Facilitation of arm movements by their outcome desirability

Tatjana Aue & Klaus R. Scherer

University of Geneva, Geneva, Switzerland

Address correspondence to:

Tatjana Aue

Swiss Center for Affective Sciences

University of Geneva

7, rue des Battoirs

1205 Geneva

Switzerland

tatjana.aue@unige.ch

Keywords: Arm movements, action tendencies, motivation, emotion, appraisal

Abstract

A large body of research suggests arm extension and arm flexion to be indicators of automatically generated withdrawal and approach motivation, respectively. However, such a view has not remained unchallenged. Recent research suggests that the motivational significance of arm movements may be largely context dependent. The aim of this research was to demonstrate that an essential facilitating context factor for arm movements relies on the desirability of their expected outcomes. Participants viewed negative and positive stimulus material (pictures and words) and were asked to concurrently perform either an arm extension or an arm flexion. Arm movements were embedded in a meaningful context, leading to a stimulus size decrease or increase, thus giving the visual illusion of withdrawing from the stimulus or approaching it. Results show that the significance of arm movements is indeed influenced by the desirability of their respective effects.

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Different attempts have been made to assess emotion-generated action tendencies such as approach and withdrawal. Studies carried out by appraisal theorists, for instance, generally used self-report measures to assess action tendencies (e.g. Frijda, 1987). These measures may be problematic not only with respect to recall or social desirability, but also because they are largely subject to conscious processes. One might question whether automatically generated action tendencies, which are not necessarily conscious, can be assessed by a questionnaire. Other potential, and perhaps less subjective, candidates for the assessment of action tendencies are postures (Neumann, Förster, & Strack, 2003), facial expressions (Frijda & Tcherkassof, 1997), and (neuro) physiological responses (e.g. Davidson, 1992).

Another frequently used method consists of the assessment of arm movements (e.g. Chen & Bargh, 1999; Duckworth et al., 2002; Solarz, 1960). Authors in this tradition have long postulated that the cognitive evaluation of stimulus valence is directly reflected in arm movements. Arm extension has been supposed to indicate withdrawal from negative stimuli because it would give the impression of increasing distance toward a stimulus (Solarz, 1960).[1] Arm flexion, in contrast, would signal approach motivation toward positive stimuli because it would give the impression of decreasing distance toward an object. Whether this link between stimulus evaluation and arm movements is postulated to result from the activation of innate motor programs or to be a product of learning processes remains unclear.

Participants in Solarz's (1960) study displayed slower reaction times (RTs) when they had to perform an arm extension in response to positive words and an arm flexion in response to negative words than for the reverse combinations of stimulus valence and arm movement. Results thus appear to support the idea of a fixed link between appraisals of stimulus valence, on the one hand, and arm movements as supposed indicators of motivational states, on the other hand (cf. Chen & Bargh, 1999). Similar results have been obtained with pictorial stimuli (Duckworth et al., 2002). Moreover, Cacioppo, Priester, and Berntson (1993) presented results that suggest that the association proposed by Solarz (1960) may be bidirectional. In the studies by Cacioppo et al., neutral stimuli seen during extensor tension were rated as less positive than those seen during flexor tension. In line with these results, Neumann and Strack (2000) found faster categorization of positive words as compared with negative words during arm flexion and the reverse pattern for arm extension.

Together, the results of the studies reported so far could suggest the existence of hard-wired links between arm extension and withdrawal motivation associated with negative stimulus evaluation, on the one hand, and between arm flexion and approach motivation associated with positive stimulus evaluation, on the other hand. However, arguing against the assumption of a rigid automatic mechanism, Rotteveel and Phaf (2004) showed that the observed link between stimulus evaluation and arm extension or arm flexion, as reported by Solarz (1960), Chen and Bargh (1999), and Duckworth et al. (2002), might depend on the conscious processing of stimulus valence. What is more, Chen and Bargh conclude in their 1999 article that the relationship between attitudes (i.e. stimulus evaluations) and arm movements could have been different in a different context, “as long as the laws within the psychological situation remain intact” (222). Such a view is in accordance with postulates from another group of researchers (e.g. Clore & Ortony, 2000) stating that the motivational significance of arm movements should be dependent on so-called situated meanings. Clore and Ortony write, for instance:

> Interestingly, there is evidence that the connection is between appraisal and motivation rather than between appraisal and behavior because variations on this procedure produce

> the opposite results [than reported by Solarz and Chen and Bargh] when arm flexion can be interpreted as withdrawing one’s hand from an object (rather than as pulling an object toward oneself), and when arm extension can be interpreted as reaching for the object (rather than as pushing an object away) (M. Brendl, personal communication, 20 October 1997). Hence, it is the situated meaning of flexion and extension that is critical; the affective appraisals are manifested in the motivational realm as the desired end states of approaching or avoiding stimuli, rather than simply as triggers for distance-modulating behaviors (muscular flexion or extension). (51)

