Emotional Valence, Arousal, and Appraisal Influence Hand Movements

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Abstract

This study investigated the effects of emotional valence (positive-negative), arousal levels (high, medium, low), and conscious evaluation on push-pull actions. Three experiments were conducted, collecting reaction time (RT) and hand movement metrics. Experiment 1 employed images with high, medium, and low arousal levels under positive-negative valence for both evaluation and push-pull action tasks; Experiment 2 utilized neutral and gray blank images to complete the same tasks; Experiment 3 performed push-pull actions without valence evaluation. The results indicated: (1) Emotional valence significantly influenced reaction time, movement time, and time to peak velocity: when dragging images upward, negative images were dragged faster; when dragging downward, positive images were faster. (2) Emotional arousal modulated the effect of emotional valence on push-pull actions: the higher the arousal, the greater the effect of emotional valence, particularly negative emotions, on push-pull actions; conversely, the effect was smaller. (3) Under no-evaluation conditions, emotional valence had no significant effect on push-pull actions; that is, the influence of emotion on action requires conscious evaluation. These results suggest that the influence of emotion on push-pull actions may occur at an early stage, affecting not only action planning but also subsequent action execution, with high arousal and conscious evaluation enhancing this effect.

Full Text

Valence, Arousal, and Appraisal Influence Hand Movements

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Abstract

This study investigated how emotional valence (positive-negative), arousal level (high, medium, low), and conscious appraisal influence push-pull hand movements. Three experiments were conducted, collecting reaction time (RT) and hand movement kinematics. Experiment 1 employed a valence evaluation task with positive and negative pictures at three arousal levels, followed by push-pull actions. Experiment 2 used neutral and gray blank pictures in the same task. Experiment 3 required push-pull actions without valence evaluation. Results showed: (1) Valence significantly affected RT, movement time, and time to peak velocity: when dragging pictures upward, negative pictures were moved faster; when dragging downward, positive pictures were faster. (2) Arousal moderated the valence effect on push-pull actions: higher arousal amplified the influence of valence, particularly negative emotions, while lower arousal diminished it. (3) Without conscious appraisal, valence showed no significant effect on push-pull actions, indicating that emotional influences on action require conscious evaluation. These findings suggest that emotional effects on push-pull actions occur early, influencing both action planning and execution, with high arousal and conscious appraisal enhancing these effects.

Keywords: approach-avoidance; emotion; hand movement; arousal; appraisal
Classification Code: B842

Emotion research represents a prominent area in psychology. Studies demonstrate that emotion can influence neurophysiological activity (e.g., [?]), decision-making tasks ([?]), and elicit specific behavioral actions ([?]; [?]). The "fight-or-flight" response exemplifies the evolutionary relationship between emotion, physiological systems, and stress-related behaviors. When facing threats, an organism' s physiological systems can rapidly change following evaluation to produce "fight" or "flight" responses—demonstrating that emotion affects motor behavior. Embodied cognition theory further posits that bodily sensations or motor changes can influence individuals' understanding of and interaction with the environment through motor cortices (see [?]), meaning motor and sensory experiences shape cognition and judgment.

The peripheral theory of emotion and somatic marker hypothesis ([?]) similarly view emotion as embodied. However, few studies have examined how emotion affects motor tasks. In daily life, surrounding stimuli evoke positive or negative emotions ([?]), and individuals must execute actions under emotional influence —such as removing rats or spiders from a room, handling dangerous toxic materials at work, or athletes performing under high stress. Whether motor behavior is influenced by stimulus-evoked emotion, and which emotional factors primarily affect it, holds significant implications for cognitive ergonomics, sports psychology, and emotion research. Investigating the emotion-action relationship can help explain genuine emotions or attitudes through overt behavior, aid individuals in understanding their own and others' actions, and enable behavior prediction and emotion regulation through knowledge of emotion-action interaction mechanisms.

Emotion comprises multiple dimensions. Russell (1980) combined "valence" and "arousal" to propose a circumplex model of affect ([?]). Research on valence' s effect on reaction time has primarily focused on push-pull actions. People show faster reaction times when pulling positive stimuli and pushing negative stimuli ([?]; [?]). Yet how valence influences action execution remains unclear.

