approach or avoidance systems and *proprioceptive cues* drive the process, there is no reason to restrict compatibility effects to behavior, expression patterns, or motor cues. Hence, we tested the hypothesis that the same resource differences can be obtained with other sense modalities, specifically with gustatory stimulation. We predicted that activation of approach or avoidance systems via differentially valenced tastes prepares the organism for valence-compatible information, freeing residual attention. Distractions of behavior by external valenced cues can be experimentally ruled out with taste manipulations, because there is no distractive behavior.

In both experiments, participants were asked to learn either positive or negative words while simultaneously working on a secondary task. In both experiments, participants were highly motivated by monetary incentives to learn the information. Ideally we would not expect any differences in the main task. Here, the reward should motivate participants to overcome deficits in cognitive resources which should then be reflected in performances of the secondary task (Förster & Strack, 1996). Capacity deficits in incompatible conditions, however, were predicted in the secondary task. If it is possible to obtain compatibility effects, these can not be due to the distraction of movements in case of incompatibility. Rather, they must be due to the facilitation or inhibition of the bodily states themselves. In summary, if it is possible to show capacity deficits due to incompatibility between information and easily maintained bodily states, we can assume that these bodily states have inhibiting or facilitating influences on valenced information.

EXPERIMENT 1

Expression patterns that differ clearly in their association with approach versus avoidance are those which are specific to emotions. For example, people smile when they are happy, stand upright when they are proud, and slouch when they feel guilty (Ekman, 1992). In the present study, the body postures of kneeling down versus standing upright were chosen, postures which have been shown to be related to avoidance and approach, respectively (Stepper, 1992; Stepper & Strack, 1993; Riskind, 1983). Standing upright, for example, is an expression of pride, an emotion that is usually experienced after positive feedback, whereas rounding the back is an expression of guilt or shame emotions, normally experienced after negative feedback (Stepper, 1992). Thus, standing upright should be closely associated with positive information (i.e. approach), whereas kneeling down should be closely associated with negative information (i.e. avoidance). Consistently, earlier research has shown that participants in a slumped bodily posture were faster at recalling negative than positive life events, whereas participants in an upright bodily posture were faster at recalling positive than negative life events, findings which indicate a higher accessibility for valenced information compatible with the induced expression pattern (Riskind, 1983).

To capture participants' differences in cognitive capacities while learning, a dual task paradigm was used. More specifically, participants were asked to complete a main task, a word learning task, and a secondary task, a motor dexterity task the solution to which depended on participants' residual attention (e.g. Hasher & Zacks, 1979). To ensure that participants' attention was directed at the encoding of the words, the main task was an intentional learning task. As a secondary task participants had to insert three metal pins into each of 100 holes in a wooden board (O'Connor, 1932).

The hypothesis was that participants in compatible conditions (kneeling down and negative words; standing upright and positive words) would have more capacity available to perform the secondary task than participants in incompatible conditions (kneeling down and positive words; standing upright and negative words).

Method

Participants

Forty students at the University of Trier were recruited for an ostensible experiment on ergonomic research for which a compensation of DM 10.- (*ca* US $7.- at the time) was offered.

Stimulus Material

Twelve very positive (e.g. 'schön', beautiful) and 12 very negative (e.g. 'schrecklich', terrible) adjectives from the word pool of Förster & Strack (1996) were used plus four neutral words which served as fillers.

Procedure and Design

Participants were asked to learn words presented via headphones. To ensure that the motor dexterity task was viewed as the secondary task, a reward (DM 20.-, US$14.- at the time) was offered for the best memory performance despite the potentially distracting effects of a secondary motoric task. Participants were further informed that the study dealt with learning under different conditions of ergonomic body postures. To preclude participants from theorizing about their body posture, both groups were told that they were in a control condition in which less extreme body postures would be investigated than in other experimental groups.