Indeed, recent research suggests that the above-reported relationship between arm movements and stimulus evaluations or action tendencies (e.g. Chen & Bargh, 1999; Solarz, 1960) can be reversed by manipulating the experimental setting (e.g. Wentura, Rothermund, & Bak, 2000). An attempt to reconcile these ostensibly inconsistent findings has been made by Seibt and colleagues (2008). The authors were able to show that changing reference points can influence the observed relationship between arm movements and action tendencies. They predicted that if participants consider themselves as a stable and spatially fixed point of reference for the executed arm movements, extension could be interpreted as pushing something farther away (withdrawal action) and flexion could be interpreted as pulling something toward oneself (approach action). However, if the object (in their case, a word presented on a computer screen) is taken as a stable and spatially fixed point of reference, flexion should be experienced as a withdrawal action from the object, whereas extension should constitute the approach action. Consistent with these hypotheses, in their study, arm flexion was facilitated during the presentation of positive words and arm extension during the presentation of negative words in the self-reference-point condition only. The opposite was observed for the object-reference-point condition. On the basis of these results, Seibt et al. concluded that participants in the Solarz and Chen and Bargh studies must have adopted a self reference point, whereas participants in the Wentura et al. study took over an object reference point.

Further evidence for contextual influences on the arm movement-action tendency link has been reported by Puca, Rinkenauer, and Breidenstein (2006). These researchers manipulated the location of a sound source (in front versus behind the participants) and showed that individuals with high avoidance motives more rapidly performed an extension when a sound stimulus was located behind them than when it was located in front of them. The reverse was observed for arm flexion. From these observations, Puca et al. concluded that "…it is not the physical direction (forward or backward) but rather the movement's effect of distance reduction (approach) or distance increase (avoidance) in regard to the stimulus that defines a movement as an approach or an avoidance movement" (980).

What is more, an earlier experiment by Markman and Brendl (2005) demonstrated that the effect may not depend on an individual's physical location but rather on the individual's representation of his or her self in space. Participants in their study viewed their names (representations of their selves) presented on a screen. Positive and negative words appeared either in front of their names or behind their names. Regardless of type of arm movement, shorter RTs were displayed for the movements that brought positive words closer to the representations of participants' selves and sent negative words farther from these representations than for the movements associated with the combinations "positive word–increasing word-name distance" and "negative word–decreasing word-name distance."

Finally, Eder and Rothermund (2008) showed that the instructed affective significance of arm movements was able to influence their facilitation in response to affectively laden stimuli. The authors argued that verbal instructions that labeled arm flexion or arm extension as “up,” “down,” “away,” or “toward” applied affective codes to the respective arm movements. Depending on their attributed affective codes, the performance of arm flexion and arm extension was then facilitated by either positive or negative stimulus material. Moreover, the facilitation effect extended to sideward movements, thus suggesting that it is not specific to distance reduction of an individual’s body with respect to the presented stimulus material.

Albeit the observation that contextual factors are able to influence the stimulus evaluation–arm movement link, to date it is not clear which concrete contextual factors are influential. In this regard, it has been hypothesized that the outcome of an arm movement plays an important role (cf. Clore & Ortony, 2000). In real life, arm movements usually have some adaptive effect, provoking changes in the environment. The experiments conducted so far have uncoupled the arm movements from specific consequences (e.g. Chen & Bargh, 1999; Puca et al., 2006; Solarz, 1960) or have not independently varied the arm movements and the resultant effects on the presented stimuli (e.g. Wentura et al., 2000; extension always yielded an increase of word size and flexion always yielded a decrease of word size; for comparable paradigms with respect to this issue concerning pictorial stimulus material, see Heuer, Rinck, & Becker, 2007, as well as Rinck & Becker, 2007**)**. Consequently, an independent contribution of outcome desirability on the facilitation of arm movements could not be determined. Therefore, in the current study, the performance of a specific arm movement was not restricted to a single outcome.

What is more, instructions in the current study differed substantially with respect to earlier studies. Neither did we attach explicit labels to arm flexion or arm extension by varying the instructions (cf. Eder & Rothermund, 2008; Seibt et al., 2008), nor was it the explicit goal of the participants to approach or withdraw from positively and negatively valenced stimuli in the experimental task (e.g. Krieglmeyer, De Houwer, & Deutsch, 2011; Markman & Brendl, 2005). Instead, our experimental task relied on a more naturalistic environment, with participants having the explicit goal to display rapid RTs in response to displayed symbols to gain a monetary reward. In addition, our participants did not know in advance whether they needed to perform an arm extension or an arm flexion; in contrast to most of the earlier studies, movement direction was varied within rather than across experimental blocks, thus reducing the degree of conscious processing of experimental aims. Lastly, another distinctive aspect of the current work is that we investigated whether words and pictures were characterized by similar or different facilitation effects.

