Rudimentary Determinants of Attitudes. II: Arm Flexion and Extension Have Differential Effects on Attitudes

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In the pain-flexor reflex, arm extension is temporally coupled with the onset of the unconditioned aversive stimulus, whereas flexion is associated with its offset; when retrieving desirable stimuli, arm flexion is more closely coupled temporally to the acquisition or consumption of the desired stimuli than arm extension. It was posited that these contingencies foster an association between arm flexion, in contrast to extension, and approach motivational orientations. Six experiments were conducted to examine this hypothesis. Ideographs presented during arm flexion were subsequently ranked more positively than ideographs presented during arm extension, but only when the Ss' task was to evaluate the ideographs when they were presented initially. Arm flexion and extension were also each found to have discernible attitudinal effects. These results suggest a possible role for nondeclarative memory in attitude formation.

> In general, we should not be terribly surprised that it is so difficult to change attitudes and preferences by cognitive methods. These methods do not reach the motor system and other somatic representational systems of the organism. They only deal with one representational system—the one that exists in the form of associative structures, images, and other subjective states. Since attitudes contain such a substantial affective component, they are likely to have multiple representations—and somatic representations are probably among the more significant ones. (Zajonc & Markus, 1982, p. 130)

The term *attitude* comes from the Latin words *apto* (aptitude or fitness) and *acto* (postures of the body), both of which have their origin in the Sanskrit root *ag,* meaning to do or to act (Bull, 1951). The connection between attitude and action carried into the 18th century, when attitude referred to a physical orientation or position in relation to a frame of reference. Herbert Spencer (1865) and Alexander Bain (1868) were among the first to introduce the term *attitude* into psychology, where they used it to refer to an internal state of preparation for action (see also Darwin, 1873; Washburn, 1926). Galton (1884, cited in Fleming, 1967) suggested that the interpersonal attitudes (sentiments) of guests at a dinner party could be measured by gauging their bodily orientation toward one another, but it was Thurstone's (1928) seminal article, "Attitudes can be measured," that precipitated empirical research on the determinants of attitudes.

Drawing on his background in psychophysics, Thurstone (1928) conceived of an attitude as the net affective perception of (i.e., feeling toward) a stimulus rather than as a bodily orientation. He demonstrated in pioneering research that these feelings could be scaled by constructing a set of relevant belief statements that were ordered along a unidimensional continuum ranging from maximal positivity to maximal negativity. Since that time, research on attitudes and attitude change has relied largely on persuasive messages and self-report measures (Dawes & Smith, 1985; McGuire, 1985). From this paradigm, the view emerged that the perception of some fact triggers positive or negative beliefs and feelings (i.e., attitudes), which gives rise to verbal, somatovisceral, and behavioral expressions (Cacioppo, Petty, & Geen, 1989; Tesser & Shaffer, 1990; Zanna & Rempel, 1988). The present research investigates a complementary perspective: that some forms of motor biases or their sensory consequences may subtly influence a person's attitude, such that the attitude would have different manifestations had the motor component been absent.

Specifically, we report evidence from six experiments showing that isometric arm flexion and extension have differential effects on attitudes toward novel, unrelated stimuli that are the target of evaluative processing (e.g., like–dislike judgments). The present research on the attitudinal effects of motor processes has been guided by the distinction in cognitive neuroscience between declarative and procedural (Cohen, 1984; Squire, 1982) or nondeclarative memory (Squire, 1992). Declarative memory "is memory that is directly accessible to conscious recollection" (Squire, 1987, p. 152) and includes semantic and episodic memories. It is declarative memories that are most frequently lost in clinical amnesic syndromes (Squire,

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1987) and it is elements in declarative memory, accessible to conversant awareness, that have been the focus of most attitude theory and research since Thurstone (1928; cf. Banaji & Greenwald, 1991; Cacioppo, Petty, & Berntson, 1991). Nondeclarative memory, in contrast, includes information acquired during skill learning (motor, perceptual, and cognitive skill learning), habit formation, classical conditioning including some kinds of emotional learning, priming, and "other knowledge that is expressed through performance rather than recollection" (Squire, 1992, p. 233). Nondeclarative memory is frequently ineffable and is often spared in amnesic syndromes. Nondeclarative memory processes, therefore, may subsume the motor processes to which Zajonc and Markus (1982) alluded. Although theorists have emphasized learning in their definitions of nondeclarative memory, the distinction between inherent and acquired dispositions is blurred by apparent constitutional biases or preparedness for specific patterns of acquired behaviors (Garcia, Brett, & Rusiniak, 1989; Timberlake & Lucas, 1989; see Berntson, Boysen, & Cacioppo, in press). The important points here are that if nondeclarative memories derived from motor processes can influence attitudes, these attitudes should have different manifestations than had the motor component been absent. These attitudinal effects may be more evident in comparative preference assessments that allow the manifestations of motor biases than in traditional paper-and-pencil attitude scales that assume subjects are motivated and able to retrieve and report their attitudes (cf. Squire, 1992). Our aims in the present studies, however, were to ensure any attitudinal effects we observed were replicable, identify some of the limiting conditions for the effects, and examine alternative interpretations for the effects. Although the possibility that not all attitude measurements are equally sensitive to motor biases is important, attitudes were assessed comparatively in the present series of studies to maximize the likelihood of detecting an attitudinal effect of motor processes.

Interestingly, recent research in cognitive psychology can be interpreted in terms of nondeclarative memories derived from motor processes and their influences on attitudes. Van den Bergh, Vrana, and Eelen (1990) investigated typists' and nontypists' preferences for letter combinations using a forced choice paradigm. Within each pair of letter combinations in the forced choice test, one combination would be typed with one finger and the other combination would be typed with different fingers. Subjects were unaware that their status as a typist or nontypist was important, and no typing was anticipated or performed during the experiment. However, by virtue of the prior pairing of letters and finger movements, letter perception should activate nondeclarative memory in skilled typists but not in nontypists. Van den Bergh et al. (1990) hypothesized that typists would prefer the letter combination that would be typed with different fingers (which minimized motoric conflict), whereas nontypists would show no such preference. The results of two studies were consistent with this hypothesis. Additionally, Van den Bergh et al. (1990) requested subjects to specify what differentiated the pairs of letter combinations to which they had been exposed. They found that neither typists nor nontypists were able to detect the categorical difference that appeared to underlie their preference judgments. Although it was not the focus of their study, Van den Bergh et al.'s data are consistent with the notion that, even in the absence of an explicit intention to perform a movement, ineffable nondeclarative memories can be activated and influence attitudes.

William James (1884), an early proponent of motor processes in affect and ideation, related the activation of the flexors to negative emotions and the activation of the extensors to positive emotions. James provided no experimental data to support these suggestions, of course, but observed that "In depression the flexors tend to prevail; in elation or belligerent excitement the extensors take the lead" (James, 1884, p. 192). Prior research has examined the attitudinal effects of a message recipient's body posture (Petty, Wells, Heesacker, Brock, & Cacioppo, 1983; see also related work by Duclos et al., 1989; Riskind, 1984; Riskind & Gotay, 1982), facial expression (e.g., Duncan & Laird, 1977; see Adelmann & Zajonc, 1989, for a recent review of this research), and head movements (Wells & Petty, 1980), but not flexion or extension. One limitation of these studies is that subjects may have been aware of the putative hedonic effects of these somatic manipulations despite the use of cover stories. William James' hypothesis regarding the hedonic effects of flexion and extension of, for instance, the arms is interesting because these somatic actions are not commonly believed to be associated with pleasant or unpleasant emotions or attitudes.

