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Perceived Facial Expressions of Emotion as Motivational Incentives: Evidence From a Differential Implicit Learning Paradigm

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Participants ($N = 216$) were administered a differential implicit learning task during which they were trained and tested on 3 maximally distinct 2nd-order visuomotor sequences, with sequence color serving as discriminative stimulus. During training, 1 sequence each was followed by an emotional face, a neutral face, and no face, using backward masking. Emotion (joy, surprise, anger), face gender, and exposure duration (12 ms, 209 ms) were varied between participants; implicit motives were assessed with a picture–story exercise. For power-motivated individuals, low-dominance facial expressions enhanced and high-dominance expressions impaired learning. For affiliation-motivated individuals, learning was impaired in the context of hostile faces. These findings did not depend on explicit learning of fixed sequences or on awareness of sequence–face contingencies.

Keywords: implicit motives, implicit learning, operant conditioning, facial expressions, incentives, awareness

Traditionally, research on the functions of facial expressions of emotion (FEE) has emphasized FEE's role as core constituents of an individual's emotional experience (e.g., Adelmann & Zajonc, 1989), as universal nonverbal messages broadcasting the individual's emotional state and intentions to others (e.g., Ekman & Friesen, 1971), and as elicitors of ordinary and pathological emotional states in the perceiver (e.g., Mogg & Bradley, 1999a). More recently, however, some researchers have proposed that perceived FEEs may also function as motivational incentives and thus shape the perceiver's behavior. Keltner (Keltner, Ekman, Gonzaga, & Beer, 2003; Keltner & Haidt, 1999) has argued that FEEs Displayed × An Interaction Partner can act as rewards that people will work for or punishments that they will try to avoid. This hypothesis is supported by studies showing that in primates and humans, neurobiological substrates of motivation and learning, such as the amygdala and orbitofrontal cortex, respond strongly to FEEs (for a summary, see Rolls, 2000), but so far it has generated little systematic experimental research to evaluate its validity.

In our present work, we tested the FEE-as-incentive hypothesis by studying the rewarding and punishing effects of joy, surprise, and anger expressions on the acquisition of arbitrary behaviors, a hallmark of motivation (LeDoux, 2002). In so doing, we propose that an FEE's incentive value is determined primarily by three factors: the expression's meaning as a dominance or affiliation signal, the perceiver's motivational needs for power and affiliation, and the match or mismatch between the perceiver's and the sender's gender.

Dominance and affiliation are two key aspects of social organization in many group-living mammalian and nonmammalian species, including humans (Eibl-Eibesfeldt, 1995; E. O. Wilson, 1980). *Dominance* refers to the negotiation of status hierarchies within a group, with higher dominance status providing privileged access to mates and material resources. Attaining dominance over conspecifics is associated with behavioral and physiological signs of reinforcement, whereas being in the subordinate role is often stressful and aversive and can lead to pathological outcomes (e.g., Kuhar, 2002; Mazur, 1985; Packard, Cornell, & Alexander, 1997; Sapolsky, 1987). *Affiliation* refers to the formation of friendly social ties and alliances with the aim of receiving and providing support. In animals and humans, having close affiliative ties to conspecifics is rewarding and contributes to enhanced mental and physical health, whereas lack of such ties and separation from one's social group is stressful (e.g., Insel & Young, 2001; Keverne, Martensz, & Tuite, 1989; Uvnäs-Moberg, 1998).

Given the importance and centrality of dominance and affiliation in social relationships and interactions, it is perhaps not surprising that the meaning of FEEs as social signals can be assessed with scales representing the orthogonal dimensions dominance (vs. submission) and affiliation (vs. rejection), with joy being rated as high on both dominance and affiliation, anger being rated as high on dominance and low on affiliation, and surprise being rated as moderately low on traits related to dominance but neither high nor low on affiliation (Conway, Di Fazio, & Mayman,

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1999; Hess, Blairy, & Kleck, 2000; Knutson, 1996; LeGal & Bruce, 2002; see also Wiggins & Trobst, 1999). In addition, the display of a surprise face has also been linked to the violation of an expectation (e.g., Camras et al., 2002), which in the case of a social interaction is likely to have been committed, either verbally or nonverbally, by the person to whom the sender directs the surprised expression. Thus, surprise often reflects a power differential between sender's and perceiver's control over the interaction, with the "surprisor" having more power than the "surprisee" (cf. Conway et al., 1999). To the extent that every individual aspires to a high social status and close affiliative ties with others and tries to avoid being in a subordinate role or rejected by others, we predict that FEEs signaling another person's low dominance (e.g., surprise) and affiliative intent (e.g., joy) represent positive incentives and reinforce the perceiver's behavior, whereas FEEs signaling another person's dominance (e.g., anger— but also joy!) and interpersonal rejection (e.g., anger) represent negative incentives and inhibit the perceiver's behavior.

The literature on human motivation suggests that individuals differ in their dispositional capacity to derive pleasure from, and thus to strive for, dominance over others (the power motive) and close, friendly relationships with others (the affiliation motive; McClelland, 1987; McClelland, Koestner, & Weinberger, 1989). These motive dispositions are also called *implicit motives*, because they often operate outside of conscious awareness (see McClelland, 1987; McClelland et al., 1989; Schultheiss & Brunstein, 2001) and are assessed indirectly, through empirically derived scoring systems that are used to analyze stories individuals write in response to picture cues (Smith, 1992). The validity of these picture–story measures of implicit motives has been amply documented by studies relating them to mental and physical health, psychosocial adjustment, long-term life and career success, and societal and historical developments (McClelland, 1987). It has also been suggested that implicit motives respond preferentially to nonverbal stimuli (Klinger, 1967; Schultheiss, 2001) and have close ties to biologically based motivational systems (cf. McClelland et al., 1989), as documented by their association with the release of hormones related to dominance, reproduction, and sympathetic arousal (McClelland, 1987; Schultheiss, Dargel, & Rohde, 2003; Schultheiss & Rohde, 2002) and their capacity to amplify the effects of reward and punishment on implicit learning (Schultheiss & Rohde, 2002).

We propose that the predicted rewarding effects of affiliative and submissive FEEs and the corresponding punishing effects of dominant and rejecting FEEs on behavior are more pronounced in individuals with strong dispositional needs to strive for dominance and affiliation than in those low in these motives. Thus, for power-motivated individuals, relative to individuals low in power motivation, a surprised look in an interaction partner's face should be rewarding (both because it signals low dominance and because power-motivated people like to "make a splash" and have emotional impact on others, particularly if the elicited emotion does not threaten their own dominance; cf. Winter, 1973) and an angry or joyful expression should be aversive, because these expressions signal the other's dominance (cf. Hess et al., 2000; Knutson, 1996). For affiliation-motivated individuals, relative to individuals low in affiliation motivation, a joyful expression, signaling friendliness, should be rewarding, and an angry expression, signaling hostility and rejection, should be aversive (cf. Hess et al., 2000; Knutson, 1996). An expression of surprise should have neutral valence, because it signals neither friendliness nor rejection.

Schultheiss and Hale (2004) recently obtained evidence in support of these predictions from a study on the effects of power and affiliation motivation on attentional orienting to FEEs. Using a modified dot-probe task (cf. Mogg & Bradley, 1999b) in combination with dispositional motive measures, they found replicable evidence that power-motivated individuals orient their attention toward surprise faces, but away from anger or joy faces. Affiliation-motivated individuals oriented attention toward joy faces and away from anger faces presented outside of conscious awareness, but toward anger faces presented within conscious awareness. Schultheiss and Hale suggested that the attention-grabbing effect of supraliminal anger faces in the context of affiliation motivation may be explained by affiliation-motivated individuals' having a lower threshold at which they shift from attentional avoidance to vigilance for the threat of rejection (cf. E. Wilson & MacLeod, 2003). Thus, although the direction of attentional orienting may sometimes be associated in a nonlinear fashion with incentive valence, Schultheiss and Hale's results are consistent with the rewarding and punishing effects of FEEs we propose here.