Inspired by the Heuer et al. (2007), Rinck and Becker (2007), and Wentura et al. (2008) studies, we used a zooming function in the visual domain and varied this zooming function orthogonally to arm flexion and arm extension. In accordance with earlier research in the field, we assumed that positive stimuli can be considered as rewarding and should provoke approach tendencies (cf., Lang, Bradley, & Cuthbert, 1990; Solarz, 1960). Consequently, increasing the size of positive stimuli should be experienced as desirable or goal conducive (goal = maximization of positive stimulation). Decreasing the size of positive stimuli, in contrast, can be assumed to be undesirable or goal obstructive. Negative stimuli may be supposed to provoke withdrawal tendencies. Decreasing the size should provide relief or be goal conducive and increasing the size should be undesirable or threatening and goal obstructive (goal = protection from potential harm). We argue that a given movement should be facilitated only if it can be expected to lead to a desired outcome. According to this standpoint, either arm flexion *or* arm extension can be facilitated during the presentation of a positive stimulus, that is, when it decreases the distance between ourselves and the desired object (e.g. a positive image).

Participants in our study viewed affectively laden pictures and words (negative and positive) while performing the arm movements. For half of the participants (Group Ext-), the stimuli increased in size after the performance of arm flexion and decreased in size after the performance of arm extension. For the other half (Group Ext+), the reverse occurred. By including two groups, with reversed outcomes for extension and flexion, context or outcome effects could be separated from the performance of specific arm movements. We postulated faster responses for arm movements that lead to a desired effect (decrease of negative stimuli and increase of positive stimuli) than for those leading to an undesired effect (increase of negative stimuli and decrease of positive stimuli).

Method

Participants

Forty-two female University of Geneva undergraduates, aged between 18 and 29 years (M = 22.3; SD = 3.04), participated in this study. They were paid 15 CHF (30 participants) for their participation or took part in the context of an introductory psychology course (12 participants). The four best performers (rapid response times with no or few errors) obtained an additional 50 CHF each. All participants had normal or corrected-to-normal vision.

Experimental design

The experimental design was a 2 × 2 × 2 × 2 mixed-factorial design with one between-subjects factor and three within-subjects factors.

1. Between-subjects factor

    a. *Visual effect following an arm movement = Group* (two levels; Group Ext-: extension-small/flexion-large versus Group Ext+: extension-large/flexion-small). For half of the participants (Group Ext-), the image/word size became smaller when they pushed the joystick and larger when they pulled the joystick; for the other half (Group Ext+), the reverse was true. This way, the arm movements were embedded in a meaningful context. Visually, arm flexion in Group Ext- gave the impression of approach, whereas extension gave the impression of withdrawal (reverse for Group Ext+).

2. Within-subjects factors

    a. *Material* (two levels: pictures versus words). The experiment included two different blocks (counterbalanced presentation), which differed with respect to the included stimuli only (60 pictures versus 60 words). Pictures were chosen from Lang, Bradley, and Cuthbert's (1999) International Affective Picture System and an own picture evaluation study. Words were chosen from a list published by Bonin et al. (2003).

    b. *Valence* (two levels: negative (versus neutral) versus positive). Pictures and words differed with respect to their valence. Negative and positive pictures were matched for subjective arousal and complexity (Appendix A). Negative and positive words were controlled for concreteness, imageability, subjective frequency, and word length (Appendix B). Neutral stimuli were inserted as filler items.

    c. *Arm movement* (two levels: extension versus flexion). The apparition of two different symbols superimposed on the stimuli approximately 500 ms after stimuli onset indicated whether the participants had to push or to pull a joystick. The push symbol **(**triangle – pointing upward) and the pull symbol (triangle – pointing downward) were projected onto 15 images/words each. Participants had to push the joystick five times and to pull it another five times within each valence level. There was no fixed combination of picture and push or pull symbol.

Setting and apparatus

Participants were seated comfortably in a reclining position, facing a computer screen (Sony CPD-E400E) at a distance of approximately 1.4 m (picture size 16 cm × 24 cm) in a sound attenuated room (3.50 × 4 m). Participants performed the arm movements with a Logitech Extreme 3D Pro Twist Handle Joystick (Fremont, CA, USA) fixed on their right side. The joystick was blocked to prevent lateral displacements. Thus, only extension and flexion movements were possible. The joystick automatically returned to the center position after every response. Participants were able to comfortably pose their arm on an armrest while giving their responses.