In addition, a competing hypothesis to James' about the potential attitudinal effects of arm flexion and extension is suggested by higher order Pavlovian conditioning theory (Wagner & Brandon, 1989). To the layperson, the pain-flexor reflex, which refers to the flexor withdrawal of a limb from a nociceptive stimulus, appears to support the Jamesian hypothesis of an association between flexion and negativity. Theory and research on the classical conditioning of human attitudes, however, suggest precisely the opposite (Zanna, Kiesler, & Pilkonis, 1970). In contacting a nociceptive stimulus, arm extension is temporally coupled with the onset of the unconditioned aversive stimulus, whereas flexion is associated with its offset. Furthermore, in retrieving something desirable, arm flexion is more closely coupled temporally to the acquisition or consumption of the desired object than arm extension. In both cases, the conditioned stimulus–unconditioned stimulus (CS-US) contingencies foster an association between arm flexion (in contrast to extension) and positive motivational orientations (e.g., approach). The countless repetitions over an individual's lifetime of the pairing of these somatic actions and evaluative contingencies, coupled with the subtlety of the arm flexion–approach and arm extension–withdrawal associations, is also compatible with nondeclarative memory playing a role in the attitudinal effects of arm flexion versus extension. Because the activation of arm flexion–extension is posited to trigger these effects, we refer to this formulation as the *motor processes hypothesis.*

This is not to suggest that people never grasp and consume something unpleasant (e.g., unpalatable medicines and foods) or retreat from a pleasurable stimulus (e.g., delicious foods when dieting). However, these actions, in contrast to the pain-flexor reflex and the acquisition–consumption of appetitive stimuli, are less common and typically require more thought about the stimulus, induce more conflict, and require more self-control —cognitive reactions that tend to weaken the strength of the associations formed through classical conditioning in humans (e.g., see Cacioppo, Marshall-Goodell, Tassinary, & Petty, 1992; Shimp, Stuart, & Engle, 1991; Stuart, Shimp, & Engle, 1987).

The first three experiments were designed to extend previous research on the motor processes hypothesis of arm flexion and extension. Arm flexion and extension were varied by instructing subjects to achieve and maintain (a) an isometric flexor contraction of the arms by pressing upward on a table (Experiment 1) or an exercise bar (Experiments 2 and 3), and (b) an isometric extensor contraction of the arms by pressing downward on a table (Experiment 1) or exercise bar (Experiments 2 and 3). Subjects were led to believe these tensional maneuvers were part of a series of studies on the effects of physical and psychological tension on human judgment. Subjects were instructed to achieve and maintain a mild isometric contraction before the presentation of the attitudinal stimuli. Twelve stimuli were presented during arm flexion and 12 different stimuli were presented during arm extension. To eliminate the possibility that the subjects' prior attitude toward the experimental stimuli might influence somatic activity, neutral Chinese ideographs (Zajonc, 1968) were used as experimental stimuli. To ensure the target stimuli were heeded and processed evaluatively during the subjects' exposure to them, we instructed subjects to judge whether they liked or disliked each ideograph (Experiments 1 and 2); to determine whether motor activation was the critical factor or whether it was the motor activation in the psychological context of evaluation that was critical, we conducted an experiment in which subjects were instructed to judge whether the design of each ideograph was simple or complex (Experiment 3). To assess possible carryover or sensitization effects, we counterbalanced the order of somatic contractions (flexion and extension) across subjects. Thus, Experiment 2 was a replication of Experiment 1 and was conducted to determine the reproducibility of the attitudinal manifestations identified in Experiment 1, whereas Experiment 3 was designed to determine whether the attitudinal effects of arm flexion or extension would be manifested when subjects did not think about the likability of the ideographs when they were presented during arm flexion or extension. If arm flexion produced a more positive general affective state than arm extension, we would expect that arm flexion, in contrast to arm extension (a) would be rated as a more enjoyable task and (b) would result in more positive preferences toward the ideographs in the comparative preference assessment that was administered following both isometric contraction tasks in all three experiments. On the other hand, if the differential effects of arm flexion versus extension were mediated by a motor bias on evaluative (e.g., affective) processing rather than by a general affective state, then arm flexion, in contrast to arm extension (a) would not be rated as any more or less enjoyable (because the task was not the object of evaluation during arm flexion or extension) and (b) would result in more positive preferences toward the ideographs in the comparative preference assessment that was administered following both isometric contraction tasks, but only when the experimental instructions required that subjects process the ideographs evaluatively, not when they required the subjects judge the ideographs in terms of an evaluatively irrelevant dimension such as the simplicity–complexity of their shape.

Experiments 1–3

Method

Subjects and Design

In Experiment 1, 44 students enrolled in introductory psychology participated for partial course credit. The experimental design was a 2 (somatic activation: isometric arm flexion vs. isometric arm extension) × 2 (activation order: flexion vs. extension first) × 6 (experimenter) × 2 (gender) factorial in which the first factor was manipulated within subjects. Subjects were randomly assigned to the cells of the factorial design, except for those cells determined by gender. Data from 2 subjects were deleted before analysis because of failure to perform the attitude assessment correctly, leaving 42 subjects from whom complete data were obtained.

Experiment 2 was conducted during the quarter following that for Experiment 1. As in Experiment 1, 44 students enrolled in introductory psychology participated for partial course credit. The experimental design was a 2 (somatic activation: isometric arm flexion vs. isometric arm extension) × 2 (activation order: flexion vs. extension first) × 2 (experimenter) × 2 (gender) factorial design in which the first factor was manipulated within subjects. Again, subjects were randomly assigned to the cells of the factorial design except as determined by gender.

In Experiment 3, another 44 students enrolled in introductory psychology participated for partial course credit. The experimental design was a 2 (somatic activation: isometric arm flexion vs. isometric arm extension) × 2 (activation order: flexion vs. extension first) × 2 (gender) factorial design in which the first factor was manipulated within subjects. Again, subjects were randomly assigned to the cells of the factorial design except as determined by gender. The first and second 22 subjects in Experiment 3 were tested in different academic terms, and there were minor procedural differences (e.g., experimenter) between the two terms. When term was used as a factor, however, no main effect of interaction involving this factor approached statistical significance; for instance, the t value for the effect of term on the preference measure was less than one. Therefore, we collapsed across this factor to achieve the same sample size as used in Experiments 1 and 2.

Experimental Stimuli

Twenty-four Chinese ideographs adapted from Hull (1920) and Zajonc (1968) were reproduced on 21.59-cm × 27.94-cm (8.5-in. × 11-in.) forms and served as the experimental stimuli. Subjects in these experiments attended a preliminary session in which they rated the pleasantness of each of the 24 ideographs on an 11-point scale (1 = *very unpleasant*, 11 = *very pleasant*). Although the ideographs were rated near the midpoint of the scale, each subject's ratings were used to compose two sets of 12 ideographs. Specifically, the 24 ideographs were rank ordered on the basis of the pretest data from each subject, and each successive pair of ideographs in the ranking was randomly assigned to one of the two sets of 12 ideographs that were presented during that subject's participation in the experiment. One set of ideographs served as the experimental stimuli for the arm flexion condition and the other served as stimuli for the arm extension condition. Which set was used in the flexion and extension conditions was determined randomly. At the end of the pretest, subjects were scheduled to participate in an ostensibly unrelated experiment 5–9 days later.

Procedure

Experiment 1. Subjects were tested individually. When subjects arrived, they were told that prior research had linked tension to a variety of problems in thinking and health and that the aim of this research was to examine the effects of muscle tension on thinking and judgment. They were further told that they would be asked to perform isometric exercises while responding to various figures. Each subject was seated in a chair approximately 45 cm in height at a table approximately 71 cm in height. The experimenter was positioned across the table from the subject. In the flexion condition, subjects were instructed to place their palms on the bottom of the table, to lift lightly so that they felt a slight tension in their arms, and to maintain this tension on the table. In the extension condition, subjects were instructed to place their palms on the top of the table, to press lightly so that they felt a slight tension in their arms, and to maintain this tension on the table. In both conditions, subjects were seated such that their upper arms were perpendicular to the floor and only their palms were touching the table. Subjects were further instructed that graphical figures (ideographs) would be presented while they were tensing their muscles. Subjects were informed that their task was simply to indicate whether they liked or disliked each of the figures. They were further instructed that there was no correct answer, and there was no particular number of figures that should be rated as liked or disliked. In each condition, 12 unique ideographs were presented serially. Each ideograph was held in front of the subject until it was categorized as liked or disliked.[1] A 5-min rest period separated arm flexion and arm extension.