Finally, when making predictions about the rewarding or punishing effects of FEEs on behavior, we believe that it is also necessary to take the sender's and the perceiver's gender into consideration. Partly because of intrasexual competition for mating partners, dominance hierarchies emerge more strongly within a gender than across genders in humans and other primates (E. O. Wilson, 1980), and signals of dominance and submission should therefore be more salient and have stronger incentive value if emitted by a member of one's own gender than by a member of the opposite sex. We therefore predicted that same-gender FEEs signaling dominance (e.g., joy) should be more aversive and same-gender FEEs signaling submissiveness (e.g., surprise) should be more rewarding than the same FEEs displayed by the opposite gender.

To recapitulate, we propose that the rewarding or punishing properties of a perceived FEE on the perceiver's behavior depend on (a) the FEE's dominant and affiliative character, with FEEs signaling low dominance and high affiliation being rewarding and FEEs signaling high dominance and low affiliation being punishing; (b) the perceiver's dispositional motivational needs for power and affiliation, which amplify the rewarding and punishing effects of FEEs; and (c) the match between the sender's and perceiver's gender, with same-gender FEEs expressing dominance or submission being stronger incentives than similar expressions displayed by the opposite gender. In addition, we also explored to what extent these predicted incentive effects of FEEs depend on whether facial expressions are presented within or outside of a person's conscious awareness.

The Differential Implicit Learning Task

To evaluate the validity of our hypotheses, we devised an operant-conditioning task in which participants were first trained on the three-way contingency between a discriminative stimulus (color), a response (performing a visuomotor sequence), and a reinforcer (the presentation of an emotional face) and then tested in extinction (i.e., when the response was no longer followed by a reinforcer and thus not confounded with its unconditioned effects on performance) to gauge participants' motivation to work for the reinforcing stimulus even when it was absent. To ascertain that whatever effects of emotional faces on learning we would find could really be attributed to a specific emotional display and to differentiate them from features of the sender's face unrelated to the emotion expressed, we compared each participant's performance on responses that during training were contingent on the presentation of a sender's emotional face with (a) responses that were contingent on the same sender's neutral face and (b) responses that were never followed by the presentation of a face. In general, we expected participants to learn responses to these control stimuli equally well but to exhibit differences in learning of responses contingent on emotional faces relative to learning of responses contingent on control stimuli, such that emotional faces with positive incentive value should elicit enhanced learning and emotional faces with negative incentive value should elicit impaired learning relative to control stimuli.

The responses participants had to learn in this paradigm consisted of visuomotor sequences of a type used frequently in studies on implicit procedural learning, that is, learning that occurs without conscious intention or awareness and requires little attentional resources (cf. Nissen & Bullemer, 1987; Reed & Johnson, 1994). We chose an implicit learning task because there is considerable evidence that implicit motives such as power and affiliation often operate at a nonverbal level and influence behavior that is not under a person's conscious control (cf. McClelland, 1987; Schultheiss, 2001; Schultheiss & Brunstein, in press). Thus, we were particularly interested in exploring whether motives can, in fact, shape relatively complex behavioral learning processes outside of a person's conscious awareness.

In the differential implicit learning task (DILT), we used three maximally distinct, color-coded sequences. On each sequence, participants responded 12 times to asterisks presented sequentially in four different screen locations. Because the pattern in which asterisks appeared in these screen locations was fixed for each sequence, participants could implicitly learn the regularity underlying the stimulus presentations and use this knowledge to perform the sequence of responses corresponding to the stimulus sequence more efficiently. In research on implicit sequence learning, specific learning gains can be differentiated from general performance changes by comparing individuals' performance on fixed sequences to their performance on random sequences. Sequence knowledge on fixed sequences can be used to anticipate stimuli and prepare responses, whereas sequence knowledge can no longer be applied to this end in the random phase. Although differences between fixed- and random-sequence performance are usually calculated for individuals' response latencies, which robustly increase from the fixed-sequence to the random-sequence phase (e.g., Nissen & Bullemer, 1987), they can also be obtained for response accuracy, for which corresponding decreases from the fixed-sequence to the random-sequence phase can be observed (e.g., Feeney, Howard, & Howard, 2002). Both the increase in response latency and the decrease in response accuracy from the fixed- to the random-sequence phase are interpreted as evidence for implicit learning of the fixed sequence.

Although implicit sequence learning is typically studied from a cognitive psychology perspective, there is evidence that the magnitude of learning gains depends on motivational factors if rewarding or punishing stimuli are presented contingent on sequence completion (Corr, Pickering, & Gray, 1997; Schultheiss & Rohde, 2002; see also Lewicki, Czyzewska, & Hoffmann, 1987). We therefore expected latency and accuracy difference measures of learning, which we obtained during the extinction phase of our operant-conditioning procedure, to be sensitive to the hypothesized incentive effects of FEEs and their interaction with participants' motivational needs.

Method

Participants

Two hundred sixteen undergraduate and graduate students (85 men; mean age = 21.59 years) participated in the study. During data collection, 21 participants had to be replaced because they exceeded a predefined error cutoff on the DILT (further details are given below).

Design

Motive scores (continuous power and affiliation motive scores) and participant gender (men, women) represented measured between-subjects factors, and emotion (anger, joy, surprise), face gender (male, female), and exposure duration (12 ms, 209 ms) represented experimentally varied between-subjects factors. Sequence (emotional face, neutral face, no face) and phase (fixed, random) were varied within subjects. Dependent variables were participants' speed and accuracy on the implicit learning task.

Procedure

After participants had given their informed consent, their motive levels were assessed with a picture–story exercise (PSE). Next, participants worked on the DILT and on a series of tests probing their awareness of the sequences, stimuli, and their contingencies during the DILT. Finally, participants provided demographic information about themselves, were debriefed, and were paid $25 for their participation. Sessions lasted about 2.5 hr.

All instructions, stimuli, and materials were presented and all responses recorded using the Experimental Run Time System (BeriSoft Cooperation, Frankfurt, Germany, a. M., Germany) on Dell Pentium personal computers with 14-in. (36-cm) cathode-ray color monitors (86.6 Hz vertical retrace) and standard keyboards. Exceptions were the PSE, for which participants wrote stories on sheets provided by the experimenter, and the DILT, for which participants used four-key keypads, which allowed us to record response times (RTs) with a measurement error of less than 1 ms.

Implicit Motives

Implicit motives were assessed by having participants write an imaginative story about each of six pictures: ship captain, couple by river, trapeze artists, women in laboratory (from Smith, 1992), boxer (from McClelland & Steele, 1972), and nightclub scene (from McClelland, 1975). Pictures were presented using standard instructions and procedures described in Smith (1992). Stories were later coded for power and affiliation imagery by two trained, independent coders using Winter's (1994) *Manual for Scoring Motive Imagery in Running Text* (for validity and reliability of this instrument, see Winter, 1991). According to the manual, power motive imagery is scored whenever a story character acts forcefully; tries to persuade, manipulate, and influence others; elicits strong emotions in others; or shows a concern with prestige. Affiliation motive imagery is scored whenever a character shows a concern for being close to others by establishing, maintaining, or restoring a relationship; engaging in friendly, reciprocal activities; expressing positive affect about a relationship; or being sad about a separation. Coders were blind with regard to participants' gender, experimental condition, or performance on the learning and awareness tasks. Interrater reliability, assessed by the index of concordance, was 78% for power imagery and 83% for affiliation imagery. Averaged across both coders, participants' stories contained a mean of 2.96 ($SD = 2.08$) power and 3.89 ($SD = 2.04$) affiliation images. Because total protocol length ($M = 573$ words, $SD = 145$) was significantly associated with power and affiliation scores (rs $> .33$, ps $\leq .0000005$), we corrected each motive score for protocol length by multiplying it by 1,000 and dividing it by word count. To ensure normal distributions, we subsequently transformed word-count-corrected motive scores with the following formula: square root (1 + word-count-corrected motive score). We used these transformed scores in all further analyses.

The DILT

Overview. The DILT featured three fixed color-coded visuomotor sequences participants had to learn simultaneously. After an initial baseline phase, during which participants were exposed to the fixed sequences only, participants entered training, during which one sequence was always followed by an emotional face, one sequence by a neutral face, and one sequence by nothing. During extinction, no faces were presented and participants first worked on the fixed sequences and then switched to random sequences, which were coded in the same colors as the previously presented sequences but no longer featured the fixed stimulus pattern. Participants' RTs and accuracy on fixed and random sequences during extinction constituted the dependent variables in this study. Color-coding of the sequences (red, blue, and yellow) was used as a discriminative cue that signaled whether a particular sequence would end with an emotional, a neutral, or no face during training. Sequences were organized in blocks of nine (three red, blue, and yellow sequences in random order, with the constraint that no sequence could be presented twice in a row within a block). The baseline phase consisted of 3 blocks, training of 18 blocks (with a break after the 10th block), and extinction of 2 fixed-sequence and 2 random-sequence blocks. Thus, each participant had completed each sequence 54 times under training conditions before being tested on it.