Before the actual experiment started, participants were given two dexterity training sessions without the learning task. In one session all participants inserted the metal pins while sitting at a table (no body postures); in the other session, participants performed the same task while assuming one or the other of the body postures. This was done to determine participants' average performance, which was subsequently used as individual baselines. For the experimental conditions, the experimenter demonstrated the required body postures by kneeling down on the floor or by standing upright in front of a shelf, *ca* 1.50 m in height. After the training sessions, participants were asked to put on the headphones. The tape began with 60 seconds of music (tangos by Astor Piazzola) followed by a list of 12 words of one valence (including a neutral buffer item at the beginning and the end of the list) presented at 3-seconds-intervals. The record concluded with 30 seconds of the same tango music and a final stop signal. Participants were instructed to memorize the words, to assume the body posture, and, simultaneously, to place three metal pins in series of 100 holes in a wooden board. To rule out social comparison mechanisms as mediators for the expected effects, the experimenters were instructed to sit down on a chair that was placed behind the participant. When the experimenter noticed the audible stop sign on the tape, he or she immediately stopped the participants from performing the finger dexterity task. Next, participants were led to a table and asked to perform an unrelated filler task, which lasted about 20 minutes. Participants were then given a free recall test, specifically, they were given a self-determined length of time to write down all the words they could remember from the encoding phase. Afterwards, they were told to fill out a mood questionnaire, containing a general current mood question ('How do you feel right now?' rating scale from '1' = very bad, to '9' = very good), the pleasantness of the body posture ('How pleasant was the body posture?' rating scale from '1' = very unpleasant, to '9' = very pleasant), and, as a manipulation check, the subjective valence of the words ('How positive or negative were the words?' rating scale from '1' = extremely negative, to '9' = extremely positive). Then, participants were asked what they believed the purpose of the experiment had been. All participants believed the cover story. None of them reported any hypotheses about the body postures that were relevant to the true purpose of the study. The participants were then thanked, rewarded, and debriefed.

Accordingly, the experimental design was a 2 × 2-factorial comparing Body Postures (standing upright versus kneeling down) and Word Valence (positive versus negative) between participants. The Time of Measurement (baseline versus while learning) was added as a factor within participants.

Results

Mood, Pleasantness, and Subjective Word Valence

To test whether the body postures or the valence of the words induced different mood states or whether they differentially affected experiences of pleasantness, several analyses of variances (ANOVAs) were conducted on the mean ratings from the final questionnaire. They are summarized in Table 1.

As can be seen from Table 1, the induced body postures or the valence of the words were not sufficient to induce measurable current mood states: all main effects or interactions were non-significant, Fs < 1.81, ps > 0.20, respectively. Replicating earlier results (Stepper & Strack, 1993), standing upright was rated as being more

Table 1. Mean ratings of mood, pleasantness of body posture, subjective valence of the words, and mean recalled words as a function of body posture and valence of the words in Experiment 1

Body posture	Standing upright		Kneeling down	
Valence of the words	Positive	Negative	Positive	Negative
Mood	6.5	6.6	7.4	6.1
Pleasantness of the body postures	6.8	6.9	5.9	4.6
Subjective valence of the words	6.9	3.1	6.2	2.2
Mean number of correct recalled words	5.3	5.7	5.6	6.0

Note. Judgments were made on 9-point rating scales for mood (1 = very bad, to 9 = very good), pleasantness of the body posture (1 = very unpleasant, to 9 = very pleasant), and subjective valence of the words (1 = very negative, to 9 = very positive).

pleasant than kneeling down, $F(1, 36) = 6.15, p = 0.018$, for the main effect of Body Posture, regardless of the valence of the words or the joint function between the factors, Fs < 1.18, ps > 0.285, respectively. As expected, and as can also be seen from Table 1, positive words were rated as more positive ($M = 6.55$) than negative words ($M = 2.65$), $F(1, 36) = 67.60$, $p < 0.001$, for the main effect of Word Valence. Furthermore, cursory examination of Table 1 indicates that words were rated as more positive when participants encoded them while standing upright ($M = 5.00$) than when participants encoded them while kneeling down ($M = 4.20$), but the analyses could not confirm this suggestion at the conventional 5%, $F(1, 36) = 2.84, p > 0.10$, for the main effect of Body Postures. The interaction of the two factors was non-significant, $F < 1$.