After completion of the flexion and extension tasks, the preferences that developed toward the ideographs were measured. Subjects were taken to another cubicle, where six trays were arranged in a row atop a table. The trays were labeled, from left to right, as *extremely unpleasant, very unpleasant, unpleasant, pleasant, very pleasant,* and *extremely pleasant.* The subjects were given a deck of 21.59-cm × 27.94-cm (8.5-in × 11-in) forms, with 1 of the 24 ideographs depicted on each form. The cards were ordered randomly within this deck. Subjects were instructed to sort the cards into the appropriate trays on the basis of how they felt about each figure. The experimenter additionally stipulated that each tray should contain four cards when the subject had finished. Thus, subjects were forced to express their preferences among subsets of the ideographs. Subjects were allowed to spread the cards across the table in front of the trays while performing this task, and approximately 5 min separated the completion of the contraction tasks and the onset of the preference assessment. The experimenter was not present while the subject completed this preference assessment.

After completing the preference assessment, subjects were seated at a third cubicle and were given a short postexperimental questionnaire. Subjects used 11-point scales to rate the flexor contraction and to rate the extensor contraction in terms of its difficulty, enjoyment, and effort (1 = *not at all,* 11 = *extremely*). Following debriefing, subjects were given experimental credit, thanked, and dismissed.

Experiment 2. The experimental stimuli, pretest, cover story, procedure, dependent measures, and analyses used in Experiment 1 were used in Experiment 2, with one exception. To increase the comparability across subjects in the experimental manipulation, subjects pressed on an exercise bar mounted elbow-high between two walls of a cubicle. Subjects stood a forearm's length from the bar such that the subject's upper arms were perpendicular to the floor and the subject's lower arms were parallel to the floor.

Experiment 3. The experimental stimuli, pretest, cover story, procedure, dependent measures, and analyses used in Experiment 2 were used in Experiment 3, with one major exception. Subjects were led to believe that the study was concerned with the effects of physical tensional maneuvers on their cognitive (simplicity–complexity) judgments of stimuli and events in their environment. Thus, subjects were informed that their task was simply to indicate whether the design of each of the figures was simple or complex. They were further instructed that there was no correct answer and there was no particular number of figures that should be rated as simple or complex.

Data Reduction

The subjects' responses to the preference ranking task served as the major dependent variable. The six categories into which subjects sorted the ideographs were assigned numeric values ranging from −3 (*extremely unpleasant*) to 3 (*extremely pleasant*). The preference measure was then calculated on a subject-by-subject basis to reflect the difference between the mean rating of 12 ideographs associated with isometric arm flexion and the mean rating of the 12 ideographs associated with isometric arm extension. Because of the nature of the preference ranking task, the mean ratings within subjects of ideographs associated with isometric flexion and isometric extension were equal in extremity but opposite in sign. The difference score, calculated for each subject, represents the relative preference of ideographs associated with the activation of the arm flexors (i.e., mean flexor rating minus mean extensor rating). Thus, if a subject categorized the 24 ideographs randomly across the six preference ratings, the difference score would be zero; if a subject categorized all 12 of the ideographs associated with isometric flexion in the bottom three preference ratings (and, hence, all 12 of the ideographs associated with isometric extension in the top three preference ratings), the difference score would be −4; and if a subject categorized all 12 of the ideographs associated with isometric extension in the bottom three preference ratings (and, hence, all 12 of the ideographs associated with isometric flexion in the top three preference ratings), the difference score would be 4. As a consequence of this scoring procedure, (a) a t test to determine whether this difference score deviates significantly from zero tests the experimental hypothesis, and (b) the sign of the difference score indicates whether flexion (positive difference score) or extension (negative difference score) resulted in relatively positive attitudes toward the ideographs.

Similar indices were calculated for subjects' ratings of task enjoyment, difficulty, and effort. Specifically, difference scores were calculated in which each rating of the extensor task was subtracted from the corresponding rating of the flexor task. Thus, a positive enjoyment score for a subject indicated that the subject rated the flexor contraction as more enjoyable than the extensor task, whereas a negative score indicated the opposite. Using this scoring procedure, we performed t tests to determine whether the difference scores for enjoyment, difficulty, and effort differed from zero and correlational analyses to examine the covariation between the attitude preference scores and each of these scores.

[1] The primary focus in this research is on the preferences that develop toward the stimuli as a function of their presentation during arm flexion or extension. The like–dislike judgments were used to ensure that evaluative processing was engaged when subjects attended to the attitude stimuli. Arm flexion and extension would have little theoretical significance if their attitudinal consequences did not manifest following the isometric tasks. Therefore, the decision was made to use a dichotomous judgment to engage evaluative processing, to instruct subjects to make these like–dislike judgments of the experimental stimuli during the isometric tasks, and to allow the context in which these like–dislike judgments were made to unfold as subjects were exposed to the set of experimental stimuli. Not surprisingly given the insensitivity of this measure, the proportion of like–dislike judgments did not differ as a function of somatic activation in this experiment or in any of the remaining experiments reported in this article. Therefore, these judgments as a dependent variable are not discussed further. However, the design of Experiment 3, and comparisons of the results across Experiments 1–3, bear on the importance of having subjects evaluatively categorize the experimental stimuli during arm flexion and extension.

Results and Discussion

In Experiments 1–3, preliminary analyses were performed using the full factorial design to examine the effects of experimenter, order of muscle contraction, and gender of subject. No test involving any of these factors was statistically significant in any experiment.[2] Hence, the remaining tests were conducted pooling across these factors.

Experiment 1

To test the experimental hypothesis, a t test was conducted to determine whether the preference scores deviated significantly from zero. Results indicated that the ideographs viewed during arm flexion were subsequently ranked as being slightly but significantly more positive than the ideographs viewed during arm extension ($M = 0.36$), $t(41) = 2.80$, $p < .05$. Additionally, analyses of the postexperimental questionnaire revealed no significant differences between flexion and extension for enjoyment ($M = 0.12$), $t(41) < 1$, difficulty ($M = -0.25$), $t(41) < -1$, or effort ($M = -0.12$), $t(41) < -1$. Furthermore, analyses to examine how these ratings covaried with the preference scores revealed no reliable correlations. Thus, collateral somatic activity appear to be sufficient to influence preferences for novel stimuli that were the target of evaluative processing, and this effect does not appear to be due to any general differences in the tension, enjoyment, or effort of the somatic tasks.

Because the mean difference in preference was small, we inspected the distribution of these preference scores across the 42 subjects. The preferences of 30 subjects conformed to the experimental hypothesis (i.e., the preference score was positive), the attitude posttests of 2 subjects revealed no differences between the preferences of ideographs associated with flexion and extension (i.e., the preference score was zero), and the preferences of 10 subjects were in the opposite direction of the experimental hypothesis (i.e., the preference score was negative). The difference in the number of subjects who responded consistently versus inconsistently with the experimental hypothesis was statistically significant, $\chi^2(1, N = 40) = 7.71$, $p < .01$.

Experiment 2

Although the data from Experiment 1 were consistent with the notion that the development of preferences could be shaped by the attitudinal posture displayed by subjects when they were exposed to novel stimuli, we replicated Experiment 1 because of the small effect size and the unprecedented nature of the independent variable examined in Experiment 1.

Analysis of the preference data from Experiment 2 revealed that the ideographs viewed during arm flexion were rated as being more positive than the ideographs viewed during arm extension ($M = 0.26$), $t(43) = 2.23$, $p < .05$. As in Experiment 1, we inspected the distribution of the preference scores across subjects. The difference in the number of subjects who responded in accordance ($n = 28$) versus discordance ($n = 12$) with the experimental hypothesis was again significant, $\chi^2(1, N = 40) = 6.40$, $p < .01$.