To prevent participants from becoming aware of the fixed nature of sequences and applying this knowledge to their responses, the DILT was presented under dual-task conditions. Participants counted beeps occurring at random within each block (three beeps per block) and later reported the total count, once during the break in the training segment and once after extinction.

Before participants entered the baseline phase of the DILT, they completed a warm-up during which they responded to random stimulus sequences and received feedback whenever they responded with the wrong key or pressed the right key too late (i.e., with a latency greater than 1,500 ms). Participants had to correctly respond to 24 stimuli in a row or complete a total of 200 stimuli before they could proceed with the DILT. Before they entered the DILT, they were instructed to work as accurately and quickly as possible and to keep a precise count of the beeps. Because in a pilot study ($N = 46$) we had found that FEEs cease to influence learning on the DILT if participants produce more than 12% error responses, we calculated each participant's error rate on the entire DILT and replaced 21 participants whose error rate exceeded 12%.

Stimulus materials. For the DILT and the subsequent forced-choice test, we used digitized slides from Matsumoto and Ekman's (1988) Japanese and Caucasian Facial Expressions of Emotion (JACFEE) and Neutral Faces picture set. For each of the emotions joy, anger, and surprise, we selected one male and one female Caucasian poser displaying the emotion with the highest intensity, as judged by 271 U.S. raters (Slides ES1-2C17, LR-1C24, DG-1C05, EA-1C06, JG-1C17, and MM-1C17; cf. Biehl et al., 1997), as well as these posers' neutral expressions. All faces were cropped so that each was visible from cheekbone to cheekbone and hairline to chin and resized to 17.7 cm in height (width varied with posers' physiognomy). A 20.0 cm (height) × 22.0 cm (width) mask was created by filling a 13 × 14 checkerboard grid with random rotated fragments taken from each poser's neutral expression. The mask was always presented for 81 ms across the entire DILT either 12 ms (in the 12-ms exposure condition) or 209 ms (in the 209-ms exposure condition) after the offset of each 12th asterisk (i.e., at the end of a fixed sequence during the portions of the DILT featuring fixed sequences). During training, face stimuli (on emotional- and neutral-face sequences) or a blank screen (on no-face sequences) were presented in the interval between offset of the 12th asterisk and mask onset.

Visuomotor sequences. We constructed three 12-stimulus sequences with four different stimulus positions (A, B, C, and D) that satisfied the following constraints: (a) Within each sequence, each of the four screen positions was presented three times; (b) within each sequence, each first-order transition (e.g., AB, AC, AD, BA, BC, BD, and so forth) occurred with equal likelihood (if the sequence is looped back on itself); (c) each sequence started with a different screen position; and (d) each sequence shared only one second-order transition (e.g., ABD, DBA, BAD) with another sequence. Thus, the overall aim guiding the sequence construction was to create three maximally distinct stimulus sequences that moreover required participants to learn complex (i.e., at least second-order) stimulus transitions in order to show learning gains (cf. Reed & Johnson, 1994). Each of the three resulting sequences was always presented in a particular color: red (ABDBACDCBCAD), blue (BDACABCDBADC), and yellow (DABDCACBADBC). Pairing of sequence type (red, blue, yellow) with stimulus type (emotional face, neutral face, no face) during training was balanced across participants and within conditions. Therefore, when we talk about emotional-face, neutral-face, or no-face sequences in the following, we refer to whichever sequence was associated with the presentation of an emotional face, a neutral face, or no face during training for a particular participant.

The four screen positions, A, B, C, and D, were marked by four continually visible 1.5-cm-wide dashes, with a 2.5-cm distance between adjacent dashes, spread out horizontally in the middle of the screen. On each trial, response registration started with a 1-cm-wide asterisk (*) appearing above one of the dashes and was terminated with a keypress. The interval before the presentation of the next asterisk was 300 ms. Asterisks and dashes were presented on a black background in the color of a given sequence. Twelve trials made up one sequence, and participants' RTs were averaged per sequence presentation for subsequent analyses, with RTs greater than 1,500 ms and RTs generated by error responses (i.e., when a nonmatching key was pressed) excluded. An error score on a given sequence was measured by summing error responses. A score of 0 represented perfect accuracy, and a score of 9 represented the chance-level baseline. To create our dependent variables, we averaged participants' RTs and error scores separately for emotional-face, neutral-face, and no-face sequences (a) across the fixed-sequence blocks and (b) across the random-sequence blocks presented during extinction. Thus, each RT and error score derived for the fixed-sequence and the random-sequence phase is based on six aggregated 12-stimulus sequences. We corrected each of the resulting 2 (phase) × 3 (sequence) error score variables with a log transformation (log [0.5 + error score]) to make them conform to a normal distribution.

Contingency Awareness Test

We probed participants' awareness of the specific contingencies between the fixed character of the sequences, color coding, and stimulus type (emotional, neutral, no face) presented during the training phase. We also tested participants' awareness of the overall relationship between fixed sequences, color codes, and stimulus types with a set of general-contingency questions. Specific-contingency questions probed for (a) participants' awareness of the fact that the colored asterisk sequences followed a fixed pattern throughout most of the DILT (three questions with the stem "Typically, the asterisk sequence presented in red (blue, yellow) was . . ." and the response alternatives "systematic" and "random"); and (b) for their awareness that during training, specific sequence colors were predictive of the presentation of specific stimulus types (three questions with the stem "Red (blue, yellow) asterisks predicted . . ." and the response alternatives "an angry [smiling, surprised] face," "a neutral face" and "no face"; response alternatives differing between questions are represented by parentheses, and response alternatives differing between experimental conditions are represented by brackets). For the latter set of questions, participants were told that because faces were presented for a very short amount of time, they may not have become aware of them, and they were encouraged to provide their best guess when responding. For the three general-contingency questions, the stem "What kind of sequence and face, or no face, was associated with RED (blue, yellow) ASTERISKS? Please choose one" was used, and the following response alternatives were listed:

1. Red (blue, yellow) asterisks > systematic sequence > angry [smiling, surprised] face
2. Red (blue, yellow) asterisks > systematic sequence > neutral face
3. Red (blue, yellow) asterisks > systematic sequence > no face
4. Red (blue, yellow) asterisks > random sequence > angry [smiling, surprised] face
5. Red (blue, yellow) asterisks > random sequence > neutral face
6. Red (blue, yellow) asterisks > random sequence > no face

Sequence Recognition Test

To probe participants' awareness of the fixed patterns inherent in the three stimulus sequences, we presented these sequences and three distractor sequences (ACABDADBCDCB, BDBCDCDABACA, and DCBCDACABDBA) in random order. Asterisks were shown for 500 ms each, with an interstimulus interval of 300 ms. After presentation of each sequence, participants indicated to what degree they were sure that the sequence was one of the three predictable DILT sequences using a 5-point scale, with response categories labeled *definitely not* (1), *probably not* (2), *not sure* (3), *probably* (4), and *definitely* (5). We created average scores of participants' responses to real sequences and to distractor sequences.

Forced-Choice Face Identification and Discrimination Tests

On a face identification task, we tested whether participants were able to decide whether a face had been presented before the mask or not and thus probed whether they had been able to tell no-face sequences apart from emotional- and neutral-face sequences during training. On a face discrimination task, we tested whether participants were able to discriminate emotional faces from neutral faces and thus probed whether they had been able to tell emotional-face sequences apart from neutral-face sequences during training. For both tasks, participants were exposed to the same faces and at the same durations as during the DILT.

On face identification task trials, participants first saw a fixation cross in the middle of the screen, then either a face (neutral or emotional) on half of the trials or nothing on the other (in random order), followed by the mask, and then by a choice screen featuring the face on the left side and the words *No picture* on the right side of the screen. If a face had been shown before the mask, it was shown with the same expression (neutral or emotional) on the choice screen; if none had been shown, an emotional face was presented on one half of all trials and a neutral face on the other. Participants worked on 32 trials, half of which featured a face before the mask.