Free Recall

To see whether participants' attention was equally limited by the learning task, the mean number of recalled words (see also Table 1) was entered into a 2(Body Posture) × 2(Word Valence) ANOVA. As intended, neither the main effects nor the interaction was significant, all Fs < 1.

Dexterity Performances

Our main hypothesis was that participants in compatible conditions would perform better on a secondary task than participants in incompatible conditions (see Table 2). First, a 2(Body Posture) × 2(Word Valence) × 2(Time of Measurement) ANOVA for mixed factorial designs revealed a marginally significant main effect of Body Posture, $F(1, 36) = 3.21$, $p < 0.10$, showing that performance was better while standing ($M = 14.5$) compared to kneeling ($M = 13.4$), and a significant main effect of Time, $F(1, 36) = 7.37$; $p < 0.05$, showing that participants were worse while learning ($M = 13.6$) than while performing the dexterity task before learning ($M = 14.3$). The latter finding might suggest that while learning, participants defined the task as a secondary task or that they were simply distracted by the additional learning task.

Table 2. Finger dexterity task: mean performance (holes filled with three metal pins) as a function of body postures, valence of the words and time of measurement in Experiment 1

Body posture	Standing upright				Kneeling down			
Time of measurement	Baseline		While learning		Baseline		While learning	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Valence of the words								
Positive	14.9	2.1	14.9	2.8	14.3	2.3	12.7	2.1
Negative	14.4	2.0	13.7	2.5	13.4	1.3	13.1	1.2

Those main effects, however, were qualified, as predicted by the significant three-way interaction, $F(1, 36) = 4.31$, $p < 0.05$. No other effects were significant. Within the kneeling condition, participants performed significantly less compared to baseline when they where learning positive words, $F(1, 36) = 10.89$, $p < 0.01$, and this change was significantly greater than the difference within the standing-upright condition, $F(1, 18) = 5.45$; $p < 0.05$, for the simple interaction. On the other hand, for participants who learned negative words within the standing upright condition, the simple main effect of Time was not significant, $F(1, 36) = 2.22$, $p > 0.10$, nor was this change different from that in the kneeling condition, $F < 1$, for the simple interaction. There were also no significant simple main effects in the two compatible conditions, Fs < 1.

Thus, the study provides first evidence for our preparedness hypothesis, especially for the avoidance body posture. To test whether this effect was mediated by feelings of pleasantness or participants' mood, the mean pleasantness and current mood ratings were entered into the analysis as covariates. The interaction still remained significant, ruling out those variable as potential mediators for the obtained motor-compatibility effect.

Discussion

The results show that cognitive resources are reduced in the case of incompatibility between body postures and valenced stimuli. Participants who kneeled down while learning positive words performed worse on the secondary task compared to baseline whereas for all other groups this inhibition effect could not be observed. The lack of a similar finding for the standing upright condition might reflect the lack of power in the experiment or the fact that this body position is not specific enough for the suggested motivational approach orientation without feedback. Stepper (1992) for example only found influences of standing upright postures on pride judgments, when positive feedback was provided before the judgment but not, when no feedback was given.

However, the findings demonstrate the benefits of conceptual-motor compatibility with emotionally expressive body postures at least for avoidance patterns. This effect was not mediated by participants' mood or their experiences of pleasantness of the body postures. Thus, the compatibility between sensory stimulation and the valence of information directly determines participants' capacity to work on a second task. The overlearned association between kneeling down or a slumped position and negative information leads to observable attentional advantages, showing that compatibility effects are not restricted to head movements (Förster & Strack, 1996). Moreover, and central to our main reasoning, the results suggest that easily maintained expression patterns like kneeling down prepare the input of compatible information, providing first direct evidence for the 'preparedness hypothesis' described above. The mere and unconscious activation of an avoidance motivational system seems to influence attentional resources during the process of information processing.

However, this experiment might not be compelling enough to rule out the distraction hypothesis. For example, one might argue that the valence of the information immediately motivates a person to behave in a congruent manner. Participants in compatible conditions are thus already in a matching bodily posture, whereas participants in incompatible conditions are not. In the latter case, participants might be immediately motivated to change their posture, resulting in distraction. On the other hand, it might be the case that the expression patterns themselves facilitated or inhibited processing of valenced information.