Analyses of the postexperimental questionnaire also replicated the results of Experiment 1. No significant differences between flexion and extension were found for enjoyment ($M = -0.01$), $t(43) < -1$, difficulty ($M = 0.05$), $t(43) < 1$, or effort ($M = -0.30$), $t(43) < -1$. Furthermore, correlational analyses again revealed that the preference scores did not covary significantly with these ratings. Thus, Experiment 2 replicated the findings of Experiment 1.

Experiment 3

The third experiment was conducted to determine whether the attitudinal effects of flexion or extension would manifest even were subjects to make a nonevaluative (simple–complex) judgment of the ideographs during the isometric contraction tasks. The preference data again constituted the main dependent measure.

Analyses of the preference data indicated that the ideographs viewed during arm flexion and arm extension were rated equivalently ($M = -0.004$), $t(43) < -1$. Inspection of the distribution of preference scores indicated that the preference rankings of 20 subjects conformed to the experimental hypothesis and the rankings of 24 did not, ($\chi^2(1, N = 44) < 1$). As in Experiments 1 and 2, analyses of the indices of task enjoyment, difficulty, and effort indicated that arm flexion and arm extension were rated similarly, and none of these measures correlated significantly with the preference scores.

As with any new finding, more questions than answers were raised, particularly regarding the boundary conditions for the effect and the underlying psychological mechanisms producing the effect. The results of Experiments 1 and 2, for instance, indicate that the ideographs that had been shown during arm flexion were subsequently ranked as being more positive than the ideographs that had been shown during arm extension. The effect on the preference assessment was small in both studies, but it manifested comparably in men and women (see footnote 2), and it was statistically reliable whether parametric or nonparametric analyses were performed. Furthermore, Joseph R. Priester served as one of the experimenters in the first study and was aware of the experimental hypothesis, but the remaining experimenters across the two experiments were unaware of the hypothesis, and the effect nevertheless manifested equivalently across experimenters. Thus, experimenter bias does not appear to be a plausible explanation for the effect. Finally, in neither of these studies was arm flexion versus extension found to affect task enjoyment, difficulty, or effort ratings in the same manner as the posttask preference rankings of the ideographs. Thus, the results of these experiments are consistent with the notion that arm flexion and arm extension produce their attitudinal effects by a motor bias on evaluative (e.g., affective) processing rather than by a general affective state.

The results of Experiment 3 are also consistent with this motor bias hypothesis. Although the attitudinal effects of arm flexion and arm extension were differentiable when novel stimuli were the target of like–dislike judgments (Experiments 1 and 2), they were not when the ideographs were the target of simple–complex judgments. However, this characterization is based on statistically significant attitudinal effects in Experiments 1 and 2 and nonsignificant effects in Experiment 3. The

[2] No significant effects or interactions involving these factors have been found in the research conducted to date. Therefore, all of the tests of the experimental hypotheses in this article were conducted pooling across these factors.

subject population and procedures were comparable across the experiments, with the exception of the task instructions. Therefore, two ancillary analyses were performed in which the preference data from Experiment 1 and from Experiment 2 were contrasted with those from Experiment 3 using one-tailed t tests. The first (Experiment 1 vs. Experiment 3) and the second (Experiment 2 vs. Experiment 3) contrasts confirmed that the preference score was significantly more positive when subjects formulated like–dislike judgments of the ideographs during arm flexion–extension than when they formulated simple–complex judgments of the ideographs, $t(42) = 2.49$, $p < .01$, and $t(43) = 1.93$, $p < .03$, respectively. Furthermore, the chi-square test to combine these analyses (Winer, 1971, p. 49) was highly significant, $\chi^2(4) = 13.44$, $p < .01$. Together, these results suggest that motor activation is not the critical factor, but instead it is motor activation in the psychological context of individuals evaluating the attitude stimuli that generates the attitudinal effects.

Experiments 4 and 5

Two important assumptions underlying this research are that (a) arm flexion and extension activate different evaluative (motivational, approach–withdrawal; hedonic, pleasant–unpleasant) orientations; and (b) it is the motoric act, not the knowledge or observation of arm flexion and extension per se, that produces the evaluative effect. Experiments 4 and 5 were designed to examine these assumptions. Subjects in Experiment 4 performed arm flexion and extension, whereas subjects in Experiment 5 were treated identically except that they observed the experimenter perform these tasks rather than performing these motoric acts themselves. Together, Experiments 4 and 5 have the additional advantage of bearing on the possible role of demand characteristics. If observers in Experiment 5 associate observed arm flexion and arm extension with the same motivational or emotional orientation as identified in Experiment 4, then there would be no need to postulate or ascribe any special significance to motor processes. Conversely, experimental demands become less plausible if the subjects in Experiment 5 cannot accurately specify the motivational or hedonic orientation that the subjects in Experiment 4 uniquely associate with arm flexion versus extension after performing (rather than observing) these somatic tasks.

Method

Subjects, Design, and Experimental Stimuli

Twenty-nine subjects enrolled in introductory psychology participated in Experiment 4 for partial course credit in the experiment. Subjects were randomly assigned to the cells of a 2 (somatic activation: arm flexion vs. arm extension) × 2 (activation order: flexion vs. extension first) factorial in which the first factor was varied within subjects.

Experiment 5 was conducted later in the quarter, and another 29 subjects enrolled in introductory psychology participated for partial course credit. The experimental design was a 2 (observed somatic activation: arm flexion vs. arm extension) × 2 (activation order: flexion vs. extension first) factorial in which the first factor was varied within subjects. Again, subjects were randomly assigned to cells.

Subjects in both experiments were led to believe the isometric arm flexor and extensor contractions were part of a series of studies on the effects of physical and psychological tension on human judgment. Subjects were informed that the particular study in which they were participating dealt with the effects of physical tension on ideation. The stimulus materials used in Experiments 4 and 5 were the same as used in the preceding experiments.

Procedure

Experiment 4. This experiment was designed to test whether arm flexion and extension activate different motivational (e.g., approach–withdrawal) or emotional (e.g., pleasant–unpleasant) orientations. The procedure used in Experiment 4 was identical to that used in Experiment 1 through the completion of the flexion and extension tasks. Rather than administering the preference assessment following these tasks, however, subjects in Experiment 4 were given two forms to complete. On one form, the labels *first task* and *second task* appeared under one column, and the words *approach* and *withdrawal* appeared under a second column. In the other form, the labels *first task* and *second task* appeared under one column, and the words *pleasant* and *unpleasant* appeared under a second column. We used both the terms *approach–withdrawal* and the terms *pleasant–unpleasant* in separate forms to explore whether and at what level arm flexion and arm extension might activate different evaluative associations.[3] Subjects were instructed to draw a line linking each task in the first column to the term in the second column they felt best characterized the task. Thus, subjects could match both flexion and extension with the same term or with different terms in the second column. All subjects completed both forms, and the order of their administration was counterbalanced across subjects.

Experiment 5. This experiment was designed to test whether observers could produce the same pattern of data as found in Experiment 4, where subjects performed rather than observed the isometric arm flexion and extension tasks. Thus, the procedure was identical to that used in Experiment 4 except that (a) subjects observed the experimenter perform the isometric contraction tasks before completing the matching task and (b) the phrases *isometric contraction of the flexors in the arms* and *isometric contraction of the extensors in the arms* were used in place of the labels *first task* and *second task* on the two forms of the questionnaire. Care was taken to ensure that subjects knew which task they saw involved arm flexion and which task they observed involved arm extension.