Face discrimination task trials were identical to face identification task trials, except that we always presented a face before the mask (emotional on half of the trials, neutral on the other, in random order), and the choice screen featured an emotional face on the left and a neutral face on the right side of the screen. Participants worked on 32 trials, half of which featured an emotional face before the mask.

Statistical Analyses

We performed all analyses using SYSTAT, Version 10. We used SYSTAT's multiple regression and repeated-measures multiple regression procedures.

Table 1
Intercorrelations Between Personality Measures, Gender, and Measures of Implicit Learning

Variable	1	2	3	4	5	6	7	8	9	*M*	*SD*
1. Power motive[a]	—									2.36	0.68
2. Affiliation motive[a]	−.01	—								2.75	0.67
3. Participant gender[b]	−.13†	−.18**	—							1.39	0.49
4. Emotional-face sequence (Δms)[c]	−.05	−.06	−.07	—						26.38	33.45
5. Neutral-face sequence (Δms)[c]	.17*	−.03	−.04	.30***	—					24.20	38.99
6. No-face sequence (Δms)[c]	.06	−.01	−.13†	.25***	.40***	—				24.10	37.77
7. Emotional-face sequence (Δerror)[d]	−.05	−.03	−.03	.16*	.18**	.16*	—			0.08	0.45
8. Neutral-face sequence (Δerror)[d]	−.01	−.00	−.04	.10	.05	.13†	−.03	—		0.10	0.44
9. No-face sequence (Δerror)[d]	−.10	−.06	.08	.04	.05	.07	.03	−.04	—	0.06	0.40

[a] Motive scores were word-count corrected and then square-root transformed. [b] Participant gender was coded 1 for female and 2 for male. [c] Difference scores were created by subtracting fixed-sequence response times from random-sequence response times; higher scores represent stronger implicit learning by the speed criterion. [d] Difference scores were created by subtracting fixed-sequence from random-sequence log-transformed error scores (number of incorrect keypresses); higher scores represent stronger implicit learning by the accuracy criterion.
† $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Results

Derivation of Implicit Learning Measures

Regression analysis, with sequence (emotional face, neutral face, no face) and phase (fixed vs. random) as within-subjects factors, indicated that participants showed significant overall increases in log-transformed error scores from the fixed- ($M = 0.14$, $SD = 0.33$) to the random-sequence phase ($M = 0.22$, $SD = 0.36$), $F(1, 215) = 23.28$, $MSE = 0.091$, $p < .000005$, and in RT scores from the fixed- ($M = 367$ ms, $SD = 59$ ms) to the random-sequence phase ($M = 392$ ms, $SD = 55$ ms), $F(1, 215) = 180.99$, $MSE = 1{,}109.06$, $p < 10^{-15}$. There was no effect of sequence or the Sequence × Phase interaction for either dependent variable (ps $> .14$). Both the error and the RT increase from the fixed- to the random-sequence phase indicated that during the random phase, participants were no longer able to apply the previously acquired procedural knowledge of the sequences and thus constitute evidence for implicit learning. For all subsequent analyses, we therefore created difference scores for speed (random- minus fixed-sequence RTs) and accuracy (random- minus fixed-sequence error scores) that code for the magnitude of each participant's learning gain on each sequence type, with higher scores on both measures reflecting better learning.[1] As reported in Table 1, RT difference scores were moderately correlated across sequences, indicating that participants who had high learning gains on one sequence type also had high learning gains on the other two. However, the magnitude of these correlations also leaves room for substantial differences in learning gains between the three sequences. Accuracy difference scores showed no substantial overlap, suggesting that accurate performance on one sequence was independent of accurate performance on the other two. Correlations between RT and accuracy difference scores were generally low and positive, indicating no speed–accuracy trade-offs. Rather, participants who learned well according to the speed criterion also tended to be more accurate in the execution of the keypress pattern, particularly on emotional-face sequences.

Motive Effects on FEE-Dependent Learning Accuracy

To test for motive effects on FEE-driven learning accuracy, we regressed accuracy scores on the between-subjects factors emotion (joy, surprise, anger), exposure duration (12 ms, 209 ms), participant gender (men, women), face gender (men, women), and power motivation (continuous variable). We obtained a significant Power Motive × Emotion × Participant Gender × Face Gender × Sequence interaction, $F(4, 384) = 3.42$, $MSE = 0.186$, $p < .01$, which could be simplified into a Power Motive × Emotion × Gender Match × Sequence interaction, $F(4, 408) = 3.92$, $MSE = 0.186$, $p < .005$, in which the factor gender match coded for whether participants were exposed to faces matching their own gender ($n = 105$) or not ($n = 111$). In keeping with our focus on documenting differential learning on emotional-face sequences relative to control sequences for each emotion, we split the interaction by emotion and found significant Power Motive × Gender Match × Sequence interactions in the joy-face condition, $F(2, 136) = 2.88$, $MSE = 0.180$, $p = .06$, and the surprise-face condition, $F(2, 136) = 4.92$, $MSE = 0.200$, $p < .01$, but not in the anger-face condition ($p = .84$).

Further analyses in the joy-face condition indicated that power motivation interacted with sequence type only when face gender matched participant gender, $F(2, 70) = 2.90$, $MSE = 0.175$, $p = .06$, but not when it did not ($p = .63$). As depicted in Figure 1, in the same-gender condition ($n = 37$), the power motive was a negative predictor of learning accuracy on joy-face sequences ($B = -0.25$, $SE = 0.70$, $p = .05$), but not of neutral-face or no-face sequences (ps $> .26$), and the slope of the joy-face

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[1] Note that the use of difference scores is common practice in implicit learning research and also defensible on the basis of the type of analytical design we use here, that is, repeated measures regression. Linear combinations of variables are at the heart of this type of analysis (Cohen, Cohen, West, & Aiken, 2003). As a consequence, all F statistics and p values reported for analyses involving fixed-random difference scores are exactly identical with those obtained when separate performance measures for the fixed and the random phase are added as a within-subjects factor phase to the effects reported in the article. We also repeated all of our analyses with scores from the three fixed sequences residualized by regression for their random-sequence counterparts—all findings, effect sizes, and significance levels were virtually identical to those we report for the difference scores, suggesting that our results are not an artifact of the calculation of difference scores.