Experimental control (i.e. stimulus presentation, registration of RTs, and direction of joystick movements) was performed by DirectRT v2004 (Empirisoft Corporation, New York, NY, USA), running on the presentation computer (HP Compact d530 CMT).

Procedure

Participants were informed that they were participating in an experiment on sensorimotor coordination with the registration of bodily reactions, with the four best performers winning 50 CHF each. After their arrival in the laboratory, the participants signed a consent form and electrodes for physiological response registration were attached (psychophysiological data from this study are presented elsewhere; Aue & Scherer, 2011).

The task consisted of viewing pictures/words presented on a computer screen (picture size: 256 × 192 pixels, word size: 24 (medium)) and reacting as rapidly as possible to two symbols superimposed on these pictures/words approximately 500 ms after picture/word onset. For one group of participants, the image/word size increased (pictures: 640 × 480 pixels, covering the whole screen; words: size 72 (extremely huge)) in response to arm flexion and decreased (pictures: 100 × 75 pixels, details no longer identifiable; words: size 8 (very tiny)) in response to arm extension. For another group of participants, the reverse was true. After the execution of an arm movement,[2] the picture/word in its new size was presented for 4 s and then followed by a black screen (on average 2 s).[3] Each performance block was preceded by a training period of six trials. A neutral picture/word was shown as the first picture in each performance block to ensure that reactions to the first relevant stimulus were not simply an effect of surprise.

Finally, in a postinterview, participants were asked about their hypotheses concerning the aim of the study, their involvement, and their physical and psychological well-being. No participant indicated physical or psychological disturbance or that she had guessed the real aim of the study. Involvement was stated as having been sufficiently high ($M = 2.3$, $SD = 1.08$) on a scale ranging from 0 (*not at all*) to 4 (*extremely*). Before leaving the laboratory, participants were debriefed.

Dependent variable

Reaction times (RTs). A particular RT describes the latency between the apparition of the push or the pull symbol on a picture/word and the moment when the joystick traversed the point describing 50% of the maximum possible deflection in either the extension or the flexion direction. RT was measured in milliseconds.

Data analysis

Outlier detection and exclusion of participants. RTs deviating more than three standard deviations from an individual’s mean RT in a given experimental block (pictures versus words) were treated as outliers and set to missing (1.2% of all valid responses; another 3% were excluded because a response had been given too late, taking more than 1000 ms (extreme outliers), or was wrong (flexion in response to the push symbol or extension in response to the pull symbol)). Participants were excluded from RT analyses when more than 10% of their responses in a given block were errors or outliers. This was the case for two participants in the picture block. RTs of a single participant were eliminated from both experimental blocks because of RT registration problems. For the remaining participants (n = 39), RTs related to errors or outliers were discarded.

Statistical analysis. An analysis of variance with the between-subject factor *Group* (two levels: Ext-, Ext+) and the within-subject factors *Stimulus Material* (two levels: pictures, words), *Valence* (two levels: negative, positive), and *Arm Movement* (two levels: extension, flexion) was calculated.

Results

RTs for pictures were longer than RTs for words; main effect for Stimulus Material, $F(1, 37) = 79.76$, $p < .000001$, $\eta^2 = .68$ (*M*s = 536 and 484 ms, respectively). Arm movements were performed more rapidly for positive as compared with negative stimulus material; main effect for Valence, $F(1, 37) = 5.42$, $p < .05$, $\eta^2 = .13$ (*M*s = 507 and 513 ms, respectively). The significant interaction Stimulus Material × Valence, $F(1, 37) = 7.10$, $p < .05$, $\eta^2 = .16$, revealed a significant difference in RTs between positive and negative pictures but not between positive and negative words (all Tukey pairwise comparisons: $p < .005$, except positive words versus negative words: $p = 1.00$).

More importantly, in accordance with our expectations, the interaction Valence × Arm Movement failed to reach significance, $F(1, 37) = 0.01$, *ns*, $\eta^2 = .00$, demonstrating that facilitative effects on arm movements do not rely on a fixed valence–arm movement link. Instead, in accordance with our predictions, goal conducive arm movements were generally executed more rapidly than were goal obstructive arm movements (Figure 1), as reflected in the significant interaction Group × Valence × Arm Movement, $F(1, 37) = 6.36$, $p < .05$, $\eta^2 = .15$. Moreover, the effect was visible in both groups of participants, $ts(37) = 1.66$ and 1.91, $ps = .05$ and $< .05$ (one-tailed).[4] Thus, it seems that outcome desirability strongly determines the psychological significance of arm movements. Interestingly, the differences between positive and negative images are much more pronounced in the increasing stimulus size conditions (flexion in Group Ext- and extension in Group Ext+) than in the decreasing size conditions (extension in Group Ext- and flexion in Group Ext+). Finally, the four-way interaction Group × Stimulus Material × Valence × Arm Movement was not significant, $F(1, 37) = 0.80$, *ns*, $\eta^2 = .02$, suggesting that the above-reported facilitation effects hold for pictures as well as for words.