Results and Discussion

Experiment 4

Responses to the approach–withdrawal form were reduced by constructing a 2 × 2 contingency table to determine how

[3] There is a precedent in psychobiology and social psychology for distinguishing between positive motivational orientations and subjective states. Berridge and Zajonc (1991), for instance, recently found that approach and consummatory behaviors could be potentiated by hypothalamic cooling "without activating intermediary pleasure" (p. 188). They suggested that manipulations of rudimentary affective mechanisms might influence "wanting" without altering "liking" or "pleasantness" possibly because these manipulations operate relatively close to or within the motor system. Given this distinction and the potentially muted attitudinal manifestation of motor processes in declarative memory, we examined subjects' associations of arm flexion–extension to approach–withdrawal and to pleasant–unpleasant states. We considered it an empirical question whether the distinction suggested by Berridge and Zajonc (1991) would prove useful in the present context.

many of the 29 subjects who performed the isometric contractions associated flexion and extension to approach, flexion to approach and extension to withdrawal, flexion to withdrawal and extension to approach, and flexion and extension to withdrawal. The frequencies in these four categories, which are mutually exclusive and exhaustive, are depicted in the top left quadrant of Figure 1. First, a chi-square test was calculated to determine whether the observed frequencies in this 2 × 2 table differed from what would be expected by chance (n = 7.25). Results were statistically significant, $\chi^2(3, N = 29) = 8.93, p < .05$. Follow-up tests on each pair of the marginal frequencies revealed that flexion was associated with approach significantly more often than with withdrawal, $\chi^2(1, N = 29) = 7.76, p < .01$, whereas extension was linked to withdrawal nonsignificantly more often than with approach, $\chi^2(1, N = 29) < 1$ (see the marginal frequencies in the top left quadrant of Figure 1).

A second frequency table was constructed to characterize the subjects' responses to the pleasant–unpleasant form (see the top right quadrant of Figure 1). The expected frequency for each of these four cells was again 7.25. This chi-square statistic was not statistically significant, $\chi^2(3, N = 29) = 3.45$. In addition, neither of the chi-square tests on the marginal frequencies was statistically significant ($ps > .10$).

To summarize, subjects who performed isometric arm flexion and extension associated these tasks with different motivational (approach–withdrawal) orientations even though subjects did not uniquely link these tasks to emotional (pleasant–unpleasant) orientations. Was muscular activation necessary for these results, or would subjects respond similarly to the matching task if they completed the rating forms after observing another person perform the somatic tasks rather than after having just performed the tasks themselves? The results of Experiment 5 bear on this question.

Experiment 5

The frequency tables from Experiment 5 are depicted in the bottom half of Figure 1. The observers' responses to the approach–withdrawal form are summarized in the lower left quadrant of Figure 1. The chi-square test to determine whether the observed frequencies differed from what would be expected by chance (n = 7.25) was statistically significant, $\chi^2(3, N = 29) = 13.62, p < .01$. However, the distribution of these frequencies differed from that observed in Experiment 4. The marginal frequencies, for instance, revealed a reversal of the pattern of sums found when subjects performed (rather than simply watched) the flexion and extension tasks before performing the matching task. Although slightly more subjects linked flexion with withdrawal than with approach and slightly more subjects linked extension with approach than with withdrawal, neither test of the marginal frequencies was statistically significant, $\chi^2\text{s}(1, N = 29) < 1$.

The observers' responses to the pleasant–unpleasant form are summarized in the lower right quadrant of Figure 1. A chi-square test revealed that the observed frequencies did not differ from what would be expected by chance, $\chi^2(3, N = 29) = 7.0$, *ns.* (No follow-up test on the marginal frequencies was statistically significant, either; see lower right quadrant of Figure 1.)

To summarize, the results of Experiment 4 indicated that arm flexion, in contrast to extension, was associated with an approach motivational orientation; the results of Experiment 5, in contrast, indicated that the association between flexion–extension and approach–withdrawal orientations was nonsignificant when subjects watched rather than performed the muscular contractions before performing the matching task.[4] The data from these experiments are consistent with the assumption that isometric arm flexion and arm extension are asso-

EXPERIMENT 4

Extension Condition	Flexion Condition: Approach	Flexion Condition: Withdraw	
Withdraw	9	4	13
Approach	13	3	16
	22	7	

Extension Condition	Flexion Condition: Pleasant	Flexion Condition: Unpleasant	
Unpleasant	11	5	16
Pleasant	8	5	13
	19	10	

EXPERIMENT 5

Extension Condition	Flexion Condition: Approach	Flexion Condition: Withdraw	
Withdraw	3	14	17
Approach	10	2	12
	13	16	

	Flexion Condition: Pleasant	Flexion Condition: Unpleasant	
Unpleasant	7	8	15
Pleasant	12	2	14
	19	10	

Figure 1. Contingency tables for Experiments 4 and 5.

[4] The expected values used to calculate the chi-square statistics reported for Experiments 4 and 5 were determined by assuming an equal distribution of responses across the four cells of each 2 × 2 contingency table, the result being an expected frequency of 7.25 in each cell. A more conservative test of the importance of motor processes per se can be constructed using the observed frequencies from Experiment 5 as the expected frequencies in the analysis of Experiment 4. That is, the associations subjects provided in the absence of having just performed the somatic tasks (i.e., the observed frequencies in Experiment 5) could serve as the expected frequencies in Experiment 4 to determine what additional reportable associative effects are attributable to the motor process of arm flexion and extension. When these chi-square tests were conducted, the results reported for Experiment 4 were replicated: The matching of arm flexion–extension to approach–withdrawal produced the same pattern of frequencies and statistically significant differences, $\chi^2(3, N = 29) = 20.54, p < .01$ (see left half of Figure 1). Follow-up tests on the marginal frequencies again revealed that flexion was associated with approach significantly more often than with withdrawal, $\chi^2(1, N = 29) = 11.29, p < .01$, whereas extension was associated nonsignificantly more often with withdrawal than with approach, $\chi^2(1, N = 29) = 2.27$, *ns.* Turning to the matching of somatic tasks to the terms *pleasant* and *unpleasant,* a significant difference was found between the expected (i.e., observed values in Experiment 5) and the observed values (from Experiment 4), $\chi^2(3, N = 29) = 9.24, p < .05$ (see right half of Figure 1). This effect is due primarily to a reversal in the pattern of the frequencies across all four cells between the two experiments. The chi-square tests on the marginal frequencies revealed that neither test approached significance, $\chi^2\text{s} < 1$.

ciated with different motivational (approach–withdrawal) orientations and suggest that the distinction between *liking* and *wanting* proposed by Berridge and Zajonc (1991) may have heuristic value. It is interesting in the light of these data, for instance, to question whether the effects documented in Experiments 1 and 2 would manifest more strongly in preference assessments and motivationally sensitive behavioral measures, where subjects are forced to discriminate behaviorally among the stimuli, than in traditional attitude scales that rely more on the discriminable affective responses evoked by the stimuli.

Experiment 5 further demonstrated that simply observing arm flexion and arm extension was not sufficient to evoke the approach–withdrawal associations found in Experiment 4. These data suggest that the differential motivational associations of arm flexion–extension identified in Experiment 4 are activated by motor processes in the context of evaluative processing rather than by knowledge or observation of the motoric act in this context. It is not known from these experiments, of course, whether the differential activation of approach–withdrawal associations derives from collateral central nervous system activity that results from the efferent commands for arm flexion and arm extension, or from somatic feedback (i.e., proprioception). This ambiguity also characterizes studies of facial and postural feedback (Hatfield, Cacioppo, & Rapson, in press), and its theoretical significance pales in comparison with the nature of the effects of motor acts on ideation and attitudes. More important, the results of Experiments 4 and 5 diminish substantially the plausibility of demand characteristics (Orne, 1969) and straightforward self-perception processes (Bem, 1972) as explanations for the attitudinal effects documented in Experiments 1 and 2.

Experiment 6

A final experiment in this series was designed to determine whether isometric arm flexion led to the development of positive preferences toward the ideographs, isometric arm extension led to the development of negative preferences toward the ideographs, or both effects occurred. This was accomplished by testing two groups of subjects. The subjects in one group pressed downward against the exercise bar (arm extension condition) or relaxed with their palms resting on top of the exercise bar (no-contraction control condition) while viewing the Chinese ideographs. Subjects in the second group pressed upward on the exercise bar (arm flexion condition) or relaxed with their palms resting on top of the exercise bar (no-contraction control condition) while viewing the ideographs. Subjects were randomly assigned to groups. Thus, arm flexion and extension were manipulated between subjects, and the effects of each could be compared with the effects of a no-contraction control condition.