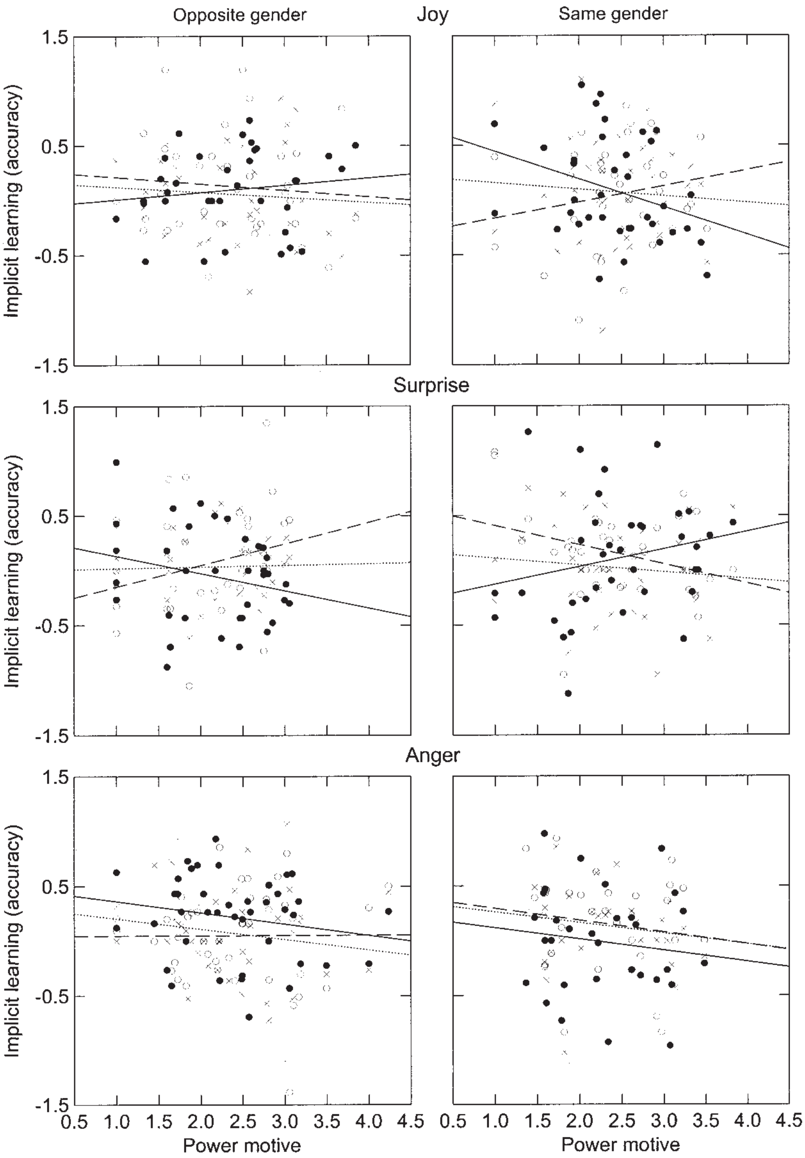

Figure 1. Power Motive × Emotion × Gender Match × Sequence interaction effect on implicit learning accuracy (log-transformed error scores on random sequences minus log-transformed error scores on fixed sequences; higher values reflect better learning). Solid circles and lines = emotional face; open circles and dashed lines = neutral face; exes and stippled lines = no face.

sequence significantly differed from the slope of the neutral-face sequence, *F*(1, 35) = 6.84, *MSE* = 0.148, *p* = .01, but not from the slope of the no-face sequence (*p* = .27).

In the surprise-face condition, the Power Motive × Sequence effect approached significance in the same-gender condition (*n* = 37), *F*(1, 70) = 2.84, *MSE* = 0.195, *p* = .07, reflecting the finding that the power motive was a nonsignificant positive predictor of learning accuracy on surprise-face sequences (*B* = 0.16, *SE* = 0.12, *p* = .19) and a significant negative predictor of learning accuracy on neutral-face sequences (*B* = −0.17, *SE* = 0.08, *p* < .05); for the difference between slopes, *F*(1, 35) = 5.63, *MSE* = 0.189, *p* < .05. The learning slope on the no-face sequence (*B* = −0.06, *SE* = 0.09, *p* = .50) did not differ significantly from either of the other two slopes. Although Figure 1 suggests that the pattern of findings we had obtained for same-gender surprise faces was reversed in the opposite-gender condition (*n* = 35), the Power Motive × Sequence interaction failed to become significant (*p* = .11). However, when we compared surprise-face and neutral-face sequences directly in this condition, the difference between slopes was marginally significant, *F*(1, 33) = 3.47, *MSE* = 0.262, *p* = .07. We also tested whether slopes for the surprise-face sequence differed between the opposite-gender and same-gender conditions and found this to be the case at the trend level, *t*(68) = 1.90, *p* = .06. In summary, then, there was evidence that the power motive was associated with enhanced learning on surprise-face sequences, relative to neutral-face sequences, if surprise was expressed by a member of one's own gender, but not if surprise was expressed by a member of the opposite gender.

As reflected in the slight negative slopes in the anger condition (cf. Figure 1), the power motive showed a general trend to predict impaired learning in the context of an anger expression, regardless of sequence type ($B = -0.08$, $SE = 0.04$, $p = .08$, for the main effect of power motivation on sequence learning accuracy).

Replacing the power motive with the affiliation motive variable in the regression model reported at the start of this section did not yield significant effects involving the motive variable.

Motive Effects on FEE-Dependent Learning by the Speed Criterion

To test for motive effects on FEE-driven learning as reflected in response speed, we applied the overall regression model described in the previous section to speed difference scores as the dependent variable. We obtained a significant Power Motive × Emotion × Exposure Duration × Participant Gender × Face Gender × Sequence interaction, $F(4, 336) = 2.38$, $MSE = 894.85$, $p = .05$, which could be simplified into a Power Motive × Emotion × Exposure Duration × Gender Match × Sequence interaction, $F(4, 384) = 2.66$, $MSE = 903.18$, $p < .05$. Follow-up analyses revealed the results below.

In the joy-face condition, only the Power Motive × Sequence interaction was marginally significant, $F(2, 140) = 2.85$, $MSE = 844.56$, $p = .06$, indicating that motive-based slopes for learning of joy-face sequences ($B = -7.47$, $SE = 6.47$, $p = .25$) and neutral-face sequences ($B = 9.79$, $SE = 7.54$, $p = .20$) significantly differed from each other, $F(1, 70) = 5.35$, $MSE = 860.06$, $p < .05$. The slope for the no-face sequence ($B = -2.08$, $SE = 7.20$, $p = .77$) did not significantly differ from either of these sequences. Thus, as illustrated in Figure 2, power-motivated individuals showed impaired learning of joy-face sequences relative to learning of neutral-face sequences.

In the surprise-face condition, a marginally significant Power Motive × Exposure Duration × Gender Match × Sequence interaction, $F(2, 128) = 2.85$, $MSE = 1{,}127.93$, $p = .06$, could be traced back to a significant Power Motive × Gender Match × Sequence effect at 12-ms exposure, $F(2, 64) = 3.03$, $MSE = 1{,}158.38$, $p = .05$, which did not emerge in the 209-ms exposure condition. As shown in Figure 3, the effect at 12 ms was due to power-motivated individuals' impaired learning on opposite-gender surprise-face sequences ($B = -28.20$, $SE = 10.20$, $n = 20$, $p = .01$) relative to (a) opposite-gender neutral-face sequences ($B = 11.20$, $SE = 9.21$, $p = .24$), slope difference, $F(1, 18) = 12.20$, $MSE = 614.00$, $p < .005$; (b) opposite-gender no-face sequences ($B = 7.82$, $SE = 12.64$, $p = .54$), slope difference, $F(1, 18) = 5.63$, $MSE = 1{,}112.18$, $p < .05$; and (c) same-gender surprise-face sequences ($B = 10.95$, $SE = 14.37$, $n = 16$, $p = .46$), slope difference, $t(32) = 2.28$, $p < .05$.

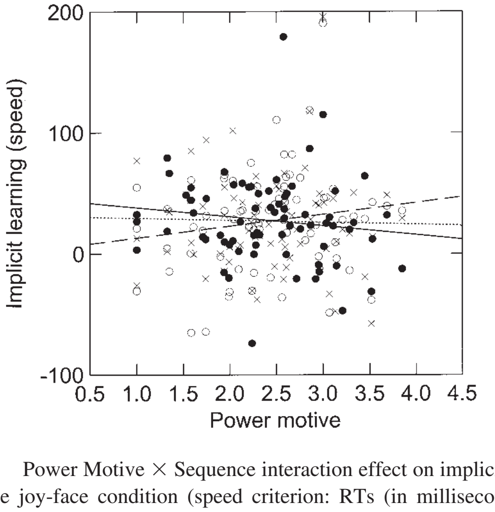

Figure 2. Power Motive × Sequence interaction effect on implicit learning in the joy-face condition (speed criterion: RTs (in milliseconds) on random sequences minus RTs (in milliseconds) on fixed sequences; higher values reflect better learning). Solid circles and lines = emotional face; open circles and dashed lines = neutral face; exes and stippled lines = no face.

The Power Motive × Exposure Duration × Gender Match × Sequence interaction as well as lower order effects failed to become significant in the anger-face condition.

When we replaced the power motive with the affiliation motive variable in the overall regression model described above, the Emotion × Face Gender × Exposure Duration × Affiliation Motive × Sequence interaction reached the level of a trend, $F(4, 384) = 1.94$, $MSE = 958.90$, $p = .10$. The trend was based on a significant Affiliation Motive × Exposure Duration × Face Gender × Sequence interaction in the anger condition, $F(2, 128) = 3.63$, $MSE = 763.27$, $p < .05$. Follow-up analyses revealed that this effect was based on a significant Affiliation Motive × Exposure Duration × Sequence interaction for male faces, $F(2, 64) = 4.36$, $MSE = 930.30$, $p < .05$, that did not emerge for female faces. The slope for learning on male neutral faces shown for 209 ms ($B = -46.09$, $SE = 18.57$, $p < .05$) differed significantly from the slope for learning on male anger faces shown for 209 ms ($B = 1.74$, $SE = 18.64$, *ns*), slope difference, $F(1, 16) = 4.73$, $MSE = 971.16$, $p < .05$, and from the slope for learning on male neutral faces shown for 12 ms ($B = 20.89$, $SE = 14.70$, $p = .17$), slope difference, $t(32) = -2.79$, $p < .01$. The difference in slopes between neutral and angry male faces in the 12-ms condition failed to become significant ($p = .15$). As illustrated in Figure 4, affiliation-motivated individuals showed impaired learning on sequences followed by a male neutral face shown for 209 ms, but not on sequences followed by a male anger face shown for 209 ms or sequences followed by a male neutral face shown for 12 ms.