To clarify this question, a second experiment was designed, in which we replaced the motor patterns with a non-behavioral sensory stimulation, specifically, positive versus negative gustatory stimulation. Here, participants are free to express either approach or avoidance behavior (such as arm movements or other bodily reactions). As a result, the expected congruence effect can only be caused by different bodily states and not by distraction, induced by the valence of the information and motivated behavior change in incompatible situations. Another obvious advantage is that the results would generalize conceptual-*motor* compatibility effects to other sense modalities. Since it is argued that activated approach versus avoidance systems guide the encoding process of valenced information, there is no reason to assume that they can be activated solely by motor cues.

EXPERIMENT 2

Our second study thus used a gustatory manipulation, experimentally varying sweet and bitter taste. There are indicators that sensations elicited by gustatory stimuli can evoke pain and pleasure. In general, people prefer consistently sweet taste and reject bitter taste (Pfaffmann, 1961). Bartoshuk and Beauchamp (1994) suggest a genetic determination. The authors argue that a preference for sweet tastes has higher survival value because sweet substances are more likely to be nutritious, while bitter substances are more likely to be poisonous. Thus, an organism's response to sensory stimulation can be categorized as one of three possible kinds: (1) approach or acceptance, (2) rejection or withdrawal, and (3) neutrality (Pfaffmann, Norgren, & Grill, 1977). Moreover, there is evidence that gustatory preferences and aversions are inborn, because a preference for sweet over neutral taste was also found in newborns from different cultural backgrounds (Desor, Maller, & Turner, 1973).

Although taste preferences may change as a function of various environmental influences (for a review, see Logue, 1986), these findings suggest that human choices about nutrition are controlled by a 'hedonic monitor system' (Steiner, 1979). If gustatory stimuli are capable of eliciting bodily states of pain and pleasure, they should be able to influence various domains of cognitive functioning even without an act of willing. In the same way that motoric stimulation presumably facilitates encoding of compatible information and inhibits encoding of incompatible information by preparing the organism for certain inputs, it is also conceivable to predict capacity advantages for the sense modality of taste: in general, sweet taste should be more associated with positive information and approach (e.g. a nice dinner), whereas bitter taste should be more associated with negative information and avoidance (e.g. poisoned food). Specifically, we predicted that participants in compatible conditions (sweet and positive, bitter and negative) would have more residual attention to perform the secondary task than participants in incompatible conditions (sweet and negative, bitter and positive).

To examine this hypothesis, we developed an experimental paradigm in which a pleasant or an unpleasant taste was elicited as an ostensible measurement of components of the saliva while participants were performing a cognitive task. Using this procedure, participants were prevented from perceiving taste as an intentional, experimental treatment. Instead, they were led to focus on a learning task which would supposedly have hormonal effects that could be registered by sampling their saliva with a cotton ball soaked in carrier fluid. This fluid actually differed in taste between experimental conditions. Again, this cover story was employed to avoid possible interpretations of predicted results in terms of self-perception mechanisms. Additionally, in order to measure cognitive resources during the learning process, the finger dexterity task of Experiment 1 was used as a secondary task.

Method

Participants

Participants were 48 students of the University in Trier, Germany, majoring in different disciplines. DM 10.- (at the time *ca* US$7.-) was offered for participation. Participants were recruited for a physiological study on 'enzymes in saliva while learning words'. This cover story was used because the physiology department at the University in Trier is well known for measuring hormones with this paradigm, lending credibility to the procedure.

Stimulus Material

Stimulus materials included 24 positive and 24 negative adjectives from the word pool of Förster and Strack (1996). For the taste induction, participants received a wad of cottonwool that was filled either with sugar water (sweet) or with yellow gentian tea (bitter). The dexterity task was the same as in the experiments above.

Procedure and Design

Upon arrival, participants were told that they would receive a wad of cotton filled with an innocuous carrier fluid and to keep it in their mouths while learning words via headphones and solving a motoric task that would distract them from learning. Again, to channel participants' attention, an award of DM 20,- (at the time *ca* US$ 14.-) was offered for the best performance in the recognition test.