Goodale and colleagues proposed that perception and action belong to two independent yet interacting visual systems (e.g., [?]): the ventral stream processes object perception, while the dorsal stream guides action. Specifically, the ventral system transforms visual information into perceptual representations reflecting enduring object characteristics, enabling object recognition and establishing causal relationships between objects and meaning. The dorsal system processes moment-to-moment information about object positions relative to effectors to regulate visuomotor control. Recent research demonstrates that attentional bias for positive stimuli occurs rapidly and automatically in early processing stages, and emotional priming effects emerge during early lexical processing stages ([?]; [?]). According to dual-system theory, if environmental influences occur before or during initial signal processing in primary visual cortex, these effects would be transmitted to both visual systems and consequently affect subsequent actions. If emotional influence occurs later, actions would be less affected by perception-evoked emotion. Therefore, investigating whether valence evoked by perceived objects influences subsequent motor operations can help understand the mechanism underlying valence' s action on movement.

Arousal, as a crucial emotional dimension, has been extensively studied ([?]; [?]; [?]). The relationship between emotion and action tendencies can be distinguished by different emotional experiences, and arousal' s role in action preparation and cognitive processing cannot be ignored ([?]). Previous studies show inconsistent findings regarding arousal' s effects. For instance, high arousal shows no significant differences in step initiation patterns between positive and negative valence stimuli, yet reaction times differ significantly ([?]). Under high arousal, older and younger adults show no significant age differences in fixation duration for different valence pictures, whereas significant age differences emerge at other arousal levels ([?]). Emotional arousal level also affects individual responses—for example, higher activation of priming words under high arousal, with priming effects for high-arousal words only when prime-target stimulus onset asynchrony reaches 300 ms ([?]). Meanwhile, EEG research indicates that high-arousal stimuli are more difficult to inhibit ([?]). High emotional arousal may increase emotional stimulus intensity. Therefore, if emotion affects subsequent action processes in the current study, whether arousal level influences subsequent action speed and amplitude warrants further investigation. Previous research has emphasized valence while neglecting arousal' s potential behavioral effects. This study integrates different valences and arousal levels to explore their combined effects on action modulation.

Furthermore, previous emotion research predominantly employed subjective evaluation, which may enhance memory for stimulus valence or affect participants' arousal, thereby influencing results. [?] suggested that valence results from conscious, cognitively demanding elaborative processing of emotional stimuli, affecting recollection and familiarity processes. [?] found that incidental perception of desired objects (positive stimuli, considered emotional) triggers unconscious preparation of the motor system. From primitive affective reflexes ([?]; [?]) to subcortical computations ([?], [?]) and higher-level cortical processing ([?]), conscious stimulus evaluation operates at multiple levels throughout the nervous system. [?] presented lexical stimuli and had half the participants only pull while half only pushed to eliminate conscious evaluation, yet still found emotion-response tendency interactions, suggesting valence' s influence on motor tendencies can occur automatically without consciousness. Conversely, [?] found no valence-motor tendency interaction when participants processed only gender information while ignoring valence, indicating that emotion' s effect on action requires conscious participation. Therefore, this study examines whether conscious appraisal enhances individuals' perception of their own emotions and consequently affects behavior.

In summary, previous research has primarily examined how push and pull actions affect reaction time. However, action planning before execution involves not only reaction time but also subsequent hand movement speed, suggesting valence may continue to influence post-initiation actions. Moreover, emotion' s behavioral effects may vary across arousal levels. The "arousal-biased competition" (ABC) theory posits that emotional arousal enhances perception and memory of salient stimuli (e.g., life-threatening weapons, reward/punishment-associated objects, goal-relevant stimuli), with stimulus perception helping organisms respond rapidly ([?]). From this perspective, different arousal levels and conscious appraisal may differentially influence push-pull action processes. This study addresses these issues through three experiments. Experiment 1 examines whether valence affects hand actions differently across arousal levels, hypothesizing that both valence and arousal influence motor operations. Experiment 2 uses neutral and gray blank pictures to rule out potential effects of subjective random dragging from Experiment 1. Experiment 3 tests whether previous emotion-action effects occur under unconscious conditions to verify whether conscious appraisal influences action patterns. The hypothesis posits that emotion affects actions early and influences subsequent movements, with different arousal levels modulating emotion' s effects, and that appraisal of emotional stimuli constitutes an important component.