Awareness Tests

Contingency awareness. On the three items assessing participants' judgment of whether sequences presented in a specific color had been fixed or random, we found that 52.78% opted for fixed on emotional-face sequences, 54.63% on neutral-face sequences, and 56.48% on no-face sequences (*p*s > .05; chi-square test). Participants' judgments were not significantly correlated with their sequence awareness, as assessed on the recognition task (*p*s > .33; see below). Thus, participants did not seem to be aware that particular cue colors were associated with specific fixed sequences.

Table 2 reports results for participants' awareness of color-cue/stimulus-type associations. There was little evidence that participants were aware of which color predicted which type of stimulus at the end of a sequence. Exposure duration did not moderate this finding.

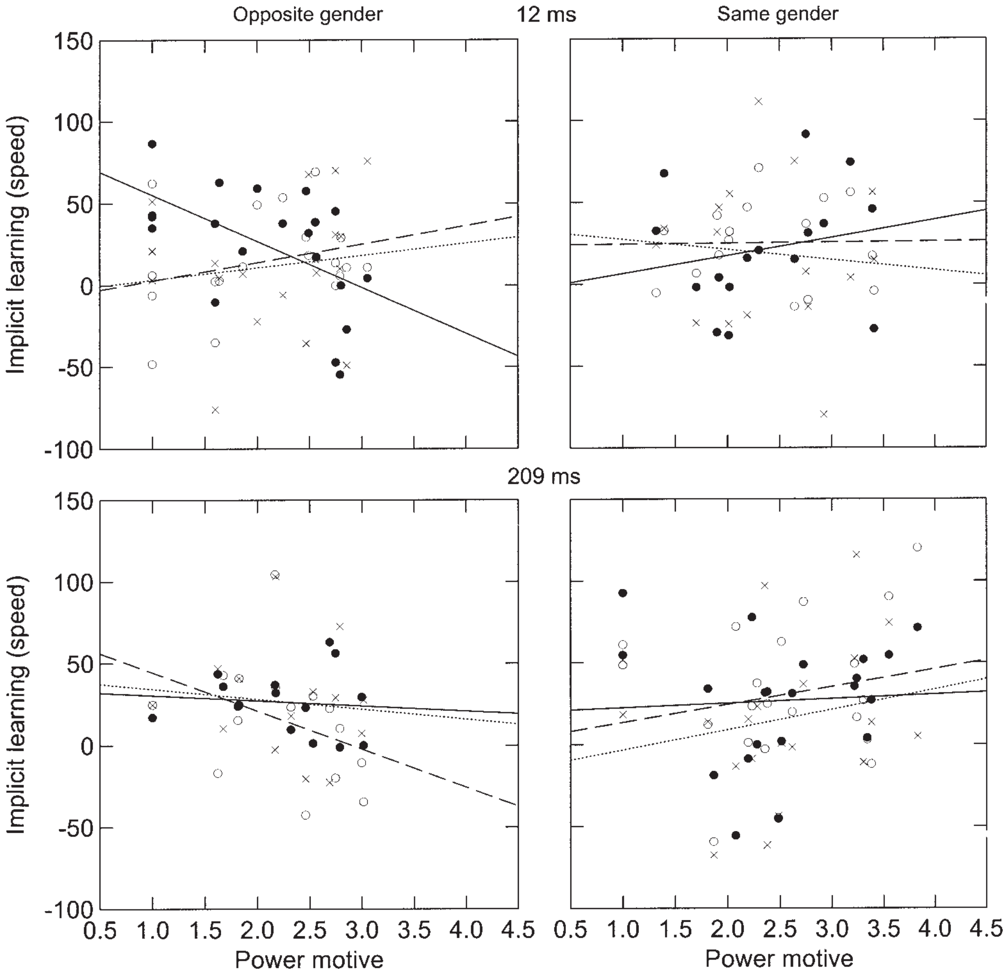

Figure 3. Power Motive × Gender Match × Exposure Duration × Sequence interaction effect on implicit learning in the surprise-face condition (speed criterion: RTs [in milliseconds] on random sequences minus RTs [in milliseconds] on fixed sequences; higher values reflect better learning). Solid circles and lines = emotional face; open circles and dashed lines = neutral face; exes and stippled lines = no face.

Results for the three items that assessed participants' awareness of the full three-way contingency involving color cue, sequence type, and stimulus type are reported in Table 3. Participants had above-chance hit rates when indicating what combination of cue and sequence led to the presentation of an emotional face but only chance-level hit rates when trying to identify cue-and-sequence combinations leading to the presentation of a neutral face and even below-chance hit rates when indicating what cue-and-sequence combinations were not followed by a face stimulus. Moreover, although more participants picked the correct cue > sequence > emotional face contingency than would be expected by chance, the vast majority of the sample was not able to identify the correct contingency for emotional-face sequences. Thus, participants' awareness of three-way contingencies between color cue, sequence type, and face stimulus was slightly better than chance on emotional-face sequences, but not on other sequences.

Sequence recognition. Participants had slightly higher average recognition scores for real sequences ($M = 3.26$, $SD = 0.62$) than for distractor sequences ($M = 3.08$, $SD = 0.60$), $t(215) = 2.72$, $p < .01$, $d = 0.30$. To assess whether sequence recognition affected any of the previously reported findings, we created a measure of sequence awareness by subtracting averaged recognition scores on distractor sequences from average recognition scores on real sequences. We found that only the Affiliation Motive × Exposure Duration × Face Gender × Sequence on Speed interaction in the anger-face condition was significantly moderated by sequence awareness, $F(2, 112) = 4.34$, $MSE = 787.66$, $p < .05$, for the five-way interaction. Follow-up analyses revealed that the original four-way interaction held only for individuals with below-median sequence awareness, $F(2, 54) = 3.50$, $MSE = 874.87$, $p < .05$, but not for those with above-median sequence awareness ($p = .59$). We therefore conclude that the effects we observed in this study did not depend on participants' awareness, and thus explicit knowledge, of the sequences they worked on.

Face recognition. For the face detection and face discrimination tasks, participants' hit rate (i.e., faces correctly detected or discriminated) was at chance levels when faces were presented for

