Influence of Overt Head Movements on Memory for Valenced Words: A Case of Conceptual–Motor Compatibility

Jens Förster and Fritz Strack
Universität Trier

The present article reports 3 studies that demonstrate the influence of overt behavior on recognition and elucidates the theoretical basis for such an influence. In 2 experiments it was found that participants who were induced to nod while incidentally encoding positive and negative adjectives were more likely to recognize positive adjectives, whereas participants who were induced to shake their heads were more likely to recognize negative words. In a third experiment, with a double-task procedure, it was shown that when encoding was accompanied by head movements that were compatible with words, participants were better at performing the secondary task than when words and head movements were incompatible. These findings suggest that performing incompatible motoric and conceptual tasks concurrently requires more cognitive capacity. Where this capacity is allocated and when it is withdrawn depends on the characteristics of the task. Implications of this mechanism for different phenomena in social psychology (e.g., facial feedback and masking of emotional displays) are discussed.

How a behavior may affect people's thinking has typically been conceptualized in terms of self-perception. It has been postulated (Bem, 1967) that a behavior may be used to infer internal states if the latter are weak or ambiguous. Self-perceptual mechanisms have subsequently been demonstrated in a variety of domains (see Olson & Hafer, 1990). To draw such inferences, however, people must be aware of the meaning of the observed behavior. That is, only if they know (or believe) that, for example, eating is a behavioral manifestation of liking food (see Bem, 1966), or that smiling is a behavioral expression of being amused (see Olson, 1992), can they infer their internal state from the perception of their own behavior. Although this mechanism operates under many circumstances, it may not be the only means by which behavior influences cognition.

Relevant evidence comes from studies on the regulative function of emotional expressions. Researchers have shown, primarily in the context of the so-called facial-feedback theory (for a review, see Adelman & Zajonc, 1989), that behavioral expressions affect reported feelings and subsequent judgments even when people are effectively prevented from recognizing the meaning of those expressions (e.g., Martin, Harlow, & Strack, 1992; Strack, Martin, & Stepper, 1988; Zajonc, Murphy, & Inglehart, 1989). For example, Strack et al. (1988) found that when participants held a pen with their teeth to facilitate a smiling expression, they rated cartoons as being funnier than did participants who held a pen with protruded lips, precluding a smiling expression. Stepper and Strack (1993) also found nonobtrusive influences for body posture and furrowing the brow.

Although these findings result from manipulating responses that express feelings and emotions, other research has shown that movements may have similar effects. Cacioppo, Priester, and Berntson (1993) found that participants liked neutral stimuli more after participants had performed a type of approach behavior (pressing the arm upward against a table) than a type of avoidance behavior (pressing the arm downward on a table; see also Priester, Cacioppo, & Petty, 1996).

That such motor influences may operate in more complex social situations was ingeniously demonstrated by Wells and Petty (1980), who showed that certain motor actions may affect attitudinal persuasion. Participants were asked to move their heads either horizontally, vertically, or in an unspecified fashion while they listened to music and editorial radio broadcasts, presumably to find out if headphones can be worn during walking.
or dancing. These editorial statements were composed such that they either supported or contradicted participants' preexisting attitudes. Wells and Petty found that regardless of participants' initial attitudes and the content of the editorial, participants who were induced to perform a vertical head movement agreed more with the editorial than did participants who performed a horizontal movement. However, the frequency of the different movements depended on participants' attitudes: When the editorial supported their attitudes, they nodded more and shook their heads less, whereas the reverse was the case when the editorial was counterattitudinal (for another application of this experimental paradigm, see Tom, Pettersen, Lau, Burton, & Cook, 1991).

Wells and Petty (1980) suggested that their findings may reflect a mechanism of response compatibility that affects the production of favorable or unfavorable arguments that determine persuasion (Petty, Wells, & Brock, 1976). Specifically, the authors assumed that because of previous learning, vertical head movements are compatible with and facilitate the generation of favorable thoughts and inhibit the production of counterarguments, whereas the reverse is true for horizontal head movements.