Following these instructions, participants were given two training sessions on the dexterity task, one with and one without a cotton ball in their mouth. Again, these two sessions served as a baseline for the performances during the learning process. After the training, the cotton ball was removed and participants received a new wad with the same taste. They then performed the dexterity task while learning 12 words of either positive or negative valence and 2 neutral buffer items which were presented via headphones. As in Experiment 1, this encoding phase lasted 150 seconds, including music at the beginning and at the end of the tape, and an audible stop sign for the experimenter to stop the participant from performing the secondary task. The cotton wad was then removed and participants performed several filler tasks for at least 30 minutes. Then, participants had to answer a yes/no-recognition test, including 12 targets (the 12 items which had been presented in the previously presented list) and 12 distractors (new items) followed by a questionnaire containing questions about the pleasantness of the taste, participants' current mood, and the valence of the words, as in Experiment 1. The memory task was now recognition because we wanted to explore whether compatibility effects on memory would more likely appear in a test more sensitive for memory effects due to encoding like yes/no recognition. Interviews following the experiment revealed that all participants believed the cover story. Finally, participants were debriefed, thanked, and paid.

Accordingly, the design was a 2 × 2 factorial, comparing Taste (sweet versus bitter) and Word Valence (positive versus negative) between participants. Time of measurement (baseline versus while learning) served as a within factor.

Results

Ratings of Mood, Pleasantness of the Taste, and Subjective Word Valence

Mean ratings of mood, pleasantness, and subjective valence of the words are presented in Table 3. As can be seen from the table, different tastes were not able to differentially affect participants' current mood, all $F\text{s} < 1$. However, the tastes differed in pleasantness, with the sweet taste being more pleasant ($M = 4.74$) than the bitter taste ($M = 2.73$), $F(1, 44) = 12.79$, $p < 0.001$, for the main effect of Taste. All other effects were non-significant. Word Valence did not affect the evaluation, $F(1, 44) = 2.12$, $p > 0.15$, neither did the joint function between the two factors, $F < 1$.

As expected, analyses on the subjective valence ratings for the words revealed that participants rated positive words as more positive than negative words, $F(1, 44) = 198.81$, $p < 0.0001$, whereas all other effects were not significant.

Recognition

The mean affirmative answers for targets (hits) and distractors (false alarms) are also summarized in Table 3. A 2(Taste) × 2(Word Valence) × 2(Item Type) repeated-measures ANOVA was conducted to assess whether participants' learning was affected

Table 3. Mean ratings of mood, pleasantness of taste, subjective valence of the words, and mean recalled words as a function of taste and valence of the words in Experiment 2

Taste	Sweet		Bitter	
Valence of the words	Positive	Negative	Positive	Negative
Mood	6.4	6.7	6.2	6.5
Pleasantness of the taste	5.2	4.3	3.1	2.4
Subjective valence of the words	7.6	1.7	8.2	1.8
Mean proportion of yes responses on targets (hits)	0.56	0.52	0.50	0.49
Mean proportion of yes responses on distractors (false alarms)	0.38	0.26	0.28	0.33

Note. Judgments were made on 9-point rating scales for mood (1 = very bad, to 9 = very good), pleasantness of the taste (1 = very unpleasant, to 9 = very pleasant), and subjective valence of the words (1 = very negative, to 9 = very positive).

by the induced taste or word valence. The only significant effect was the trivial main effect of Item Type, $F(1, 44) = 51.93, p < 0.001$, indicating that participants were able to discriminate targets from distractors. No other effects gained significance. Thus, participants attended equally to the learning task across conditions.