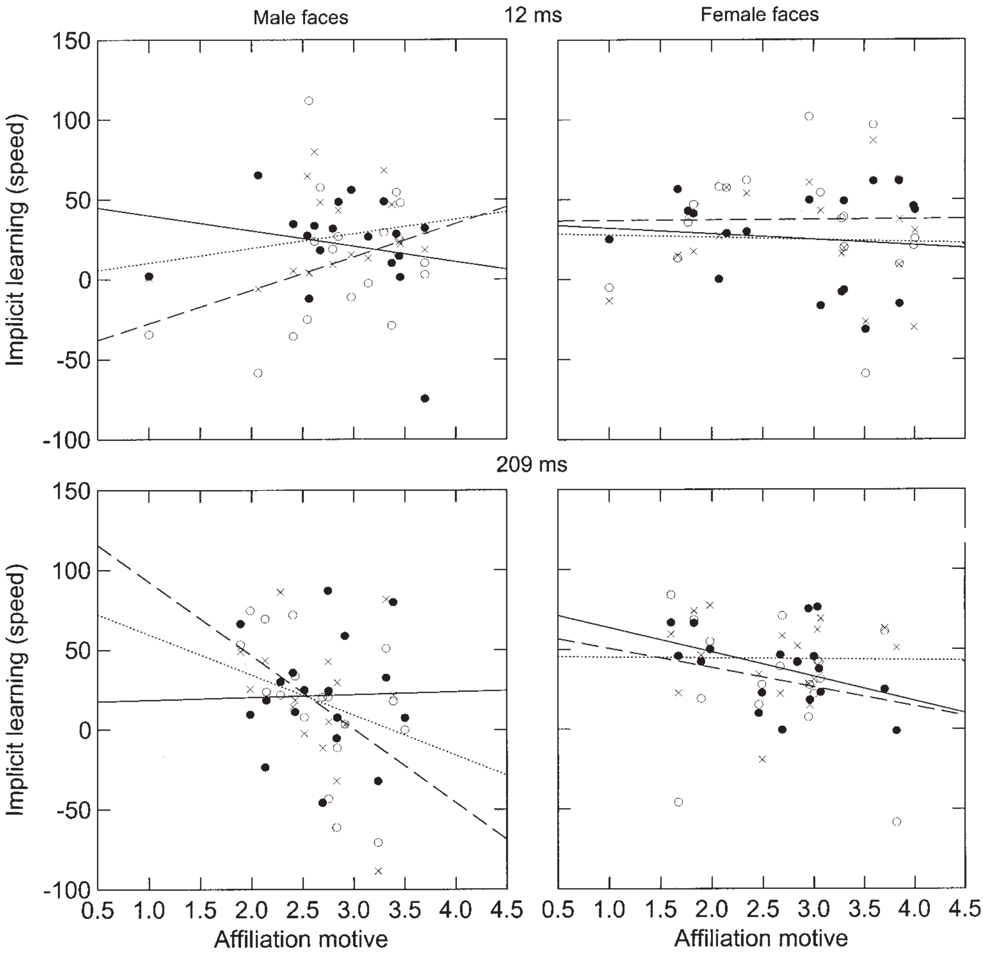

Figure 4. Affiliation Motive × Face Gender × Exposure Duration × Sequence interaction effect on implicit learning in the anger-face condition (speed criterion: RTs [in milliseconds] on random sequences minus RTs [in milliseconds] on fixed sequences; higher values reflect better learning). Solid circles and lines = emotional face; open circles and dashed lines = neutral face; exes and stippled lines = no face.

12 ms (50.17% and 51.50%, respectively) and close to perfect when faces were presented for 209 ms (97.80% and 99.45%, respectively). The main effect for exposure duration was highly reliable for both tasks, $Fs(1, 214) > 4{,}193$, $ps < 10^{-9}$, and was not moderated by emotion.

Discussion

In this study, we used an operant-conditioning approach to examine the rewarding and punishing properties of three perceived FEEs, namely, anger, surprise, and joy. We had hypothesized that an FEE's incentive value is influenced (a) by the expression's meaning as a signal of dominance or affiliation, (b) by the perceiver's dispositional needs for dominance (the power motive) and affiliation (the affiliation motive), and (c) by the match or mismatch between the sender's and the perceiver's gender. Our findings provide evidence for reinforcing effects of perceived FEEs in interaction with the perceiver's motivational needs on procedural learning of visuomotor sequences that had reliably preceded FEE presentation during training. Our findings also suggest that speed and accuracy components of implicit learning are dissociable and differentially sensitive to motive and incentive effects and cannot easily be attributed to declarative knowledge of sequences and reinforcement contingencies.

Motive-Based Incentive Effects of FEEs

We found that high levels of implicit power motivation were associated with impaired learning of sequences that had been followed by joy faces relative to sequences that had been followed by neutral faces. We obtained this effect both for the speed criterion and the accuracy criterion of implicit learning, although in the latter case, it held true for same-gender faces only.

We also found that high levels of power motivation predicted enhanced learning, by both the speed and the accuracy criterion, of sequences that had been followed by same-gender surprise faces but impaired learning of sequences that had been followed by opposite-gender surprise faces (in the case of response speed, this effect was evident only at 12-ms exposure duration). Thus, as predicted, for those with a strong dispositional need to have impact on and dominate others, a joy expression, which in past research has been classified as a high-dominance signal, is aversive, and a surprised expression, reflecting the perceiver's impact on the sender and the sender's comparatively low dominance (cf. Conway et al., 1999; Winter, 1973), is rewarding if emitted by a member of one's own gender. The finding that opposite-gender surprise faces represent a negative incentive for individuals high in power motivation may suggest that baffling, and thus potentially alienating, a member of the opposite gender may be unwise if a central goal of one's need for dominance is to be in a better position to attract a mate.

We also obtained some evidence that exposure to an angry face is aversive for power-motivated individuals. This finding is consistent with the notion that expressions of anger in others represent a threat to a power-motivated individual's own need for dominance and thus act as negative reinforcers. However, because the effect emerged only as a trend for learning accuracy, but not for speed, and generalized to neutral-face and no-face sequences, further research is needed to bolster the validity of the anger-as-dominance-threat hypothesis.

Although we did not observe effects of affiliation motivation on learning accuracy, we found that participants' affiliation motive differentially predicted sequence execution speed in the anger-face condition. Specifically, in the male-face condition, affiliation-motivated individuals showed impaired learning of sequences that were followed by a clearly visible neutral face, but not sequences that were followed by a clearly visible anger face.[2] Although we had not predicted that affiliation motivation is associated with impaired learning of sequences associated with visible neutral faces, but not visible anger faces, our results are consistent with Schultheiss and Hale's (2004) observation that affiliation-motivated individuals orient their attention toward male anger faces (and away from neutral faces!) at 231-ms exposure and suggest that a male sender who visibly displays anger may be less aversive than the same sender showing a neutral expression. We speculate that affiliation-motivated individuals may interpret a neutral expression as a sign of the interaction partner's emotional withdrawal from a relationship and thus as a negative incentive, particularly if the partner could also be angry at them and thus express some form of emotional engagement. This interpretation is supported by research showing that in romantic relationships, affiliation-motivated women are particularly likely to use aggressive behaviors as a means of getting close to their partner, especially if the relationship is threatened (e.g., Mason & Blankenship, 1987). It remains unclear, however, why in the present study affiliation-specific incentive effects were limited to male faces (no

Table 2
Endorsed Contingencies (Percentage Scores) on Three Items Assessing Participants' Awareness of Cue-Stimulus Contingencies

Exposure duration	Judged predictiveness of color for: Emotional face	Neutral face	No face
	Color predicting emotional face		
12 ms	*37.96*	30.56	31.48
209 ms	*34.26*	39.81	25.93
Total	*36.11*	35.19	28.70
	Color predicting neutral face		
12 ms	31.48	*40.74*	27.78
209 ms	34.26	*35.19*	34.26
Total	32.87	*37.96*	29.17
	Color predicting no face		
12 ms	34.26	36.11	*29.63*
209 ms	30.56	27.78	*41.67*
Total	32.41	31.94	*35.65*

Note. The three response alternatives per item are presented as rows. The baseline hit rate for each cell is 33.33%, representing random responding. Italics highlight correct judgments (i.e., the predictiveness of a color cue for a particular facial stimulus is correctly stated). Within each row, percentage scores did not significantly differ from each other (omnibus chi-square tests; *p*s > .10). The Exposure Duration × Face Stimulus (emotional, neutral, no) interaction was nonsignificant for each of the three panels.

Table 3
Endorsed Contingencies (Percentage Scores) on Three Items Assessing Participants' Awareness of Cue-Sequence Contingencies Associated With the Presentation of an Emotional, a Neutral, or No Face at the End of a Sequence

Contingency	Color predicting: Emotional face	Neutral face	No face
Cue > fixed sequence > emotional face	*24.54**	15.28	18.06
Cue > fixed sequence > neutral face	16.20	*21.30*	18.52
Cue > fixed sequence > no face	12.50	17.13	*11.11**
Cue > random sequence > emotional face	15.74	11.11*	17.13
Cue > random sequence > neutral face	12.04*	15.74	16.67
Cue > random sequence > no face	18.98	19.44	18.52
$\chi^2(5)$	13.89*	8.17	5.17

Note. Items were recorded so that correct and incorrect responses were classified with reference to the stimulus type (emotional face, neutral face, and no face). The six response alternatives per item are presented as columns. The baseline hit rate for each cell is 16.67%, representing random responding. Italics highlight correct judgments (i.e., correct identification of three-way contingencies between color cue, sequence type, and face stimulus). The Exposure Duration × Face Stimulus (emotional, neutral, no) interaction was nonsignificant in each column.
* $p < .05$.