Insert Figure 1 about here

Discussion

The current experiment is, to our knowledge, the first to independently vary arm movements and their resulting visual effects. We did this by manipulating the context in which arm movements were performed, establishing either an approach (stimulus size increase) or a withdrawal context (stimulus size decrease). In line with results from other studies (Markman & Brendl, 2005; Puca, Rinkenauer, & Breidenstein, 2006; Seibt et al., 2008), our results show once more that flexion does not unequivocally represent an approach movement and extension does not unequivocally represent a withdrawal movement. Rather, RTs in our experiment strengthen the idea of a situated or context-dependent meaning of arm movements. We were able to show that the desirability of an effect of an arm movement on a given stimulus determines its facilitation or inhibition. Participants simply preferred the movements, which initiated the decrease of negative and the increase of positive images and words.

On the whole, our data do not support the notion of an automatic, hard-wired link between arm movements and stimulus appraisals or action tendencies. Specifically, a particular outcome of the valence appraisal did not consistently facilitate or inhibit a specific arm movement. Thus, stimulus valence did not appear to have a unique or prepotent influence on the facilitation of a specific arm movement. This result is not surprising, because the simple fact that something negative or positive is presented at a certain “psychological distance” (which is the case with words or pictures) does not require a specific type of action preparation. Rather, the potential outcomes of available actions in relation to personal goals should determine which behavior is finally facilitated and shown.

Importantly, in contrast to earlier research findings, neither did our observed effects arise in an experimental environment that made use of instructions to apply motivational meanings to arm extension and arm flexion (Eder & Rothermund, 2008; Seibt et al., 2008), nor was it the explicit goal of our participants to approach or withdraw from the presented stimulus material (Krieglmeyer et al., 2011; Markman & Brendl, 2005).

In our specific case, the significance of arm movements was evidently shaped by the desirability of the visual outcomes. Thus, we were able to demonstrate that the significance of arm movement easily adapts to the context—without the need for specific task instructions. Our results also suggest that individuals do not need to consciously process the meaning of an arm movement for facilitation effects to occur.

The RT differences we found between conducive and obstructive arm movements were relatively small. One reason for this may be that, because of the inclusion of physiological measures (serving the investigation of nonrelated hypotheses, see Aue & Scherer, 2011), we were restricted to a limited number of trials and could not have rapid stimuli presentation. In addition, the rather long intervals between subsequent onsets of stimuli (~ 6.5 s) and the time elapsed between stimulus onset and requested response (~ 500 ms) may have reduced the impact of the stimuli on the facilitation of arm movements and augmented the strength of alternative influences on RT. It is possible that the extended stimulus presentation times led to changing states of attention, thus blurring RT differences between conducive and obstructive arm movements. Nonetheless, we cannot clearly determine if the influence of the visual outcomes on the facilitation of arm movements on valence would occur in studies investigating only early stages of stimulus processing.

An important point to consider is whether our pictorial stimulus material was really unambiguous with respect to valence. It can be speculated that negative images are frequently experienced as ambiguous. On the one hand, they can be thought to evoke withdrawal tendencies. On the other hand, it is also very important to pay attention to and orient toward potential threatening situations. Some participants in our study may have been curious to figure out what was being depicted on a given negative image. In extreme cases, there can even be an effect of sensation seeking (Zuckerman, 1979). Human beings often have the tendency to enjoy confrontation with negative information and stimulus material. A typical example is the pleasure that at least some of us take in watching horror films. Evidence for simultaneous activation of approach and withdrawal motivation comes from several studies (e.g. Larsen et al., 2004; Miller, 1961).

Conclusion and future perspectives

It seems unjustified to interpret the relative ease of arm flexion and arm extension as reliable indicators of the relative strength of approach and withdrawal motivation (e.g. Förster, Higgins, & Idson, 1998; Heuer et al., 2007; Rinck & Becker, 2007), at least when considered independently from contextual factors. Only when contextual factors allow an unambiguous interpretation of the motivational significance of the arm movements can these be taken as indicators for motivational states. Our study shows that visual consequences of arm extension and arm flexion can shape the motivational significance of these arm movements. Such visual outcomes could also affect whether, in the long run, a self reference point (Group Ext-) or an object reference point (Group Ext+) is adopted.