Dexterity Performances

The means for the dexterity performance are presented in Table 4. The 2(Taste) × 2(Word Valence) × 2(Time of Measurement) ANOVA or mixed factorial designs revealed a significant main effect of Time of measurement, $F(1, 44) = 11.23$; $p < 0.01$, and the significant two-way interaction between Time of Measurement and Taste, $F(1, 44) = 6.15$; $p < 0.05$, which were both qualified by the predicted significant threeway interaction, $F(1, 44) = 7.28$, $p < 0.01$. No further effects were significant. Simple main effect analyses further revealed that participants with bitter taste performed significantly worse while learning positive words compared to baseline, $F(1, 44) = 16.71, p < 0.01$, and this change was significantly greater than the difference within the sweet taste condition, $F(1, 22) = 13.94; p < 0.001$, for the simple interaction. On the other hand, participants with sweet taste performed significantly worse while learning negative words compared to baseline, $F(1, 44) = 4.27, p < 0.05$, however, here the simple interaction between Time and Taste was not significant, $F < 1$. For the two compatible conditions, those differences were not significant, (bitter and negative words: $F(1, 44) = 3.05$; $p > 0.05$; sweet and positive: $F(1, 44) = 1.43, p > 0.10$.

Entering the pleasantness and mood ratings as covariates into the statistical analyses did not weaken the observed interaction effect.

Discussion

The results of the second experiment demonstrated that the induction of gustatory stimuli can produce compatibility effects: participants with a sweet taste who learned

Table 4. Finger dexterity task: mean performance (holes filled with three metal pins) as a function of body postures, valence of the words and time of measurement in Experiment 2

Taste	Sweet				Bitter			
Time of measurement	Baseline		While learning		Baseline		While learning	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Valence of the words								
Positive	18.3	3.9	19.3	5.5	19.0	1.4	15.3	3.7
Negative	18.2	2.5	16.3	1.2	17.8	2.5	16.2	3.0

negative words and participants with a bitter taste who learned positive words were worse at the dexterity task compared to baseline, while these inhibitory effects could not be observed in the compatible conditions.

Because participants in all conditions did equally well on the memory task, the results in the secondary task could show clear differences in their residual cognitive capacity. Importantly, compatibility between taste and valence of information led to better performances on the secondary task than incompatibility, a finding that may extend the scope of the earlier conceptual-*motor* compatibility model (Förster & Strack, 1996). As in Experiment 1, no mood effects mediated this influence.

Overall the findings confirm the hypothesis that compatibility between bodily states and information requires less cognitive capacity. Through countless repetitions, a good taste is associated with something positive and with approach, whereas a bad taste is associated with avoidance. If compatibility between activated approach or avoidance systems and the valence of information is then established by the situation, further information processing requires less cognitive capacity than a condition of incompatibility. Thus, like motor perceptions or proprioceptive cues, the stimulation induced by differentially valenced taste determines residual attention during the learning process.

GENERAL DISCUSSION

In two experiments we have demonstrated that incompatibility between motor and gustatory sensory stimulation and information has its cost. Incompatibility between body postures or gustatory stimulation and evaluative information led to poorer performance on a secondary task, leaving performance on the main learning task unaffected. The lack of effects of expressions or taste on memory performances in the above experiments were intended. Because incentives for good memory performances were high, attention was paid to the learning task, whereas the secondary task captured residual attention. That is, by ensuring that all cognitive resources are equally channeled to the main task, any residual attention should show up in a secondary task (Hasher & Zacks, 1979; see Förster & Strack, 1996). Moreover, these results may point to another assumption: that the allocation of increased attention to a certain task may serve to counteract an impairment during the process of encoding valence (Förster & Strack, 1996). While it is possible to overrule pre-existing associations, this process requires additional attentional capacities, as reflected in the performance on the secondary task. These results extend prior findings (Förster & Strack, 1996), which showed compatibility effects with head *movements*, by generalizing them to emotional body *postures* and bodily *states* of pleasant versus unpleasant taste.

It has to be noted though that in our experiments we were unable to demonstrate facilitation effects (i.e. better performances in compatible conditions compared to baseline). In our paradigm in general worse performances were obtained in the learning phases compared to the baseline. This could be due to simple distraction by doing two tasks at the same time or to less attention to the 'secondary task' in the learning phases, so that the task was just insensitive to discover facilitation. Thus, further research is needed to decide if compatibility can also *facilitate* encoding. Our preparedness hypothesis, however, includes such a facilitation assumption relative to control groups given that the task at hand is not in itself too simple as well as it includes inhibition as demonstrated in the experiments above, given that the task in itself is not too difficult for everybody. The paradigm above seems to be especially useful for discovering inhibition, since it appears that for the majority of the participants performing the finger dexterity task is more difficult while learning compared to performance without learning.