This experimental design also provided a stronger test of several possible mechanisms underlying the differential attitudinal effects of arm flexion and extension. For instance, although arm flexion and extension were rated in Experiments 1 and 2 as being equally unpleasant, tense, and effortful, it is possible given the timing of the postexperimental questionnaire that subtle differences in one or more of these factors existed and contributed to the attitudinal effects we observed. In Experiment 6, isometric muscle contraction, whether of the flexors or of the extensors in the arms, should be characterized as being more effortful, more tense, and possibly less pleasant than relaxation. If subtle variations in one or more of these psychological reactions to the isometric contractions are underlying the attitudinal effects found in Experiments 1 and 2, the expected difference in rated tension, effort, and pleasantness in Experiment 6 leads to specific theoretical expectations. First, the effort justification hypothesis predicts that the ideographs viewed during arm flexion and during arm extension (high-effort tasks) should be preferred to the ideographs viewed during relaxation (low-effort task).[5] The traditional (or the declarative memory version of the) attitude-conditioning hypothesis, in which the ideographs are viewed as CS and the pleasantness of the task is conceptualized as the US, predicts that the ideographs viewed during the relaxation task (pleasant US) should be preferred to the ideographs viewed during the arm flexion and during arm extension tasks (unpleasant US). The motor-bias hypothesis predicts that the mean preference for the ideographs viewed during the relaxation task should fall between the mean preference for the ideographs viewed during isometric flexion (most preferred) and the mean preference for the ideographs viewed during isometric extension (least preferred).

Finally, the design of Experiment 6 also bears on the alternative interpretation that palm position, not the activation of motor processes, is underlying the results found in the preceding experiments.[6] Specifically, the palms were rested on top of the exercise bar facing down during the relaxation task in both groups. If palm position alone is the critical variable, isometric arm extension (palms down) and relaxation (palms down) should produce comparable attitudinal effects, whereas isometric arm flexion (palms up) should produce different effects than relaxation (palms down). This pattern of data, of course, would not provide definitive evidence that palm position was underlying the attitudinal results observed in Experiments 1 and 2, but it would call into question the role of motor processes in the differential attitudinal effects of arm flexion and extension documented thus far.

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[5] Note that effort justification would not be expected to be invoked by these procedures because subjects' choice to perform arm flexion and extension was not emphasized. Nevertheless, the design of Experiment 6 provides empirical data relevant to the possibility that arm flexion and extension influence attitude development through the processes of effort justification.

[6] Although we have posited that the differential attitudinal effects of arm flexion and extension are due to an active motor response, it is likely that the position of the hands is also important. In retrieving or consuming something desirable, arm flexion and an upward palmar position are more closely coupled temporally to the acquisition or consumption of the desired object than are arm extension and a downward palmar position when reaching for the object. Thus, the formulation we have outlined does not imply that arm flexion with fists clenched would produce the same attitudinal effects as arm flexion with palms positioned upward. In the experiments reported thus far, isometric arm contraction and palm position have been intentionally confounded (i.e., arm flexion-palms up vs. arm extension-palms down). Experiment 6, however, bears on whether palm position alone can account for the effects observed in the preceding experiments.

Method

Subjects and Design

Eighty-two students enrolled in introductory psychology participated for partial course credit. Subjects were randomly assigned to the cells of a 2 (somatic activation: isometric arm flexion vs. isometric arm extension) × 2 (activity: activation vs. relaxation) × 2 (activity order: activation first vs. relaxation first) factorial design in which the second factor was manipulated within subjects. Data from 1 subject were deleted before analyses because of the exercise bar slipping during the isometric contraction task.

Experimental Stimuli

The same 24 ideographs used in Experiments 1–5 were used in Experiment 6. Twelve ideographs were randomly selected and were presented during muscle activation (i.e., flexion or extension), and the remaining 12 ideographs were presented during muscle relaxation. Which ideographs were presented in each set, and which set of 12 ideographs was presented during somatic activation and relaxation, were determined randomly for each subject.

Procedure

When subjects arrived, they were told that prior research had linked tension to a variety of problems in thinking and health and that the aim of this research was to examine the effects of muscle tension on thinking and judgment. They were further told that they would be asked to perform isometric exercises while responding to various figures.

Subjects, who were tested individually, were instructed to stand in front of an exercise bar suspended between the two sides of a cubicle at elbow height such that their upper arms were perpendicular to the floor and their lower arms were parallel to the floor. In the somatic activation condition, subjects were instructed either to exert a mild and constant pressure downward on the bar (extension condition) or to exert a mild and constant pressure upward on the bar (flexion condition). Subjects were told that they should feel a slight but noticeable level of tension in their arms during the contraction and that they should maintain this tension until the experimenter told them to relax. In contrast, subjects in the no-contraction control (relaxation) condition were instructed to place their hands on top of the bar in such a way that they felt no tension in their arms.

After completing the postexperimental questionnaire, subjects used 11-point scales to rate the somatic contraction and relaxation tasks in terms of their difficulty, enjoyment, and effort (1 = *extremely*, 11 = *not at all*). These ratings were converted to a 1 (*not at all*) to 11 (*extremely*) scale. The remainder of the procedure was identical to that used in Experiments 1 and 2.

Data Reduction

The dependent measures were the same as used in Experiments 1–3, with two exceptions. As before, subjects sorted the 24 ideographs into six categories ranging from *extremely unpleasant* (−3) to *extremely pleasant* (3), and the preference score was again calculated on a subject-by-subject basis. Unlike Experiments 1–3, the preference measure in Experiment 6 reflected the difference between the mean ranking of the 12 ideographs that had been viewed while performing an isometric contraction (arm flexion or arm extension) and the mean ranking of the 12 ideographs that had been viewed while relaxing. Thus, a subject who categorized the 24 ideographs randomly across the six preference categories would be assigned a preference score of zero; a subject who categorized all 12 of the ideographs presented during somatic activation (flexion or extension) more positively than the 12 ideographs presented during relaxation would be assigned a preference score of 4; and a subject who categorized all 12 of the ideographs associated with somatic relaxation more positively than the 12 ideographs presented during somatic activation (flexion or extension) would be assigned a preference score of −4. Thus, a positive preference score signifies that the isometric arm contraction (flexion or extension) fostered positive preferences toward the ideographs (relative to the no-contraction control condition), whereas a negative preference score signifies that the isometric arm contraction (flexion or extension) fostered the development of negative preferences toward the ideographs (relative to the no-contraction control condition). Because this preference score represents the net attitudinal effect of the within subjects factor of activity (isometric contraction vs. relaxation), a t test was first performed to determine whether the preference score differs from zero. Next, the main effect for the between-subjects factor, somatic activation (arm flexion vs. arm extension), was performed to determine whether arm flexion produced more positive preference scores than arm extension. Finally, a priori contrasts were performed (i.e., t tests to determine whether the preference score deviated significantly from zero) at each level of this between-subjects factor to determine the absolute attitudinal effects of arm flexion and arm extension. Thus, the effects of flexion and relaxation were contrasted, and the effects of extension and relaxation were contrasted.

Three comparable indices and sets of analyses were performed using each subject's ratings of task enjoyment, difficulty, and effort, respectively. A positive index means that the isometric arm contraction (flexion or extension) led to higher ratings of enjoyment, effort, or difficulty (relative to the no-contraction control condition), whereas a negative score means that the isometric arm contraction (flexion or extension) resulted in lower ratings of enjoyment, difficulty, or effort (relative to the no-contraction control condition).