If the compatibility of head movements with cognitive contents affects the production of cognitive responses in persuasion, it seems plausible that such motor compatibility effects also may operate on more basic levels of processing. More specifically, the dynamics of memory may be subject to the compatibility of motor actions and the processed information (Förster, 1995). Thus, the effect of head movements on judgments in Wells and Petty's (1980) study could be due to memory mechanisms: Because participants performed the head movements only during the encoding phase, they may have remembered the motor cues in the judgment phase, which may in turn have influenced the subsequent judgments. It also seems possible that the processing of arguments in Wells and Petty's study was more effective when the arguments were compatible with a motor action than when they were not. As a consequence, we assumed that words with a positive valence may be better remembered when learning is accompanied by vertical head movements, whereas words with a negative valence may be better remembered when learning is accompanied by horizontal head movements. In other words, we predicted a motor-compatibility effect.

Method Overview of Experiments 1 and 2

Our participants, as did participants in Wells and Petty's (1980) study, tested headphones for an ostensible marketing research project. Specifically, they were asked to test the wearing comfort of the headphones and their sound quality for music and words while they engaged in prototypical dancing movements. We used this cover story to reduce the chance that the induced head movements would be interpreted as an expression of agreement or disagreement and that no inferences would be drawn from such an interpretation.

On this pretext, we assigned participants to conditions that required vertical or horizontal head movements or to a control condition. In an incidental encoding phase, participants heard positive and negative words through the headphones. After a delay, recognition of the words was tested.

Experiment 1

Method

Stimulus material. For the first study we selected as stimulus materials 38 German adjectives that had been rated as very positive (e.g., schön[beautiful]) and 38 adjectives that had been rated as very negative (e.g., schrecklich[terrible]). Four neutral words served as fillers.

Participants. Participants were 60 students at the University of Trier (Trier, Germany). They were recruited for headphones tests and offered DM 10.- (approximately $7.00 at the time) for their participation. They were randomly assigned to the conditions and tested in individual sessions.

Procedure and design. Participants were instructed to evaluate the comfort of headphones under different conditions of head movements for an ostensible marketing research project. The experimenter demonstrated the required head movements by shaking, nodding, or rotating his head in a circular motion. Participants were instructed to perform these movements regularly at a rate of approximately one movement per second. Participants listened to music and a word list. The tape began with 60 s of music (tango of Astor Piazzolla) followed by a list of 19 positive, 19 negative, and 4 neutral words. The recording concluded with 30 s of the same tango music. Participants were then given a questionnaire about the acoustic quality and the wearing comfort of the headphones.1 After answering these questions, participants were given a filler task in which they rated the frequency of a set of words. After 15 min, a surprise recognition test was administered: Participants received a test list that contained the 38 target words from the learning list as well as an additional 19 positive and 19 negative distractor words that had not been previously presented. Participants were not informed about the proportions of targets and distractors in the test. For each word, participants indicated whether the word had been presented previously. Finally, participants were probed for suspicion. No one mentioned a possible connection between head movements and memory. Instead, some participants believed the elaborate setup was meant to distract them from the surprise memory test that was presented as an unobtrusive measure for their understanding of the words.

The experimental design was a 3 × 2 × 2 mixed-model factorial that compared head movement (horizontal vs. vertical vs. circular) between subjects and word valence (positive vs. negative) and item type (target vs. distractor) within subjects. To test the statistical reliability of obtained mean differences, we conducted an analysis of variance (ANOVA) on participants' recognition of the target words.

Results

Recognition. The results of the study are summarized in Table 1, which contains the number of "yes" responses as a function of head movement (horizontal vs. vertical vs. circular), word valence (positive vs. negative), and item type (target vs. distractor). Additionally, Figures 1 and 2 contain means reflecting indices of participants' ability to discriminate target from distractor words (Pr) and their more general response tendencies (Br, which reflects a tendency to respond in the affirmative, independent of the target–distractor distinction). These last two indices were derived from two high threshold theory (Snodgrass & Corwin, 1988).

1 These evaluations were not influenced by the induced head movements or the valence of the words.

2 To apply the logic of signal detection theory (Green & Swets, 1966) to situations with small numbers of observations, Snodgrass and Corwin (1988) derived two measures from their two high threshold theory. Pr describes participants' discrimination performance; the higher the Pr value, the better participants' discrimination between targets and dis-
Table 1  
Mean Number of “Yes” Responses as a Function of Head Movements, Item Type, and Valence  
for Experiment I

<table>
<thead>
<tr>
<th>Head movements</th>
<th>Horizontal</th>
<th>Vertical</th>
<th>Circular</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target</td>
<td>Distractor</td>
<td>Target</td>
</tr>
<tr>
<td>Positive</td>
<td>8.6b</td>
<td>5.9c</td>
<td>11.5a</td>
</tr>
<tr>
<td>Negative</td>
<td>8.9b</td>
<td>4.8c</td>
<td>8.5b</td>
</tr>
</tbody>
</table>

Note. Number of items = 19. Values with different subscripts differ significantly at p < .05 (Scheffé test).