Experiment 1

Experiment 1 tested how emotional valence affects actions across different arousal levels, hypothesizing that: (1) Valence influences action—when dragging positive and negative pictures downward, positive pictures are moved faster; when dragging upward, negative pictures are faster. (2) Different arousal levels produce different magnitudes of valence effects on motor tendency consistency: higher arousal strengthens valence effects on motor tendencies, while lower arousal weakens them.

Participants

Twenty-four undergraduate and graduate students from Nanjing University (12 male, 12 female), all right-handed, aged 20–28, with normal or corrected-to-normal vision, and no major neurological or motor system disorders, voluntarily participated under strict ethical guidelines and received compensation. All participants completed Experiments 1 and 2, which were separated by one week.

Apparatus and Materials

The experiment was conducted in a laboratory with normal temperature and lighting. Hand movement data from participants' right index finger dragging pictures were measured using an OPTOTRAK Certus 3D motion capture system (NDI, Canada) with a sampling frequency of 200 Hz (collecting 200 movement data points per second). Experimental pictures comprised 60 emotional images from the Chinese Affective Picture System (CAPS), with 30 positive and 30 negative valence pictures. Based on participants' pre-experiment arousal ratings, the 60 pictures were divided into strong arousal (10 highest scores), medium arousal (10 middle scores), and weak arousal (10 lowest scores) for each valence. Statistical results confirmed significant valence differences between positive and negative pictures ($p < 0.01$) and significant differences among high, medium, and low arousal levels for both valences ($p < 0.01$).

Experimental Design

To prevent carryover effects from previous behaviors ([?]), a between-subjects design was adopted, with half the participants randomly assigned to complete Experiment 1 first and the other half completing Experiment 2 first. The study employed a 2×3 mixed design: (1) Picture valence as a between-subjects variable: positive or negative valence. Each participant received only one instruction set, evaluating picture valence and dragging positive pictures to the upper box and negative pictures to the lower box (or the reverse for the other half). (2) Arousal as a within-subjects variable: high, medium, and low. Because upward and downward movements differ substantially, analyses were conducted separately for each direction. For movement measures, we followed previous research (e.g., [?]; [?]; [?]; [?]) and collected upward and downward dragging reaction time, time to peak velocity, movement time, and peak velocity as dependent variables. Data were calculated via software: reaction time was defined as the interval from picture onset to when dragging velocity first exceeded 0.1 m/s; time to peak velocity was the interval from picture onset to maximum velocity; movement time was the interval from velocity exceeding 0.1 m/s to picture disappearance at drag completion; peak velocity was the maximum dragging speed during picture presentation. Due to differences in experimental settings, tasks, and analysis software from previous studies, specific parameter definitions varied slightly.

Task and Procedure

Participants stood throughout the experiment at a horizontal distance of 10–15 cm from the computer screen, with eyes approximately 75 cm from the display. Picture stimuli were presented in a consistent orientation. Practice trials preceded the formal experiment, using 6 pictures (3 positive, 3 negative) presented randomly 3 times each until participants performed three correct operations. Practice pictures did not appear in the formal experiment, and practice data were excluded from analysis. Participants stood before the screen with a motion sensor marker attached to their right index finger. Programming presented stimuli of different valences and arousal levels while recording movement kinematics. Throughout, dragging movements had to remain perpendicular to the screen' s upper and lower edges while maintaining finger contact—participants could not lift their finger from the screen. A rectangular frame at the screen center presented pictures of different valences, which participants dragged to the corresponding upper or lower box according to instructions, then returned their finger to the start box (see [Figure 1: see original paper]). If emotion affected action, then dragging positive pictures downward and negative pictures upward would show significantly faster reaction times, peak velocities, and times to peak velocity than dragging negative pictures downward and positive pictures upward. If arousal also affected action, significant differences would emerge across high, medium, and low arousal conditions.

[Figure 1: see original paper] shows the experimental flowchart. Pictures were presented and dragged on a 21.5-inch monitor with 1920×1080 pixel resolution. Participants stood 10–15 cm from the screen, positioned slightly toward the left side. The central rectangular frame presented valenced pictures, each containing a circular frame on the right side indicating where to place the index finger (with marker). Upper and lower screen edges each had rectangular drop boxes. All three frames measured 10 cm × 10 cm with a neutral beige background.

Results

Separate ANOVAs were conducted on reaction time (RT), movement time (MT), and time to peak velocity (PT). Data with RT $<$ 100 ms or $>$ 1000 ms, and PT or MT $<$ 100 ms or $>$ 2000 ms were considered outliers, and participants repeated those trials. Data were analyzed separately for upward-dragging positive/negative pictures and downward-dragging positive/negative pictures.