Although our results suggest the motivational significance of arm movements to be context dependent, this does not at all imply that the study of arm movements is worthless or without interest. Rather, it will be useful to identify more exhaustively which additional contextual factors (other than visual consequences) moderate the link between arm movements and stimulus evaluations. Krieglmeyer et al. (2011) demonstrated that an ultimate rather than an immediate distance change with respect to a desired end state played a major role in the facilitation of arm movements. Participants in this study made a manikin on a computer screen approach or withdraw from affectively laden words. In some experimental trials, the participants needed to initiate a detour that first put the manikin at even greater distance to a desired end state, but ultimately enabled the accomplishment of that desired end state. In these same trials, immediate distance reduction would have complicated the attainment of the desired end state. Participants more rapidly performed the arm movements that yielded an ultimate rather than an immediate distance reduction with respect to the desired end state. It would be interesting to embed this experimental paradigm into a more naturalistic setting, for example, a virtual reality environment that makes use of visual zooming.

In our experiment, we did not distinguish between the initiation and the execution time of the arm movements. Instead, we measured only the time elapsed between stimulus onset and halfway joystick displacement in either the extension or the flexion direction. Whether initiation or execution differences were responsible for the observed effects remains to be clarified. Results reported by Rotteveel and Phaf (2004) and Solarz (1960) suggest that the effects originate in the initiation phase. However, the Puca et al. (2006) studies suggest execution time (or response force) to be the more important determinant. Subsequent studies should further investigate this point. It will be essential to find out whether our observed differences in RTs have their origin in the differential time needed for decision making and response preparation (both influencing initiation time) or in differences in motor execution time.

In future experiments, it will also be challenging to integrate different time intervals between the image/word onset and the apparition of the symbol demanding either an arm extension or an arm flexion. An interesting question is whether the impact of context influences changes with varying time intervals between picture/word onset and symbol apparition. On the one hand, with increasing time intervals, the probability of controlled processing is probably augmented and might enhance context influences on the facilitation of arm movements. On the other hand, affective responses may rapidly fade, and influences on response tendencies could therefore be expected to be particularly strong in the early phase of stimulus presentation.

Finally, it has to be taken into consideration that our results cannot be generalized to the oppositely directed link, namely, the one in which arm movements are not taken as indicators but as causal agents of stimulus appraisals. Whereas we do present data that question the idea of specific arm movements being facilitated by positive versus negative stimulus evaluations, we cannot infer that this also questions the idea of the execution of arm flexion/extension provoking appraisals of positive/negative valence (cf. Cacioppo et al., 1993; Neumann & Strack, 2000).

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Author Note

Tatjana Aue and Klaus R. Scherer, University of Geneva.

This research was supported by grant 11-61659.00 of the Swiss National Science Foundation to Klaus R. Scherer.

Correspondence concerning this article should be addressed to Tatjana Aue, Swiss Center for Affective Sciences, University of Geneva, rue des Battoirs 7, 1205 Geneva, Switzerland. E-mail: tatjana.aue@unige.ch

Footnotes

[1]It is important to note that Solarz, in his article, did not use the label *withdrawal* but *avoidance* when referring to arm extension. However, Schneirla (1959) emphasized the importance of making a clear distinction between avoidance and withdrawal, as only the latter implies increasing distance toward a source of stimulation and thus constitutes the direct opposite of approach. For the sake of clarity, we will make use of Schneirla's approach and withdrawal terminology throughout this article.