Inspection of Table 1 reveals that recognition responses were affected by all independent variables. First, more “yes” responses were consistently uttered when the test word was a target (M = 9.27) than when it was a distractor (M = 5.72), F(1, 57) = 89.35, p < .001, for a main effect of item type. That is, participants were able to discriminate whether words had been previously presented.

Second, regardless of whether words had been presented, positive words elicited more “yes” responses (M = 8.00) than negative words (M = 6.98), F(1, 57) = 8.76, p = .004, for a main effect of word valence. This suggests that participants used a more liberal response criterion for positive words. Although this tendency was more consistent for distractors than for targets, the appropriate two-way interaction between item type and word valence was not significant, F(1, 57) = 1.71, p = .20.

Third, vertical head movements yielded a different response pattern from both horizontal and circular movements. Specifically, the appropriate two-way interaction between head movement and word valence was significant, F(2, 57) = 3.29, p < .05. Participants who were induced to nod emitted more “yes” responses for positive words (M = 9.25) than for negative words (M = 7.00), which was not the case for participants in the remaining conditions. A posteriori comparisons with Scheffé tests revealed that a significant difference (difference criterion [5%] = 1.47) between positive and negative words was obtained only for participants in the nodding condition.

Fourth, the effects of head movements and word valence depended on whether the items were targets or distractors. As predicted, vertical movements led to a better differentiation between targets and distractors when the words had a positive valence; vertical and circular movements led to better target–distractor discrimination for negative words. The appropriate three-way interaction was significant, F(2, 57) = 4.58, p < .02. A posteriori Scheffé tests (difference criterion [5%] = 1.64) indicated that only participants who were induced to nod remembered more positive targets, whereas no significant differences were obtained in the other head-movement conditions. The ANOVA yielded no other significant effects (all ps > .15).

Pr and Br measures. This pattern of results can be simplified by forming indices that reflect both participants' discrimination between targets and distractors and their indiscriminate tendency to answer affirmatively. We carried out separate 3 (head movement) X 2 (word valence) mixed-model ANOVAs for the two measures (Pr and Br). As can be seen in Figure 1, participants who performed vertical head movements produced higher Pr values for positive than for negative words; participants who nodded were better able to discriminate between positive targets and distractors than between negative targets and distractors. The reverse was true for participants who performed either horizontal or circular movements; participants

tractors. Br describes participants' response tendency; the higher the Br value, the greater participants' tendency to say "yes" regardless of whether a word was presented. Arithmetically, \( Pr = H - FA \), \( Br = FA/[1 - (H - FA)] \), where H indicates the proportion of correct identifications (hits) and FA the proportion of incorrect identifications (false alarms).

Figure 1. Experiment 1: Mean Pr values as a function of word valence and head movements. Pr is an indication of discrimination performance; higher values indicate better discrimination between targets and distractors.
who shook or rotated their heads in a circular motion were better able to discriminate between negative targets and distractors than between positive targets and distractors. This suggests that the discrimination between targets and distractors was improved when head motion was compatible with word valence. This effect was borne out by a significant two-way interaction between head movement and word valence, $F(2, 57) = 4.58$, $p = .014$, which is equivalent to the above significant three-way interaction involving "yes" responses. Participants' response tendency ($Br$), in contrast, was influenced only by the valence of the words, as can be seen in Figure 2. That is, participants adopted a more liberal criterion for a "yes" response when the item was positive than when it was negative, $F(1, 57) = 8.79$, $p = .004$, for the main effect of word valence. The ANOVAs yielded no other significant effects on the $Pr$ and $Br$ indices (all $ps > .10$).

**Discussion**

The results of Experiment 1 suggest that the recognition of positive and negative words was influenced by both the valence of the stimulus and the compatibility between valence and participants' motor actions at the time of learning. However, these two effects appear to be due to different psychological mechanisms. The finding that a positive valence yielded more recognition responses—including incorrect recognition responses—appears to be a judgmental mechanism that is independent of the actual presentation of the stimulus. As has been frequently demonstrated, different knowledge bases may be used to draw inferences about the previous occurrence of a test stimulus (e.g., Strack & Bless, 1994; Strack & Förster, 1995). The valence of a stimulus may provide such knowledge. As Matlin and Stang (1978) argued, positive aspects of our environment may cause a "Pollyanna bias," which leads to an overestimation of such events.