Upward Dragging of Positive and Negative Pictures As shown in [Figure 2: see original paper], when dragging upward, the valence × arousal interaction was significant for RT, $F(2, 44) = 17.17$, $p < 0.001$, $p^2 = 0.44$. The main effect of arousal on RT was significant, $F(2, 44) = 14.77$, $p < 0.001$, $p^2 = 0.40$. Pairwise comparisons revealed significant RT differences for negative pictures between high-medium arousal, $t(11) = -6.70$, $p < 0.001$, $d = 0.23$, and high-low arousal, $t(11) = -4.90$, $p < 0.001$, $d = 0.33$. High arousal produced significantly faster RT than medium and low arousal. At high arousal, positive and negative pictures differed significantly in RT, $F(1, 22) = 15.50$, $p < 0.001$, $p^2 = 0.41$. No other differences were significant (see [Figure 2: see original paper]a).

The valence × arousal interaction was also significant for PT, $F(2, 44) = 12.95$, $p < 0.001$, $p^2 = 0.37$. The arousal main effect on PT was significant, $F(2, 44) = 17.00$, $p < 0.001$, $p^2 = 0.44$. Pairwise comparisons showed significant PT differences for negative pictures between high-medium arousal, $t(11) = 7.89$, $p < 0.001$, $d = 0.19$, and high-low arousal, $t(11) = -5.17$, $p < 0.001$, $d = 0.23$, with high arousal producing significantly faster PT than medium and low arousal. At high arousal, positive and negative pictures differed significantly in PT, $F(1, 22) = 12.25$, $p < 0.003$, $p^2 = 0.36$. No other differences were significant (see [Figure 2: see original paper]b).

For MT, the valence × arousal interaction was not significant, $F(2, 44) = 1.33$, $p > 0.2$, but the arousal main effect was significant, $F(2, 44) = 4.89$, $p < 0.05$, $p^2 = 0.18$. Post-hoc tests indicated significantly faster MT at high arousal versus medium and low arousal ($p < 0.05$). For positive pictures, paired t-tests revealed significant MT differences between medium-low arousal, $t(11) = -2.31$, $p < 0.05$, $d = 0.20$, suggesting upward dragging was somewhat affected by arousal. At high arousal, positive and negative pictures differed significantly in MT, $F(1, 22) = 4.49$, $p < 0.05$, $p^2 = 0.17$. No other effects reached significance. Neither interaction nor main effects were significant for peak velocity (PS) (see [Figure 2: see original paper]c,d).

When dragging different valence pictures upward at high arousal, negative pictures showed significantly shorter RT, PT, and MT than positive pictures, indicating that negative valence more strongly activated and facilitated upward dragging. For negative pictures, high-arousal images elicited significantly faster RT and PT than medium- and low-arousal images. This demonstrates that arousal significantly moderates valence' s effect on action consistency during upward dragging of negative pictures: higher arousal amplifies negative valence' s activation and facilitation of upward movement, promoting faster initiation and earlier peak velocity to accelerate action execution. Movement duration also varied slightly with arousal level.

Downward Dragging of Positive and Negative Pictures Analysis of downward-dragging data revealed markedly different patterns. For RT, the valence × arousal interaction was significant, $F(2, 44) = 13.81$, $p < 0.001$, $p^2 = 0.39$. Arousal and valence main effects were also significant: arousal $F(2, 44) = 15.01$, $p < 0.001$, $p^2 = 0.41$; valence $F(1, 22) = 25.89$, $p < 0.001$, $p^2 = 0.54$. For negative pictures, downward dragging RT showed significant differences between high-medium arousal, $t(11) = -8.41$, $p < 0.001$, $d = 0.36$, and high-low arousal, $t(11) = -6.41$, $p < 0.001$, $d = 0.40$. Positive pictures showed no RT differences across arousal levels. Positive pictures were significantly faster than negative pictures, indicating that positive valence more strongly facilitated downward dragging (approach movements) than negative valence (see [Figure 3: see original paper]a).