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[2] One reviewer suggested that effects of frustrative nonreward and relief during extinction (here: omission of a potentially reassuring neutral face = frustrative nonreward; omission of an aversive anger face = relief) may have accounted for this finding (cf. Gray, 1971). We therefore explored the shape of implicit learning effects at the end of training (average RT on random sequences during extinction minus average RT on last two blocks of training) and found that here, too, affiliation-motivated individuals showed impaired learning on sequences associated with visible male neutral faces, but not on other sequences. Thus, effects of frustrative nonreward or relief are unlikely to explain the affiliation motive's effect on learning in the anger condition.

significant effects emerged for female anger faces) and were not moderated by participants' gender. More research is needed to resolve these issues.

We were unable to demonstrate an influence of the affiliation motive on learning of sequences associated with the affiliation-signaling joy expression. One possible reason for this failure may be that the measure of affiliation motivation we used in the present study reflects fear of rejection more than a need for closeness and may thus be more predictive of responses to rejection cues (e.g., anger or indifference) than to intimacy cues (i.e., joy; see McClelland, 1987, for a discussion of the differences between affiliation and intimacy motivation). Another reason may be that the joy face has incentive value for both the affiliation and the power motive. Because these motives can coexist independently within a person, it may be necessary to take both of them into account when trying to predict a person's response to a joyful expression. In line with this conjecture, we found in exploratory analyses that high levels of affiliation motivation predicted overall enhanced learning (speed criterion) in response to same-sex joy faces at 209-ms exposure, but only if participants were also high in power motivation, not if they were low in power motivation. Thus, although we focused on direct effects of motive dispositions on FEE incentive effects in the present study, a promising approach for future studies might be to look at specific configurations of two or more motive dispositions or to separate hope and fear components in the affiliation motive measure (cf. McClelland, 1987; Schultheiss & Brunstein, 1999).

Differential Sensitivity of Speed and Accuracy Components of Implicit Learning

It is notable that in our study, speed and accuracy measures of implicit learning showed comparatively little overlap and were differentially influenced by power and affiliation motives, with power motivation affecting the accuracy and, to a lesser extent, the speed aspects of learning and the affiliation motive influencing only the speed aspect. Our findings thus suggest that speed and accuracy capture different aspects of visuomotor learning and are differentially sensitive to the impact of implicit motives. This conclusion is consistent with the finding that implicit learning speed and accuracy are differentially impaired by Parkinson's disease and may thus be mediated by dissociable neurobiological systems (e.g., Sommer, Grafman, Clark, & Hallett, 1999).

Further evidence for a dissociation between accuracy and speed comes from our observation that the speed criterion, but not the accuracy criterion, was sensitive to whether incentives were presented within or outside of conscious awareness. Effects of power motivation on learning accuracy for opposite- and same-gender surprise faces, which were not moderated by exposure duration, emerged only for face stimuli presented outside of conscious awareness when we repeated our analyses for the speed criterion. In contrast, in the anger condition, affiliation motivation was more predictive of learning in response to clearly visible faces than of learning in response to faces presented outside of conscious awareness. More research is needed to determine whether the differential sensitivity of speed and accuracy aspects of implicit learning to incentives presented within or outside of conscious awareness represents a robust phenomenon or why the speed aspect of implicit learning is sometimes sensitive to visible incentives, sometimes to incentives presented outside of awareness, or sometimes to both (as in the case of the power motive's effects on learning on joy-face sequences). Taken together, however, our findings should alert other researchers to the notion (a) that implicit learning is modulated by motivational processes and (b) that speed and accuracy components of implicit learning are differentially sensitive to motivational influences on learning.

The Role of Awareness in Learning on the DILT

Finally, we want to point out that participants had little insight into the contingencies inherent in the DILT. When queried after the DILT, they showed no awareness of the fact that differently colored sequences had been associated with specific, fixed sequences during most of the test or with specific facial stimuli during training (the latter held true even in the 209-ms exposure condition, when participants' discrimination of stimuli was close to perfect). Not surprisingly, then, we also failed to find consistent evidence that participants had become aware of the whole three-way contingency between color cue, sequence, and face. When we probed specifically for participants' recognition and thus declarative knowledge of the three sequences we had used in the DILT, we found a slight recognition advantage for the DILT sequences over new sequences. However, this recognition advantage did not account for the effects of FEEs on learning we had observed, and in the case of affiliation motive-driven learning, it even worked against the emergence of between-slopes differences. Our findings are therefore entirely compatible with the notion that motivational processes can be set in motion and affect behavior in complex ways without the individual's becoming aware of these stimuli and processes or the behavioral changes they result in (LeDoux, 2002; McClelland et al., 1989; T. D. Wilson, 2002). In this sense, then, the motivational influence of perceived FEEs on individuals' behavior can be truly implicit.

Limitations and Future Directions

Apart from extending the present line of research to other FEEs (sadness, fear, disgust), we believe that the following three issues deserve particular consideration in future studies.

Exploratory and correlational nature of findings. The present study has exploratory character in that it is the first study to directly test the effects of FEEs on behavioral indicators of the perceiver's motivation and also in that it uses and validates the DILT, a novel technique for the assessment of implicit incentive motivation processes in humans. However, some findings were unexpected (e.g., impaired learning in affiliation-motivated individuals for 209-ms neutral faces in the context of anger) or not obtained as predicted (e.g., the hypothesized facilitative effect of affiliation motivation on learning of joy-face sequences), and the correlational nature of our findings does not allow us to make any strong claims about a causal effect of motive dispositions on the reward value of FEEs. These issues could be resolved in future studies by bringing individuals' motivation to dominate or affiliate under experimental control by, for instance, the presentation of situational cues or arousing movie clips.

Prototypicality of emotional displays. Because we used pictures from a single poser for each emotion–gender combination, one possible concern related to our present findings is whether they represent the effects of a prototypical emotional display on learning (e.g., the effect of a facial display of anger) or rather the idiosyncratic effect of a particular poser expressing that emotion (i.e., John showing his unique anger face, which is different from the way Jack or Josh would express anger). Given the careful and rigorous procedure through which the JACFEE picture set was developed and validated (see Matsumoto & Ekman, 1988), we believe that the findings we obtained in this study are primarily the result of prototypical emotional displays shown by the posers, with comparatively little influence of idiosyncratic features of a given poser's face on the expression. Nevertheless, future studies should further explore this issue by either including displays of emotion shown by more than one person per gender or by using schematic drawings of prototypical emotional displays (e.g., Öhman, Lundqvist, & Esteves, 2001).

What kind of conditioning? The DILT was devised so that it closely resembled a fixed-ratio schedule of reinforcement used in animal studies of operant conditioning, with the reinforcer (typically food in animal studies, faces in our study) being delivered after a fixed number of responses (barpresses in animal studies, keypresses in our study). Our task differs from many operant-conditioning paradigms, however, in that the presentation of a specific reinforcing event (emotional face, neutral face, no face) was not contingent on characteristics of the response (e.g., achieving a certain average speed or level of accuracy on a sequence) and thus may be open to alternative explanations, such as Pavlovian-conditioning accounts (cf. Berridge, 2001). This ambiguity can be resolved in further research by making the presentation of a particular reinforcer (e.g., an angry face) contingent on the speed or accuracy with which a sequence is executed.

Conclusion

To summarize, our present research shows that FEEs signaling low dominance or high affiliation enhance implicit learning, and FEEs signaling high dominance or low affiliation impair implicit learning if the perceiver has a strong implicit need for power or affiliation. Our findings thus support the hypothesis that perceived emotional expressions can act as incentives and motivate and shape people's behavior (Keltner et al., 2003; Keltner & Haidt, 1999). In addition, our research also demonstrates that motivational processes in humans can be studied rigorously with behavioral measures adapted from cognitive psychology. To the extent that the phenomena explored by cognitive psychologists overlap with core functions of motivation (e.g., attention and procedural learning), such measures allow researchers to investigate incentive-driven behavior in humans in great detail and without having to resort to participants' introspective accounts, whose veridicality is notoriously limited when it comes to explaining motivated behavior (cf. LeDoux, 1996; Nisbett & Wilson, 1977, T. D. Wilson, 2002).

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