More important, however, was the compatibility effect that depends on the actual presentation of the test stimuli. That is, participants' ability to accurately decide whether a word was presented depended on the match between word valence and head movements. As the data clearly show, participants were better at such discrimination when positive words were presented while they executed vertical head movements and when negative words were presented while they performed horizontal or circular head motions. Because compatibility affects the discrimination between stimuli that were actually presented (vs. not presented), the effect seems to be memory based. Moreover, because the head movements occurred only in the learning phase, the present effect can be assumed to occur during encoding and not during retrieval.

One finding, however, was somewhat unexpected: Participants who rotated their heads in a circular fashion closely resembled participants in the horizontal-movement condition (i.e., participants who shook their heads). In retrospect, these results seem less surprising if one views the circular motion as an extension of a horizontal movement and thus exerts similar compatibility effects. Alternatively, the circular head movements may have been affectively ambivalent because they possess both positive components (from vertical movements) and negative components (from horizontal movements). In light of a recent model of evaluative space (Cacioppo & Berntson, 1994), such an affective coactivation will be predominantly negative. Cacioppo and Berntson's (1994) model, derived from research on conflict (Miller, 1959), predicts in the case of ambivalence a steeper slope for negative than for positive input, resulting in a negativity bias.

**Experiment 2**

To obtain more information about the memorial and judgmental process underlying the motor compatibility effect, we performed a second experiment. This experiment was primarily designed to replicate the previous findings, using some procedural modifications.

The first change was in the interval between encoding and recognition. Previous research has shown that memory effects are stronger when there is a clear recollection of the item, whereas judgmental strategies are more likely to operate when a recollection is blurred or absent (e.g., Strack & Bless, 1994). Therefore, in Experiment 2 we shortened the retention interval. Because under such conditions recollection is improved and schematic retrieval processes are less likely to influence recognition (Matlin & Stang, 1978), a possible positivity bias should be attenuated. Moreover, if a motor-compatibility effect is, in fact, memory based, it should be stronger after a shorter retention interval.

A second alteration applied to the control condition. To avoid...
the described ambiguity of a circular head movement, we used a control group in which participants received no instruction about head movements. To test for affect as a mediating mechanism (e.g., Laird, Wagener, Halal, & Szegda, 1982), we assessed participants' moods immediately after the learning phase of the experiment. It seemed reasonable that the different head movements might have induced different moods in participants and that these different moods, in turn, would systematically influence recall (see Blaney, 1986).

**Method**

The stimulus materials were the same as those in Experiment 1. Participants were 30 students enrolled in an introductory psychology class at the University of Trier. These participants were recruited for a headphone test, received course credit for their participation, and were randomly assigned to the experimental conditions.

The experimental design was a $3 \times 2 \times 2$ mixed-model factorial that compared head movement (horizontal vs. vertical vs. no movement) between subjects and compared word valence (positive vs. negative) and item type (target vs. distractor) within subjects. Experiment 2 differed from Experiment 1 in the following aspects: (a) The cover story was about a test of the usability of headphones in dance therapy; such an innovation would allow clients to receive their individualized music and instructions. (b) Control participants performed no head movements. (c) After the learning phase, participants had to report their current mood on a 9-point rating scale that ranged from 1 (very bad) to 9 (very good). (d) The interval between learning and recognition was shortened to 5 min.

**Results**

**Mood.** Participants' reported moods were not affected by their head movements. Mood ratings under the horizontal ($M = 6.00$), vertical ($M = 6.10$), and no-movement ($M = 6.40$) conditions did not differ significantly from one another ($F < 1$). Apparently, the compatibility effect in this experimental context is not a function of the mood evoked by different head movements.

**Recognition.** The numbers of recognition responses are depicted in Table 2. The main effect for item type was highly significant, $F(1, 27) = 32.34, p < .001$. An inspection of Table 2 reveals that targets elicited more “yes” responses ($M = 9.48$) than did distractors ($M = 5.60$), which is consistent with the nature of the task. There was also a significant two-way interaction between word valence and head movement, $F(2, 27) = 5.00, p < .02$, which was, however, qualified by the predicted higher order interaction among word valence, head movement, and item type, $F(2, 27) = 4.94, p < .02$. This significant three-way interaction reveals that, as in Experiment 1, discrimination between targets and distractors depended on the match between the movements of the head and the valence of the words. Discrimination was improved when negative words were associated with horizontal (shaking) head movements and when positive words were associated with either vertical (nodding) or no head movements. A posteriori Scheffé tests revealed (difference criterion [5%] = 2.65) that “yes” responses for targets were significantly determined by valence in the predicted direction, whereas distractors were not.