For PT, the valence × arousal interaction was significant, $F(2, 44) = 14.54$, $p < 0.001$, $p^2 = 0.40$. Main effects of arousal, $F(2, 44) = 18.26$, $p < 0.001$, $p^2 = 0.45$, and valence, $F(1, 22) = 17.94$, $p < 0.001$, $p^2 = 0.45$, were significant. For negative pictures, downward dragging PT differed significantly between high-medium arousal, $t(11) = -8.04$, $p < 0.001$, $d = 0.24$, and high-low arousal, $t(11) = -7.91$, $p < 0.001$, $d = 0.29$. Positive pictures showed no PT differences across arousal levels. Positive pictures reached peak velocity significantly faster than negative pictures, demonstrating that positive valence more effectively facilitated downward dragging acceleration (see [Figure 3: see original paper]b).

For MT, neither the valence × arousal interaction nor main effects were significant. For PS, the interaction was not significant, but the arousal main effect was significant, $F(2, 44) = 4.68$, $p < 0.05$, $p^2 = 0.18$. Only the high-low arousal comparison approached significance, $t(11) = 1.99$, $p = 0.07$, $d = 0.16$; all other pairwise comparisons were non-significant ($p > 0.1$). This suggests high arousal may influence peak velocity compared to low arousal, but peak velocity did not differ by picture valence (see [Figure 3: see original paper]c,d).

Downward dragging of positive pictures showed activation and acceleration to peak velocity unaffected by arousal, though peak velocity itself was influenced. For negative pictures, high arousal produced faster initiation than medium and low arousal. These results indicate arousal significantly moderates valence' s effect on action consistency: higher negative valence arousal more strongly activates downward dragging and accelerates peak velocity. Downward dragging of positive pictures was significantly faster and reached peak velocity significantly earlier than negative pictures, showing that positive valence more quickly activated and facilitated downward movement initiation and execution.

Discussion Under high arousal, participants showed faster tendencies to push away negative valence pictures, with negative emotion more strongly facilitating pushing actions. Moreover, for both upward and downward dragging, higher arousal in negative emotional pictures produced stronger modulatory effects, promoting faster action initiation and execution. In summary, Experiment 1 concludes: (1) Positive emotion more strongly facilitates downward dragging initiation and completion, while negative emotion more strongly facilitates upward dragging; (2) Higher arousal accelerates both upward and downward dragging of negative emotion pictures, while arousal effects on positive emotion are less pronounced.

Experiment 2

Experiment 1 showed faster upward dragging of positive pictures and faster downward dragging of negative pictures. To confirm these results stemmed from emotional influence rather than subjective randomness or inherent up-down movement differences, Experiment 2 employed neutral pictures and gray blank images as stimuli. The hypothesis was that if Experiment 1' s results were produced by different emotional valence targets significantly influencing motor tendencies, then neutral valence stimuli would not produce significant approach-avoidance effects.

Participants

Same as Experiment 1.

Apparatus and Materials

Thirty neutral pictures from CAPS and ten gray blank pictures of identical size were used. Based on arousal ratings, these 40 pictures were divided into strong arousal (10 highest scores), medium arousal (10 middle scores), weak arousal (10 lowest scores), plus ten gray blank pictures. To confirm neutral picture valence, neutral pictures were evaluated alongside positive and negative pictures from Experiment 1, revealing significant valence differences among positive, neutral, and negative pictures ($p < 0.01$) and significant arousal differences within neutral pictures ($p < 0.01$).

Experimental Design

Experiment 2 used a 2×3 mixed design: (1) Picture "valence" as a between-subjects variable: neutral pictures versus gray blank pictures; (2) Arousal as a within-subjects variable: high, medium, low. As in Experiment 1, upward and downward dragging were analyzed separately.

Task and Procedure

Identical to Experiment 1, except practice trials required three consecutive error-free operations before proceeding to formal testing. During formal trials, participants quickly evaluated whether the picture showed "neutral content" or a "gray blank picture," then dragged it to the upper or lower box accordingly (with instructions reversed for half the participants). Each correct trial was followed by a 2000 ms rest period, during which participants returned their finger to the start box.

Results

Repeated-measures ANOVA revealed no significant main effects or interactions for any measures (largest $F = 1.65$, smallest $p > 0.2$). Because upward and downward movements differ physiologically, separate analyses were conducted as in previous experiments.

No significant differences ($p > 0.01$) emerged for upward dragging of neutral versus gray blank pictures in RT, PT, MT, or PS (largest $F = 1.56$, $p > 0.2$).