As argued within current facial feedback frameworks (e.g. Strack *et al.*, 1988), the observed effects are difficult to explain by self-perception mechanisms. In both studies, cover stories prevented participants from inferring the meaning of the manipulations. Awareness of the meaning, however, is a precondition for further inference processes. Furthermore, self-reports at the end of the studies revealed that none of the participants guessed the meaning of the manipulations. Finally, even if one assumes that participants knew that they were expressing pride, for example, it is highly unlikely that they would have made any connection between this and their performance on a finger dexterity task as compared to that of participants in the other conditions, which they did not even know about. Thus, these results strongly support facial feedback theories that predict direct influences of behavior on cognition (Strack *et al.*, 1988), and extend them by showing similar effects on attentional resources during the encoding process with stimuli other than proprioceptive ones. Moreover, the present conceptualization of facial feedback, where its effects are due to activation of proprioceptive stimulation which then activate approach versus avoidance systems, allows generalization for all kinds of sensory stimulations, as for example taste. The experiments show that motoric as well as gustatory stimulation lead residual attention while the process of encoding differentially valenced information.

Distraction of behavior by incoming incompatible information can be ruled out as the cause for this capacity-reducing process. Whereas it is possible to argue that head movements can be impeded by automatic goal-activation elicited by valence-incompatible information, it seems less compelling to argue that a valenced goal led to a motivation to change the body posture as in Experiment 1, causing differences in cognitive resources based on compatibility. Moreover, such a distraction argument seems to be at odds with the results of Experiment 2, in which participants' behavior was unspecified and mere taste experiences freed cognitive capacities in case of compatibility. We do not intend to argue that goals can not directly and automatically activate or intensify approach or avoidance tendencies, as suggested and shown by others (Chen & Bargh, 1999, see also Förster, Higgins, & Idson, 1998). However, since it had already been shown that in cases in which a situation of compatibility has been set up, behavior such as pushing or pulling (Chen & Bargh, 1999) and nodding or head shaking (Wells & Petty, 1980) can be facilitated or inhibited by information, it was important to us to show that a bodily state can also *prepare* an organism for processing valence-compatible information. Thus, both processes might work independently and in their own right.

One might now wonder about the boundary conditions for the observed effects, which still need to be investigated. One could argue that incompatibility does not affect encoding if the task at hand does not entail some effort or concentration. That is to say, if, for example, standardized movements can easily be automatized or cognitive tasks do not require very many resources, they may not be slowed down by incompatibility (Förster, 1995).

This reasoning leads to the prediction, for example, that people who automatized the performance of some incompatible expressions in social situations (e.g. smiling at a person whom one does not like) might not be affected by incompatibility. Based on the results above, one could, for example, predict capacity deficits for people who mask their facial display in a conversation (e.g. Matsumoto, 1990), so that incompatibility leads to less recall of the content of the exchange. It would be interesting to investigate if people who are trained to mask their emotional expression have the same deficits. To give just one example, it has been shown that men are less expressive than women (Henley, 1977). This might be due to the fact either that men do not feel as intensely or that they are trained to intentionally mask their expressive patterns more than women, for whatever reasons. In any case, this raises the question whether women actually encode less than men when they have to mask their internal states. One could argue that masking creates a more incompatible situation for women than for men, who do not feel so intensely to begin with or are better trained in masking their feelings, and therefore simply find themselves less frequently in situations of incompatibility.

Finally, it might be asked whether situations in which free expressions are allowed, for example when teachers support rather than impede their students' liveliness, improve the overall performance of students via the same mechanism. In sum, the question when and where such impairments due to incompatibility take place seems to us a worthwhile topic for a full exploration of the construct of conceptual-*sensory* compatibility. It may be more general than the still limited empirical examples suggest.

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