Similarly, findings with the $Pr$ and $Br$ indices (see Figures 3 and 4) show that participants were better at discriminating targets and distractors when head movements and word valence were compatible, $F(2, 27) = 4.94, p = .02$. Again, the obtained two-way interaction for the $Pr$ index is equivalent to the above significant three-way interaction for the “yes” responses. It is also interesting to note that, unlike in Experiment 1, the discrimination performance in the passive control group was much less a function of the valence of the words, perhaps because the no-movement condition is a more appropriate control condition than was a circular head movement. A Scheffé test failed to find significant differences between cells, which suggests that all differences contributed equally to the significance of the interaction effect. It should also be noted that participants' reported mood did not correlate with the recognition measures for the particular word categories. Correlations between mood ratings and $Pr$ measures ranged from $r = -.07$ to $r = -.46$ and were not significant at all ($ps < .18$).

Inspection of the $Br$ measures reveals that no consistent judgmental bias was obtained for the positive valence of the words, $F(2, 27) = 1.58, p > .20$. A significant crossover interaction between head movement and word valence in combination with additional Scheffé tests (difference criterion [5%] = 0.13) revealed that when participants performed horizontal head motions, negative words were more likely to elicit an affirmative bias; in contrast, the performance of vertical head movements or no head movements at all led to a higher bias for positive than for negative words, $F(2, 27) = 4.11, p < .03$.

**Discussion**

The results of Experiment 2 are consistent with the findings of the previous experiment. First, the compatibility effect was

<table>
<thead>
<tr>
<th>Word valence</th>
<th>Horizontal</th>
<th>Vertical</th>
<th>No movement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target</td>
<td>Distractor</td>
<td>Target</td>
</tr>
<tr>
<td>Positive</td>
<td>8.1$_{ab}$</td>
<td>5.4$_{e}$</td>
<td>11.0$_{a}$</td>
</tr>
<tr>
<td>Negative</td>
<td>10.6$_{a}$</td>
<td>5.7$_{c}$</td>
<td>7.3$_{bc}$</td>
</tr>
</tbody>
</table>

*Note.* Number of items = 19. Values with common subscripts do not differ significantly at $p < .05$ (Scheffé test).
phenomenon has been convincingly demonstrated, but the underlying mechanism has not been sufficiently understood. Although inferences based on the interpretation of the movements and affective influences can be ruled out with some confidence, it remains unclear how the different head movements may cause these memory effects.

To achieve such an understanding, it is necessary to analyze the nature of the obtained memory effect and the possible impact of motor compatibility. Our finding that the match between head movements and word valence improved participants’ ability to discriminate between presented test stimuli and distractor lures indicates that the motor activity affected memory functions per se. Moreover, because head movements occurred only during the learning phase of the experiment, they must have affected the encoding of the information; that is, compatible items from the encoding list were better learned than incompatible ones, yielding better discrimination performances on a subsequent recognition task. Therefore, a question must be asked: “Just how do head movements influence the efficiency with which information is stored in memory?”

The answer may lie in the psychological origins of motor compatibility. In our view, motor compatibility is the natural co-occurrence of overt and covert responses. For example, emotional and nonemotional feelings typically co-occur with a specific motoric expression that seems to be inborn for several “basic” emotions (Ekman, 1992). There also exist co-occurrences that are learned and automatized as a function of socialization. For example, we have learned, partly as a means of nonverbal clearly replicated. Participants were better at differentiating presented from nonpresented words when the valence of the word matched the induced head movements. That is, recognition of positive words was better when the presentation of these words was associated with vertical movements, whereas recognition of negative words was better when the presentation of these words was associated with horizontal movements. In the control condition, in which no movement was required, the valence of the words mattered much less than in the two movement conditions. A comparison with the control condition of Experiment 1 supports the previous suspicion that a circular movement may in fact be functionally equivalent to a horizontal movement in such discrimination tasks.

Second, the previous tendency to say “yes” for positive test words was not replicated. Of course, the reduction of this judgmental influence may be due to the shorter retention interval in Experiment 2 (e.g., Matlin & Stang, 1978). An unanticipated judgmental influence manifested itself as an interaction between the two variables. An ex post account for this effect may focus on inferences that are based on both compatibility and valence. The present data, however, provide no further lead to the cause of this effect.