Similarly, downward dragging showed no significant differences ($p > 0.1$) across all measures (largest $F = 1.65$, $p > 0.2$). Thus, neutral pictures produced no significant approach-avoidance effects, supporting Experiment 2' s hypothesis and ruling out subjective randomness as a confound in Experiment 1. These results confirm that emotional valence and arousal genuinely modulated motor tendencies (see [Figure 4: see original paper], [Figure 5: see original paper]).

[Figure 4: see original paper] shows upward dragging comparisons, and [Figure 5: see original paper] shows downward dragging comparisons for neutral versus gray blank pictures across all measures. The absence of significant differences supports the hypothesis that neutral pictures lack approach-avoidance effects. If participants had engaged in random dragging rather than valence-based responding, significant differences similar to Experiment 1 would have appeared even for non-emotional neutral pictures. The lack of any significant effects excludes the possibility that Experiment 1' s results were due to random dragging.

Experiment 3

Experiment 3 tested whether valence effects on motor tendencies could occur without conscious evaluation. Participants dragged pictures upward or downward as quickly as possible without evaluating valence. If significant differences in movement kinematics persisted across valences, it would indicate unconscious emotional influence; conversely, it would demonstrate that valence effects require conscious appraisal.

Participants

Fifteen undergraduates and graduates from Experiments 1 and 2 (7 male, 8 female) participated two months later, resulting in some attrition but consistent overall results. All were right-handed, aged 20-28, with normal or corrected vision, no major neurological or motor disorders, and could stand upright with free arm movement. All participated voluntarily under ethical guidelines and received compensation.

Apparatus, Materials, and Design

Identical to Experiment 1. The mixed design included valence (between-subjects: positive, negative) and arousal (within-subjects: high, medium, low). Unlike Experiment 1, participants did not evaluate valence: half ($n = 7$) dragged all pictures to the upper box, while half ($n = 8$) dragged all pictures to the lower box. Each correct trial was followed by a 2000 ms rest period for returning the finger to the start box.

Results

Separate repeated-measures ANOVAs for upward and downward dragging revealed no significant main effects or interactions for any measures ($p > 0.1$).

Analysis of upward dragging showed no significant differences in RT, PT, MT, or PS between positive and negative pictures (largest $F = 0.84$, $p > 0.3$). Downward dragging similarly showed no significant differences across measures (largest $F = 0.41$, $p = 0.53$) (see [Figure 6: see original paper], [Figure 7: see original paper]).

[Figure 6: see original paper] and [Figure 7: see original paper] show comparisons for upward and downward dragging of positive and negative pictures, respectively. The absence of significant differences demonstrates that without conscious valence evaluation, emotional valence did not affect action consistency in either direction. Combined with Experiment 1—where valence evaluation preceded dragging and produced significant effects—these results indicate that emotion' s influence on action requires conscious participation. The emotion-action relationship involves autonomous evaluation, with individuals selecting actions based on evaluation outcomes. Pairwise t-tests on arousal levels also revealed no significant effects, unlike Experiment 1, suggesting arousal does not significantly affect motor measures under unconscious conditions. Valence effects on action consistency result from conscious participation, not automatic unconscious processing.

General Discussion

Emotion plays crucial roles in social interaction, motivated behavior, decision-making, memory, attention, and perception ([?]). This study observed how individuals process emotional valence stimuli at different arousal levels, extending previous findings by demonstrating that valence affects not only reaction time but also other movement parameters. Experiment 1 confirmed that valence influences motor tendencies—shorter processing times when pushing negative pictures upward and pulling positive pictures downward. Higher arousal amplified these facilitatory effects, particularly for negative stimuli. Experiment 2' s neutral and gray blank pictures produced no significant action differences, confirming that Experiment 1' s effects were emotion-related rather than due to movement direction differences. Experiment 3' s unconscious dragging condition eliminated valence effects on motor measures, demonstrating consciousness' s role in the emotion-action relationship—valence evaluation activates or intensifies emotional effects.

These results support emotion' s influence on action, with effects mediated by cognitive appraisal. Faster RT and PT when "pulling" positive stimuli and "pushing" negative stimuli align with embodied cognition perspectives linking emotional stimuli to bodily position and activity. Using the body as reference, "up/close"is metaphorically positive while "down/far"is negative ([?]; [?]). Future research could explore additional body-action associations to better understand cognition-body-environment interactions.