Results and Discussion

Analyses of the preference score replicated and extended the primary results found in the preceding experiments. The preference score did not differ significantly from zero, indicating that the isometric contraction (flexion–extension) and the no-contraction control condition had equivalent attitudinal effects ($M = 0.06$, $p > .2$). More important, analyses produced the expected significant main effect for somatic activation, $F(1, 79) = 8.92$, $p < .01$, and follow-up contrasts revealed that (a) ideographs to which subjects were exposed during arm flexion were subsequently rated as being more positive than the ideographs to which subjects were exposed during relaxation ($M = 0.30$), $t(41) = 2.15$, $p < .05$; and (b) ideographs to which subjects were exposed during arm extension were rated as being less positive than the ideographs to which subjects were exposed during relaxation ($M = -0.24$), $t(39) = -2.14$, $p < .05$.

Analyses of the indices based on the subjects' ratings of the tasks produced the expected significant effects. Thus, grand mean tests indicated that subjects rated the isometric tasks (flexion–extension) as less enjoyable ($M = -1.15$), $t(80) = -4.94$, $p < .001$, more difficult ($M = 1.05$), $t(80) = 4.01$, $p < .001$, and more effortful ($M = 2.20$), $t(80) = 6.21$, $p < .001$, than the no-contraction control condition. Importantly, no other test approached statistical significance (ps $> .2$), and correlational analyses revealed that none of these indices covaried significantly with the preference index.[7]

[7] The no-contraction control condition was procedurally identical in the between-subjects factor (i.e., somatic activation). To determine whether this control condition was perceived to be comparable by

To summarize, results from Experiments 1 and 2 revealed that arm flexion and extension were sufficient to influence preferences toward unrelated, novel stimuli that were the targets of evaluative processing (e.g., like–dislike judgments). The design of Experiment 6, wherein arm flexion and extension were contrasted individually with a no-contraction control condition, provided information about whether arm flexion was sufficient for attitudinal enhancement, arm extension was sufficient for attitudinal diminishment, or both were the case. In addition to providing absolute information about the attitudinal effects of arm flexion and arm extension, the design of Experiment 6 also contrasted the predictions from several alternative interpretations for the results of Experiments 1 and 2.

As expected, subjects in Experiment 6 reported expending more effort during flexion and extension than during the no-contraction control conditions, and subjects reported that flexion and extension were less pleasant and were more difficult than were the no-contraction control conditions. If effort justification were accounting for these results, then both the flexion and the extension conditions should be associated with more positive preferences toward the ideographs than the no-contraction control condition. If simple classical conditioning were underlying the attitudinal effects found in Experiments 1 and 2, then the flexion and the extension conditions should be associated with more negative attitudes toward the ideographs than the no-contraction control conditions. If palm position rather than isometric arm flexion–extension was the critical variable in Experiments 1 and 2, then isometric arm flexion should produce more positive preferences than relaxation, whereas isometric arm extension should produce comparable preferences to relaxation. Finally, if evaluative (or affective) processing were biased by collateral motor processes reminiscent of motivational orientations, then arm flexion should foster more positive preferences and arm extension more negative preferences than the no-contraction control condition. Results from Experiment 6 showed that arm flexion led to more positive attitudes toward the ideographs, and extension led to more negative attitudes, when each was individually compared with a no-contraction control condition, even though the control condition was judged to be the least effortful and most pleasant. These data are consistent only with the last of these hypotheses.

Although a consistent pattern of results has emerged across these six experiments, the minor discrepancies that have also emerged warrant comment. The sum of the preference effects in Experiment 6 is larger than what might have been expected from the relative effects of arm flexion and extension observed in Experiments 1 and 2. It should be noted, however, that the variance was also slightly larger. It is nevertheless interesting to speculate on why mean differences might be higher in this experiment. One possible explanation is that the relaxation condition may act as a more powerful anchor with which to compare the effects of motor processes than may another isometric contraction condition. Alternatively, the attitudinal effects of isometric arm flexion and extension may not increase as the level (or differences in level) of tension increase but rather may manifest after some threshold difference has been surpassed up to some higher point of tension that becomes distracting, aversive, or painful. A second potential discrepancy across this set of experiments is that arm extension fostered the development of more negative attitudes toward the ideographs in Experiment 6 even though the results of Experiment 3 did not show arm extension to be associated significantly more often with a withdrawal than an approach orientation. Additional research must determine whether this difference is in fact an inconsistency, reflects the differential sensitivity of the measures, or reflects the ineffable nature of the motor–memory processes. These minor discrepancies do not alter the subtle but reliable effect isometric arm flexion and extension have been found to exert on attitudes, however.

subjects, their scale ratings of the enjoyment, difficulty, and effort of the no-contraction control condition were contrasted using t tests. None was significant, suggesting that the differences observed in the preference index as a function of somatic activation was not due to differences in the perceptions of the no-contraction control condition.

General Discussion

The present research indicates that motor processes or their sensory consequences can play a role in attitude development. In Experiments 1 and 2, subjects were shown a series of Chinese ideographs while pressing upward (flexion) or downward (extension). Analyses revealed that the ideographs to which subjects were exposed during flexion were rated more positively than the ideographs to which subjects were exposed during extension. Although the effect was small, analyses also revealed that it generalized across experimenters, order of tasks, and gender of subject. Experiment 3 was performed using the same subject population, sample size, and procedures, except that subjects were instructed to formulate simple–complex judgments rather than like–dislike about the ideographs during the arm flexion and arm contraction tasks. The results from Experiment 3, and comparisons across Experiments 1–3, suggested that the differential attitudinal effects of arm flexion and extension were attenuated or eliminated when the ideographs were processed along nonaffective dimensions.

Experiments 4 and 5 were conducted to test the assumptions that arm flexion and extension activate different evaluative orientations, and that these effects are due to motor processes (i.e., muscle contraction or its sensory consequences) in the psychological context of evaluative processing rather than mere knowledge or observation of arm flexion and extension in this context. Given the responses of subjects and observers were compared, these experiments also bore on the possible role of self-perception (Bem, 1972) and demand characteristics (Orne, 1969). In Experiment 4, subjects performed arm flexion or extension and then performed a matching task. Results indicated that arm flexion, in contrast to extension, was associated with an approach motivational orientation. Experiment 5 indicated that the association between flexion–extension and approach–withdrawal orientations was nonsignificant when subjects watched rather than performed the muscular contractions before performing the matching task. Together, these data indicate that the differential attitudinal effects of arm flexion and extension are triggered by active motor processes.

Experiment 6 was conducted to determine the absolute attitudinal effects of arm flexion and extension by contrasting arm flexion and extension with a no-contraction control condition. The experimental design also sheds further light on the possible role of effort justification, simple classical conditioning (in which the pleasantness of the task affects subsequent attitudes toward the ideographs to which subjects were exposed once briefly during the task), and pain orientation. Results showed that arm flexion led to more positive attitudes toward the ideographs, and extension led to more negative attitudes, when compared with a no-contraction control condition, even though the control condition was judged to be the most pleasant and the least effortful and difficult.

Together, these data show that arm flexion and extension have differential effects on attitude formation toward unrelated, novel stimuli that are the target of evaluative processing (e.g., like–dislike judgments). More questions than answers have been raised, particularly regarding the boundary conditions for the effect and the underlying psychological mechanisms producing the effect. However, artifacts such as experimenter bias and demand characteristics do not appear to be able to explain these data, nor do accounts based on self-perception, effort justification, palm position, or a simple conditioning account in which tasks involving somatic tension come to be nonpreferred. The randomization procedures we used rule out preexisting differences in attitudes toward the experimental stimuli as an explanation for the differential attitudinal effects of arm flexion and extension.