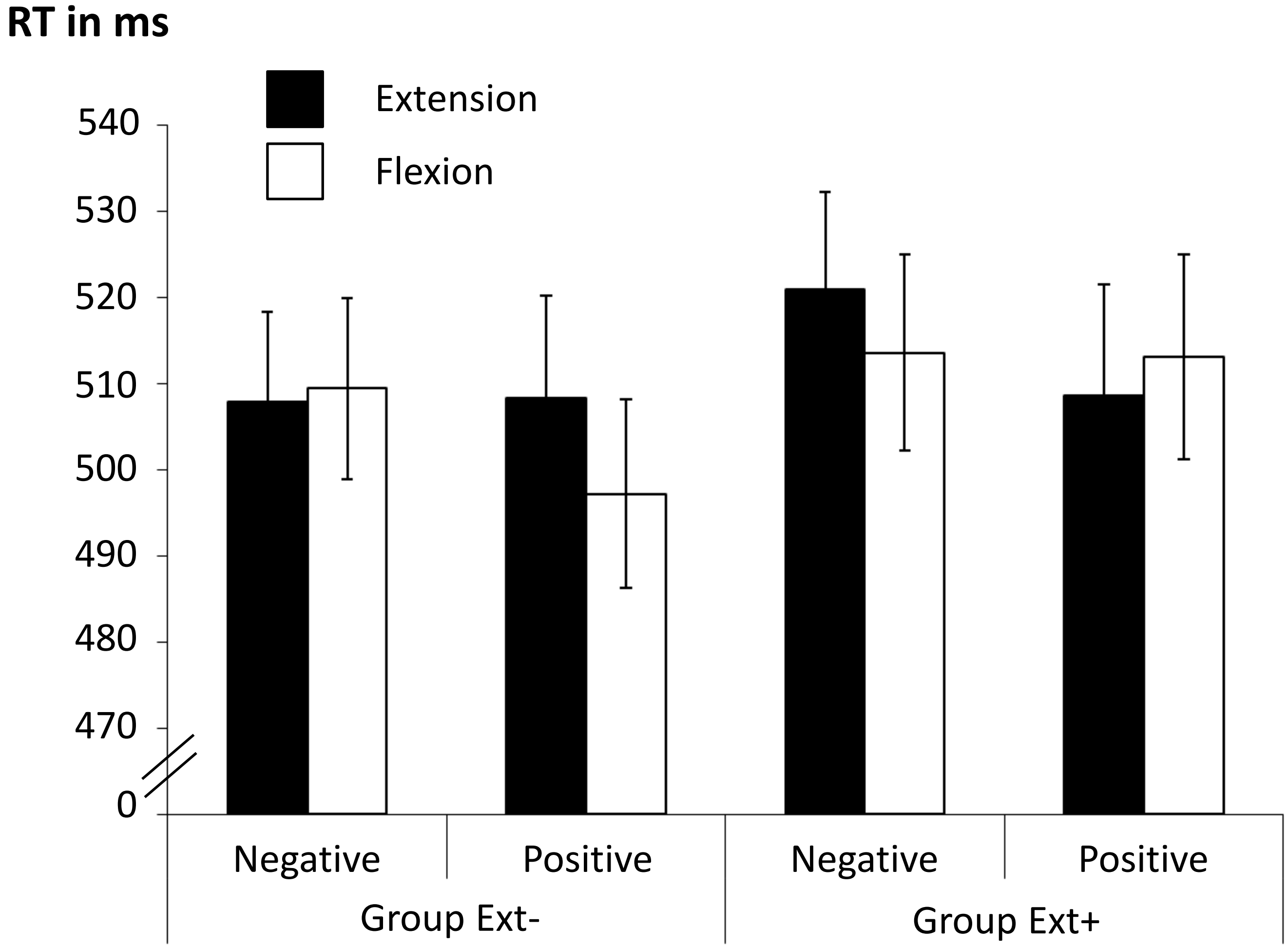
[2]More concretely, after 50% of the maximum possible deflection in either the extension or the flexion direction had been performed

[3]In contrast to earlier studies using a zooming effect (Heuer, Rinck, & Becker, 2007; Rinck & Becker, 2007; Wentura et al., 2008), we did not use intermediate steps for size changes, but just replaced the medium-sized images and words with the large or small-sized images and words.

[4]*t* values refer to the difference scores between goal conducive and goal obstructive events in each group and were tested against zero.

Figure Captions

Figure 1. Reaction times (RTs) as a function of Valence, Arm Movement, and Group. Group Ext-: extension = decreasing stimulus size, flexion = increasing stimulus size; Group Ext+: extension = increasing stimulus size, flexion = decreasing stimulus size. Error bars depict standard errors. *N* = 39.


RT in ms
Extension
Flexion
540
530
520
510
500
490
480
470
0
Negative
Positive
Negative
Positive
Group Ext-
Group Ext+

Appendix A

Means for Valence, Arousal, and Complexity Ratings for Pictures

Valence	Picture (IAPS number)	Source	Valence	Arousal	Complexity
Negative	KKKI rally (9810)	IAPS	1.59	5.75	4.95
Negative	Beggar	Web	1.75	4.47	4.38
Negative	Vomit (9320)	IAPS	1.80		
Negative	Gun (6560)	IAPS	2.01		
Negative	Nuke	Web	2.09	5.57	4.70
Negative	Burial	Web	2.36	3.47	4.24
Negative	Car accident (9911)	IAPS	2.71		
Negative	Attacking dog	Web	2.86	5.54	3.35
Negative	Soldier (9421)	IAPS	2.93		
Negative	Dirty pig	Web	3.35	4.37	4.16

Valence	Picture (IAPS number)	Source	Valence	Arousal	Complexity
Neutral	Railtracks	Web	4.30	3.40	6.20
Neutral	Building 2	Web	4.77	2.95	3.21
Neutral	Boat	Web	4.98	2.51	2.92
Neutral	Motorcyclist (8260)	IAPS	5.17		
Neutral	Man on cliff (8160)	IAPS	5.29		
Neutral	Mist	Web	5.31	3.72	5.02