Finally, the present data suggest that affect may not play a mediating role between head movements and recognition accuracy. In sum, the first two experiments demonstrate that the compatibility of head movements with the valence of information may not only determine the persuasiveness of a communication but may also affect fundamental memory processes. This

Figure 3. Experiment 2: Mean P values as a function of word valence and head movements. P is an indication of discrimination performance; higher values indicate better discrimination between targets and distractors.

Figure 4. Experiment 2: Mean B values as a function of word valence and head movements. B is an indication of response tendency; higher values indicate a greater tendency to respond “yes” regardless of whether a word was presented.
communication, to nod when we agree with another person's utterance and to shake our head when we do not. Although it is all but self-evident that covert responses may cause overt expressions, research has also provided for the reverse influence. In the domain of affect, it has been demonstrated that manipulating relevant facial or postural motor actions may have an effect on the concomitant feelings (Duclos et al., 1989). As previously noted, it has also been shown that flexion versus extension of the arm muscles affected the evaluation of stimuli that were presented during the exercise (Cacioppo et al., 1993).

Thus, these findings suggest that certain covert and overt responses are closely connected through inborn or overlearned associations; one may automatically elicit the other, and such reactions can be considered compatible. At the same time, it is possible to overrule such associations. We may smile when we are unhappy, we may suppress aggressive behaviors, and we may nod even when we happen not to agree with another person. Such incompatible behaviors may be performed; their execution, however, requires more mental capacity and behavioral effort. Because of preexisting associations (e.g., smile when happy, aggress when angered, nod when agreeing), it is less effortful to maintain two compatible responses than two incompatible ones. As a consequence, the intensity of one (or both) of the incompatible responses may be reduced. For example, when a person is induced to furrow his or her brow, it may be more difficult to feel happy; conversely, furrowing the brow may be more difficult when a person feels happy. Evidence exists that such a relationship may also obtain for nodding and shaking the head. Wells and Petty (1980) found that the frequency of participants' head movements depended on the direction of the persuasive message. That is, more vertical (nodding) movements were emitted when the message was proattitudinal, whereas more horizontal (shaking) movements occurred when the message was counterattitudinal.

This effort expenditure analysis applied to the phenomenon of memory suggests that it takes more cognitive effort to encode positive contents while performing horizontal (negative) head movements and to encode negative contents while performing vertical (positive) head movements, because those responses do not naturally co-occur. To maintain movement in the prescribed frequency, participants must devote less attention to the encoding of the incompatible words than of the compatible words.

To put this speculation to the test, we conducted a third experiment, in which we used the dual-task paradigm to measure the cognitive effort participants used in the experimental task. More specifically, participants were asked to complete a secondary task, the solution of which depends on their "residual" attention (e.g., Hasher & Zacks, 1979). This secondary task was a simple finger dexterity test in which participants had to insert three metal pins into each of the 100 holes in a wooden board (O'Connor, 1932). Because this task cannot be automatized in a few training sessions, we expected participants to do more poorly under the incompatible encoding conditions of the previous experiments. However, to detect residual attention in the manual dexterity task, we had to ensure that performing the encoding task was given first priority. Therefore, instead of presenting the words in an incidental fashion, we modified the previous experimental procedure into an intentional learning task.

### Experiment 3

**Method**

**Stimulus material.** We selected 42 words from Experiment 1 and used them as targets or distractors. Participants had to perform O'Connor's (1932) finger dexterity task simultaneously with the encoding task.

**Participants.** Sixty-eight students of the University of Trier were recruited for a memory test. They received DM 5.- (at the time, $3.37) for their participation.

**Design and procedure.** The design was a 2 × 2 factorial with head movement (vertical vs. horizontal) and word valence (positive vs. negative) as between-subjects variables. To ensure that the dexterity task was viewed as secondary, participants were recruited explicitly for a memory test, and a reward was offered for the best memory performance, despite the potentially distracting effects of the head movements and the manual task.

Before the experiment started, participants were given two dexterity training sessions (without being exposed to memory words), one with and one without head movements. This was done to determine participants' average performance, which was subsequently used as a baseline measure. After the training session, 12 words of one valence (including 2 buffer items of the same valence at the beginning and the end of the list that were not used in the final recognition test) were then presented through headphones at 3-s intervals. Participants were instructed to memorize the words and to perform either horizontal or vertical head movements at a frequency of approximately one movement per second. Participants contemporaneously performed O'Connor's (1932) finger dexterity test; more specifically, they placed metal pins in a series of 100 holes.