Despite these questions, the present studies build on prior research and suggest that some forms of motor biases or their sensory consequences can subtly influence a person's attitude, such that the attitude would have different manifestations had the motor component been absent. A motor hypothesis for the attitudinal effects of arm flexion and extension was derived from higher order classical conditioning in which CS–US contingencies foster an association between arm flexion (in contrast to extension) and positive motivational orientations (e.g., approach). There are, of course, several variations on this motor hypothesis. It is conceivable, for instance, that certain forms of somatic activity entail inherent biases, or may be subject to associative preparedness (e.g., Seligman, 1970) or releaser-induced recognition learning (Suboski, 1990) such that arm flexion inclines the associative transfer of approach responses and arm extension inclines the associative transfer of withdrawal responses. All of these mechanisms, however, depict the attitudinal effects as stemming from the activation of motor processes, and each is compatible with nondeclarative memory playing a role.

Furthermore, the present research suggests that the attitudinal effects of arm flexion–extension operate through a motor bias on evaluative (e.g., affective) processing rather than through a general affective state. Arm flexion and extension did not have distinguishable effects on the subjects' general affective state or at least on the subjects' enjoyment ratings of these tasks, and the preference scores were not found to covary with the subjects' task ratings. The results of Experiment 3, in which arm flexion and arm extension were not found to have differential attitudinal effects when subjects judged the simplicity–complexity rather than the likability of the ideographs, further suggests that the motor processes affect how subjects think about or remember their evaluative responses to the ideographs.

Related research in our laboratory suggests that these attitudinal effects are not obtained when leg rather than arm flexion is investigated. We have tested subjects individually using procedures similar to Experiment 1, except that subjects sat on the edge of a desk and pressed their heels against the desk (isometric leg flexion) or their toes against a second desk (isometric leg extension). Ideographs presented during leg flexion were not rated differently in the preference assessment than were ideographs presented during leg extension. Although we do not wish to overemphasize null results, these data are consistent with the notion that the differential attitudinal effects of arm flexion and extension are attributable to the countless repetitions over an individual's lifetime of the pairing of arm flexion and extension with differential evaluative outcomes.

It may also prove to be significant that the attitudinal effects were observed in forced choice preference assessments (Experiments 1, 2, and 6; see also Van den Bergh et al., 1990) and in motivational ratings (Experiment 4). It is uncertain at this point whether these attitudinal effects would have been manifested if subjects had simply expressed their attitudes on traditional rating scales or had been asked to guess which evaluative word (e.g., *good–bad, wise–foolish,* or *harmful–beneficial*) came closest to the meaning of each ideograph or nonword. However, one implication of the notions of attitudinal representations in nondeclarative memory is that these attitudinal effects may be more evident in sensitive behavioral assessments than in traditional self-report attitude scales. Just as a phone number learned through many episodes of dialing can sometimes be simpler to dial than to articulate and just as a motor skill acquired through extensive practice can be simpler to demonstrate than to describe verbally, attitudes acquired through or by virtue of associated motor actions may be more likely to be activated during relevant overt behavior than verbal behavior. The putative link between arm flexion–extension and motivational orientations may provide a clue regarding what contextual factors may empower behavioral assessments. For instance, subjects who have undergone food deprivation and who are exposed to edible ideographs (or some other novel and initially neutral foodstuff) may show stronger attitudinal effects of arm flexion versus extension than observed in our studies of undeprived subjects. Thus, although it remains only conjecture that these attitudinal effects are ineffable and involve nondeclarative memory, it has proved to be a useful metaphor in guiding this research.

We have no data bearing on the attitudinal effects that would result from parametric manipulations of the strength of arm flexion and extension. In all of the research we have conducted to date, flexion and extension have been operationalized by instructing subjects to achieve and maintain mild isometric contractions. From Experiments 4 and 5, however, we know that there is some minimal threshold of contraction required. We further suspect that little is added by increasing tension beyond this point, which would account for the discrepancy in the size of the attitudinal effects observed in Experiments 1 and 2 versus Experiment 6. Indeed, if the differential attitudes of arm flexion and extension are mediated by nondeclarative memories developed during a subject's exposure to the experimental stimuli, then high levels of tension in arm flexion and extension may eliminate these attitudinal effects by diverting attention from the experimental stimuli to the somatic tasks, or by changing the associations activated by the somatic tasks, or both. Furthermore, this putative limitation may not be unique to arm flexion or extension. Strack, Martin, and Stepper (1988) had subjects hold a pen in their mouths such that a smile was either facilitated or inhibited while they rated the funniness of cartoons. They found that subjects who held the pen between their teeth (thereby facilitating a smile) rated the cartoons as being funnier than subjects who held the pen between their lips (thereby inhibiting a smile). Of course, high to painful levels of tension are as likely to result in aversive conditioning and diminution of the effects reported by Strack et al. (1988) as the effects reported in this article.

Zajonc and Markus (1982) suggested that persuasive appeals have had small attitudinal effects because these appeals ignored the motor system. They suggested that manipulations focused on motor processes would produce more significant changes in attitudes. The present research supports their contention that somatic manipulations can have attitudinal consequences, but the effects identified here appear to be small compared with the attitude change found in studies of persuasion. Our primary interest in this research, however, is not in the differential attitudinal effects of arm flexion and extension per se, but in the rudimentary attitudinal effects of motor processes. Arm flexion and extension represent useful manipulations for studying these effects because, as demonstrated in Experiment 5, people who have not performed the tasks do not normally associate these actions with motivational or emotional outcomes. Thus, the significance of these studies is not in that arm flexion or extension can serve as a major determinant of people's attitudes, but rather in the suggestion that attitudinal effects of motor processes (and their memorial consequences) may well be worth future investigation. What are clear from these data are that the attitudinal effects involve active motor processes and that a person does not need to know the evaluative or motivational significance of the motor process for it to have attitudinal effects.

Finally, the present data confer additional support to the effects of motor processes on attitudes suggested in previous research. Both Wells and Petty (1980) and Strack et al. (1988), for instance, used cover stories that allowed motor processes to be manipulated surreptitiously (see also Stepper & Strack, 1992), and in each they found that the manipulation of motor processes influenced people's attitudes toward stimuli that were presented coincidentally. As noted above, Strack et al. (1988) found that a facial manipulation that fostered smiling led to cartoons being rated as funnier than a manipulation that hindered smiling. Wells and Petty (1980) studied the attitudinal effects of subjects shaking their head vertically or horizontally during their exposure to a persuasive message. Subjects were told that headphones were being developed to use during activity, and the head movements were required to assess the audio quality of the headphones during movement. Half of each group of subjects heard an editorial about raising tuition (counterattitudinal), and the remaining subjects heard an editorial about lowering tuition (proattitudinal). After a brief delay, subjects were asked what they thought the appropriate tuition should be. Subjects who heard the editorial about raising tuition advocated higher tuition than subjects who heard the editorial about lowering tuition. More interestingly, subjects who made vertical head movements agreed more with the advocated position (whether it was pro- or counterattitudinal) than subjects who made horizontal head movements. Stepper and Strack (1992) have proposed that these somatic manipulations operate through "experiential" in contrast to "noetic" representations. Experiential representations are construed as perceptions that are elicited and maintained by peripheral sensory stimulation, whereas noetic representations are based on interpretations of sensory input. It remains for future researchers to determine whether subjects' subjective experiences during the task (e.g., feelings of approach–withdrawal) are necessary for motor processes to have attitudinal effects.

In sum, memory of how an object is categorized along an evaluative dimension has been implicitly assumed to be represented in what Squire (1987) has termed *declarative memory* in humans, and paper-and-pencil measures of attitudes rest on this assumption. The representation of how an object is evaluatively categorized in declarative memory may be a recent evolutionary innovation, however. As with most evolutionary innovations, evaluative representations in declarative memory likely have not replaced prior forms of representation but rather overlay and moderate them. If evaluative dispositions such as those derived from motor processes are found to be instantiated at least in part in nondeclarative memory, then their study may extend considerably our understanding of attitude representations and processes. Indeed, the day may come when we regard attitudes as being "evaluative perceptions" (i.e., declarative knowledge) aroused by stimuli, with these evaluative perceptions representing but a narrow band within a broader spectrum of bivalent organization of cognition, emotion, and behavior.

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