Neutral	Skyscraper	Web	5.44	2.64	4.00
Neutral	Conference	Web	5.63	2.34	5.50
Neutral	Roofer	Web	5.75	3.41	3.51
Neutral	Condom (4613)	IAPS	5.88		

Valence	Picture (IAPS number)	Source	Valence	Arousal	Complexity
Positive	Lion (1720)	IAPS	6.95		
Positive	Airplane flight	Web	7.05	5.45	4.62
Positive	Carousel	Web	7.32	5.10	4.84
Positive	Young koala	Web	7.71	3.01	3.27
Positive	Kittens (1463)	IAPS	7.74	4.15	3.69
Positive	Sandcastle	Web	7.90	3.52	6.27
Positive	Dolphins	Web	8.06	3.46	3.23
Positive	Skiers (8190)	IAPS	8.08		
Positive	Sunset (5830)	IAPS	8.09		
Positive	Old couple (2550)	IAPS	8.31		

Note. Thirty-eight participants in a picture evaluation task rated the pictures on continuous scales. Average scores of all participants were transformed into values ranging from 1 (*not at all or very negative*) to 9 (*extremely of very positive*). Gray values were obtained in another experiment. IAPS: pictures taken from the International Affective Picture System; Web: pictures found on the World Wide Web.

Appendix B

Means for Concreteness, Imageability, Subjective Frequency, and Valence Ratings for Words Selected from a French Word List (Bonin et al., 2003)

Valence	French word	English translation	Concreteness	Imageability	Subjective frequency	Valence	Number of characters
Negative	Fusil	Gun	4.82	4.68	2.36	1.12	5
Negative	Seringue	Syringe	4.91	4.64	2.36	1.20	8
Negative	Araignée	Spider	4.86	4.76	3.24	1.32	8
Negative	Tombe	Grave	4.18	4.04	2.68	1.32	5
Negative	Limace	Slug	4.77	4.46	2.20	1.52	6
Negative	Serpent	Snake	4.77	4.56	2.84	1.52	7
Negative	Sang	Blood	3.95	4.20	3.88	1.72	4
Negative	Ambulance	Ambulance	4.59	4.36	3.12	1.76	9
Negative	Soldat	Soldier	4.41	4.16	2.64	1.88	6
Negative	Diable	Devil	2.55	4.00	2.52	1.92	6

Valence	French word	English translation	Concreteness	Imageability	Subjective frequency	Valence	Number of characters
Neutral	Ceinture	Belt	4.82	4.36	3.68	2.84	8
Neutral	Statue	Statue	4.68	4.29	2.68	2.84	6
Neutral	Micro	Microphone	4.36	4.40	2.84	2.88	5
Neutral	Cadran	Dial	4.14	3.16	2.28	2.96	6
Neutral	Tronc	Trunk	4.64	4.40	2.92	2.96	5
Neutral	Cube	Cube	4.32	4.56	3.00	3.00	4
Neutral	Marmite	Cooking pot	4.77	4.44	2.40	3.00	7
Neutral	Chemisier	Shirt	4.77	4.28	3.36	3.04	9
Neutral	Horloge	Grandfather clock	4.82	4.68	3.40	3.08	7
Neutral	Haie	Hedge	4.55	3.92	2.76	3.12	4

Valence	French word	English translation	Concreteness	Imageability	Subjective frequency	Valence	Number of characters
Positive	Couffin	Carrycot	4.82	3.84	2.08	4.08	7
Positive	Mûre	Blackberry	4.73	4.72	2.84	4.08	4
Positive	Bague	Ring	4.91	4.84	3.96	4.20	5
Positive	Baignoire	Bath(tub)	4.86	4.64	3.96	4.20	9
Positive	Trèfle	Clover	4.36	4.72	2.52	4.20	6
Positive	Rose	Rose	4.91	4.76	3.44	4.40	4
Positive	Hamac	Hammock	4.86	4.36	2.08	4.44	5
Positive	Famille	Family	3.23	3.44	4.72	4.52	7
Positive	Dauphin	Dolphin	4.68	4.80	2.52	4.56	7
Positive	Etoile	Star	3.86	4.68	3.96	4.60	6

Note. Ratings were given on a 5-point scale from 1 (*very little concrete/evokes a mental image with difficulty, slowly, or no image at all/word name rarely used in spoken or written language/very unpleasant*) to 5 (*very concrete/evokes a mental image very easily, rapidly, and spontaneously/word name very frequently used in spoken or written language/very pleasant*).