This encoding phase lasted 150 s (including 50 s of music at the beginning and the end of the tape, respectively). After a 3-min filler task, participants were given a recognition test consisting of eight targets and eight distractors of the same valence.

**Results**

**Recognition.** As depicted in Table 3, participants discriminated well between targets and distractors. The appropriate main effect on the number of "yes" responses was statistically significant in an Item Type × Head Movements × Word Valence ANOVA, $F(1, 60) = 55.44, p < .001$, indicating very good discrimination performances. In addition, participants who performed horizontal movements gave more "yes" responses than did participants who performed vertical movements. This difference, however, was only marginally significant, $F(1, 60) = 2.95, p = .09$. No other main effect or interaction reached significance (all $Fs < 1$). Thus, no motor-compatibility effect

<table>
<thead>
<tr>
<th>Word valence</th>
<th>Target</th>
<th>Distractor</th>
<th>Target</th>
<th>Distractor</th>
</tr>
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<tbody>
<tr>
<td>Positive</td>
<td>5.69</td>
<td>4.56</td>
<td>5.69</td>
<td>2.88</td>
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<td>2.55</td>
<td>5.13</td>
<td>2.06</td>
</tr>
</tbody>
</table>

*Note. Number of items = 8.*
was obtained. This was not surprising, because the encoding task consisted of intentional learning, which leads to a more effective encoding and thereby reduces contextual influences.

Dexterity performance. To control for a priori dexterity differences among participants, the deviation from the pre-experimental baseline (in percentage) served as the dependent variable.

Table 4 clearly reveals that participants' manual dexterity was better in the compatible conditions (i.e., vertical movements—positive words and horizontal movements—negative words) than in the incompatible conditions (i.e., vertical movements—negative words and horizontal movements—positive words). A 2 (head movement) \( \times \) 2 (word valence) ANOVA revealed a highly significant crossover interaction, \( F(1, 60) = 14.63, p < .001 \). Neither the main effect for head movement nor the one for word valence was significant (\( F_s < 1.81 \)). Scheffé tests (difference criterion [5%] = 9.4) revealed that the differences between positive and negative information were significant for both horizontal and vertical movements.

Discussion

The results of Experiment 3 show that performing incompatible responses requires more cognitive capacity than performing compatible responses. In a dual-task paradigm, participants performed much more poorly on a secondary dexterity task when the two components (head movement, word valence) of the primary task were incompatible. Assuming that cognitive capacities are limited (Duncan, 1979; Kahneman, 1973), this finding suggests that the completion of the incompatible task demanded more attentional resources than did the compatible task, which resulted in less residual capacity.

In this context, it is important to note that, in contrast to the two previous experiments, memory performance was not affected by the compatibility between motor responses and word valences. This was indeed the intended consequence of the modified instructions. Note that previous experimental tasks were set up to emphasize head movements, not attention to the stimulus words; these task instructions, in which remembering was not a primary goal for participants, were likely to reduce participants' attention to the words presented. In contrast, given the task instructions in Experiment 3, both head movements and encoding were of primary importance to participants, and all the necessary capacity was allocated to these tasks. Thus, the compatibility effect did not occur during the recognition of the stimulus words. As a result, any remaining cognitive capacity that might have been devoted to the manual dexterity task was greatly diminished.

Thus, the results of Experiment 3 shed some light on the psychological mechanism that may have produced the Experiment 1 and Experiment 2 findings. This third set of results suggests that the generation of incompatible responses requires more cognitive capacity than the generation of compatible responses. Whether these responses are motoric or cognitive, when they are both incompatible with one another and necessary to a primary task, performance on a secondary task will suffer. For example, when primary task responses were incompatible, in Experiments 1 and 2 incidental learning was diminished, and in Experiment 3 manual dexterity performance also was diminished.