Actions were imbued with or activated by emotional attributes. Consistency between the valence meaning of body actions (approach-avoidance) and emotional stimuli facilitated cognitive processing, while inconsistency created interference ([?]). This study replicated previous findings of valence effects on approach-avoidance RT ([?]; [?]) while demonstrating valence' s role in action modulation. Upward dragging differences concentrated at high arousal, suggesting only salient targets significantly influence approach-avoidance tendencies. Downward dragging showed significant differences across high, medium, and low arousal for both RT and PT, indicating that downward (approach) movements are more sensitive to valence or more responsive to stimulus valence.

Previous research used joysticks ([?]), levers ([?]), keypresses ([?]), and whole-body movements with skin conductance ([?]) to demonstrate valence effects on actions and RT. The current study analyzed not only RT but also hand kinematics. Downward dragging of positive pictures showed shorter RT and PT; upward dragging of negative pictures showed shorter RT and PT. Valence modulated both action initiation and maintenance.

Valence affects action, with arousal as a crucial factor. Emotion influenced subsequent actions more strongly under high arousal, suggesting effects occur before or during initial visual signal processing in both visual systems. However, these effects primarily manifested for negative emotion. Arousal' s influence on motor measures aligns with evolutionarily shaped mechanisms producing physiological activity and overt behavior—such as rapid "fight-or-flight" responses to threats. The findings confirm high arousal' s importance in behavioral adjustment and execution. Thus, whether emotion affects behavior depends on stimulus arousal, with stronger effects for negative pictures during upward dragging. Interestingly, for negative pictures during downward dragging, higher arousal also produced shorter RT, suggesting a potential dissociation between arousal and valence effects possibly related to negative pictures' threat information. Specific emotions like threat signals (negative emotion) show stronger action associations ([?]), enabling complete processing, rapid detection, enhanced preparation, and quick action. Weaker responses to positive emotion may reflect broadened attentional scope, as pleasant mood induces more diffuse attention ([?]). Therefore, arousal affects action more strongly for negative emotion. Future research could combine the pleasure-arousal-dominance (PAD) model to further explore emotion-action relationships ([?]; [?]).

Whether valence evaluation influenced action outcomes—that is, whether conscious participation intensified emotion's effects—supports previous findings ([?]). Absence of significant movement pattern differences without valence evaluation suggests reduced emotional arousal without conscious appraisal. Valence evaluation (positive/negative) generates motivational direction (approach/avoidance), producing adaptive behavioral adjustments ([?]). Consistent with dual-system theory, conscious appraisal enables perception of object-evoked valence, with effects potentially occurring before or during initial visual signal processing and transmitting information to both visual systems to influence subsequent actions. However, emotion research varies in evaluation timing—some evaluate pictures before experiments ([?]) and others after stimulus presentation ([?])—

which may contribute to inconsistent results. Combined with Experiment 1' s findings, consciousness may enhance emotion' s action effects through arousal. The mechanisms underlying emotion, action, and cognition require further investigation. Additionally, emotion appraisal theory proposes multiple evaluation processes derived from bodily sensations, past experience, and contextual factors ([?]). Understanding factors that influence perceived distance differences (near/far) could explain adaptive response success and failure in social contexts. Approach/avoidance constitutes a key response to environmental stimuli, with recent research showing this sensorimotor information extends to arm movements ([?]). Future studies could examine whether other body parts show similar effects as fingers and arms.

These results support cognitive appraisal theory of emotion ([?]) and action-evaluation effects ([?]), while highlighting important considerations for emotion research. Valence and arousal indeed affect hand operations, influencing both action initiation and maintenance. However, different arousal levels and emotion types affect attention differently ([?]): negative emotion with high arousal enables faster target detection, while positive emotion with low arousal produces better performance. Negative emotions like fear relate to focused attention and effective negative information processing, whereas positive emotions relate to cognitive flexibility and broad attention. Future research could explore whether different mechanisms operate in specific emotional states. This study examined positive-negative valence effects with and without evaluation; subsequent studies could investigate complex emotions like gratitude, pride, and shame to understand specific emotion-induced action differences. Additionally, this study' s programming interface for hand-screen interaction could be applied to modern smartphones and touchscreen devices. Significant action differences across valences suggest emotional or evaluative effects may occur early, transmitting positive-negative information to both visual systems to influence action. Future research could manipulate emotional picture presentation timing and duration to explore the temporal scope of emotional effects.

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Note: Figure translations are in progress. See original paper for figures.