General Discussion

It should be noted that the results of Experiments 1–3 are consistent with findings from existing research on the compatibility between stimulus and response. For example, Romaguere, Hasbroucq, Possamai, and Seal (1993) found that participants made faster muscle contractions when the task required stronger responses with an increasing intensity of the stimulus; participants were slower when the opposite was the case. Such a perceptual–motor incompatibility has frequently been found to inhibit the execution of behavior programs (for a review of this research, see Alluisi & Warm, 1990). From a less behavioristic perspective, the incompatibility between information and a behavior also was found to be inhibiting. Solarz (1960), for example, discovered that participants were faster at learning to pull positive symbols toward them than to pull negative symbols toward them; conversely, pushing away was learned faster when the symbols were negative than when they were positive. Such a conceptual compatibility appears to operate in a similar fashion. In a somewhat related vein, Greenwald (1970) proposed an "ideomotor theory," which suggests that response selection is faster if the sense modalities of stimuli and responses are compatible.

In sum, the explanation of our findings that information that is incompatible with concurrent head movements will be less efficiently encoded is consistent with results from varied lines of psychological research. One common denominator of the effects of response incompatibility—whether perceptual–motor incompatibility or conceptual incompatibility, or even conceptual–motor incompatibility—lies in the observation that "things that do not go together" (see Alluisi & Warm, 1990) may impair psychological performance. Such is not always the case, however, as the results of Experiment 3 demonstrate; by allocating more attention to the primary task, this impairment may be counteracted.

In three experiments, we demonstrated that motor behavior may affect information processing even when the social meaning of this behavior was disguised to discourage participants from drawing judgmental inferences. In the first two experiments, we demonstrated that the incidental encoding of positive and negative information depended on head movements that were executed concurrently. Specifically, the compatibility of
vertical and horizontal head movements—which are naturally associated with acts of agreement or disagreement, respectively—with the valence of the words determined the accuracy of the recognition.

Experiment 3 provided evidence of a possible mechanism for this phenomenon. Recall that participants were motivated to memorize positively and negatively valenced words while performing both head movements and a secondary dexterity task. In this situation, incompatibility affected manual skills while recognition performance remained the same.

On the basis of this series of reliable results, we concluded that head movements may have influenced memory performance and manual dexterity by diverting cognitive capacity from optional encoding (Experiments 1 and 2) and a secondary dexterity task (Experiment 3) from these secondary tasks to the required execution of the head movements. Going beyond findings about the effects of perceptual–motor compatibility, we suggest that our results are consequences of a conceptual–motor compatibility. This notion states that the activation of thought and feeling and the concurrent execution of specific behaviors depends on their natural co-occurrence. That is, thoughts and feelings that are closely associated with specific behaviors are more effortlessly elicited by the associated behaviors—either innately or by learned mechanisms—than by behaviors associated with antagonistic thoughts or feelings.

For example, it may be easier to generate a positive evaluation of a stimulus when we are required to pull our arms toward us than when we are required to push our arms away from our bodies. Cacioppo et al.'s (1993) findings may well be related to Solarz's (1960) earlier discovery, simply by reversing the dependent and independent variable: In abstract terms, it is easier both to embrace an attractive stimulus and to like a stimulus that we have embraced. It may also be worthwhile to consider this mechanism in the context of research in which emotional expressions were unobtrusively manipulated (e.g., Stepper & Strack, 1993; Strack et al., 1988; Zajonc et al., 1989). To emit a behavior that is incompatible with a feeling may require more effort than to emit a compatible behavior and therefore may decrease the likelihood of incompatible feeling. Consequently, the emotion itself may actually be felt less intensely. Similarly, an emotional stimulus, such as a funny cartoon, may be less closely scrutinized (and therefore found less humorous) when a required facial expression is incompatible with the positive affect that would otherwise be more easily or intensely experienced.

This mechanism may also explain the effect of head movements on persuasion in Wells and Petty's (1980) study if one assumes that positive arguments were better encoded when participants were nodding than when they were shaking their heads. Because of more effective encoding for compatible arguments, such thoughts might have been more accessible and influential in the subsequent judgment phase. Furthermore, the capacity hypothesis may explain some phenomena in everyday life. The present findings imply that concealing our feelings and emotions (e.g., Kleeck et al., 1976) may have its costs. Specifically, one would expect that the masking of a facial display in a social interaction (e.g., Aronoff, Stollack, & Woike, 1994; Matsumoto, 1990) would consume some cognitive capacity that cannot be used to attend to the content of a conversational exchange.

These interpretations are, no doubt, highly speculative and in need of empirical corroboration. However, the proposed mechanism of conceptual–motor compatibility may be more general than the present limited examples suggest, and the future exploration and use of this construct may illuminate everyday phenomena that are still insufficiently understood (see, e.g., Bargh, in press).

References


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