Emotion

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Easy Moves: Perceptual Fluency Facilitates Approach-Related Action

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It is well established that processing fluency impacts preference judgments and physiological reactions indicative of affect. Yet, little is known about how fluency influences motivation-related action. Here, we offer a novel demonstration that fluency facilitates action-tendencies related to approach. Four experiments investigated this action effect, its boundary conditions, and concomitant affective responses. Experiment 1 found faster approach movements (reaction times [RTs] to initiate arm flexion) to perceptually fluent stimuli when participants acted to rapidly classify stimuli as either "good" or "bad." Experiment 2 eliminated this fluency effect on action when participants performed nonaffective classifications ("living" or "nonliving"), even though fluency robustly enhanced liking judgments. Experiment 3 demonstrated that fluency can also facilitate approach action that is not immediate, as long as the delayed action involves affective classification. This experiment also found that fluent stimuli elicit genuine hedonic responses, as reflected in facial electromyography (fEMG) activity over zygomaticus "smiling" muscle. Experiment 4 replicated the physiological (fEMG) evidence for hedonic responses to fluent stimuli, but similar to Experiment 2, we observed no fluency effects on actions involving nonaffective classification. The current studies offer the first evidence that perceptual fluency can facilitate approach-related movements, when such movements are embedded in the context of affective decisions. Generally, these results suggest that variations in processing dynamics can flexibly and implicitly shape action-tendencies.

Keywords: emotion, action-tendencies, cognitive processes, facial expressions, electromyography

What determines whether we smile or frown to others, approach or avoid different objects, or judge people positively or negatively? These are classic questions about the links between emotion, cognition, motivation, and action (Frijda, 1986; Zajonc, 1998) but also about the connections between attitudes and behaviors (Allport, 1935; Petty, Fazio, & Briñol, 2009). This article addresses these questions by exploring a novel relationship between evaluation, action, and a core property of cognition—*fluency*, or its processing dynamics. Essentially, we propose that fluency gives neutral stimuli the ability to facilitate approach-related action, as elaborated next. Before that, we provide some background on emotion and motivation, and then discuss how fluency interacts with these processes in shaping action.

Starting with Darwin's (1872/1997) observation that emotions are tied to motivational states and motor tendencies, researchers have been trying to characterize these connections (Krieglmeyer, De Houwer, & Deutsch, 2013; Neumann, Förster, & Strack, 2003). Both classic and modern theories posit that affective and motivational processes are organized on an *approach-avoidance dimension* (Harmon-Jones, Harmon-Jones, & Price, 2013; Lang, Bradley, & Cuthbert, 1990). It is often suggested that these processes are linked to specific action-tendencies. For example, individuals are generally faster to pull a lever toward the body for positive stimuli and/or push a lever away from the body for negative stimuli (Krieglmeyer, Deutsch, De Houwer, & De Raedt, 2010). It is important that these approach-avoidance tendencies could be represented according to body-centered direction (toward vs. away; Chen & Bargh, 1999), specific muscle activation (bicep flexion vs. tricep extension; Cacioppo, Priester, & Berntson, 1993), object-centered directions (closer vs. farther spatial distance; Seibt, Neumann, Nussinson, & Strack, 2008), or self-relative

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movements (Markman & Brendl, 2005; but see Van Dantzig, Zeelenberg, & Pecher, 2009).

In recent years, new insights into the links between perception, cognition, emotion, and action came from examining *fluency*—or changes in processing speed and effort (Schwarz, 1998). Extensive evidence suggests that higher perceptual and conceptual fluency (usually manipulated through stimulus repetition, priming, clarity, contrast, duration, or typicality) enhances affective responses and evaluative judgments, ranging from basic preferences (Winkielman & Cacioppo, 2001), consumer choices (Novemsky, Dhar, Schwarz, & Simonson, 2007), assessments of attractiveness (Winkielman, Schwarz, Fazendeiro, & Reber, 2003), brand evaluations (Lee & Labroo, 2004), trustworthiness ratings (Winkielman, Olszanowski, & Gola, 2015), to purchases of novel stocks (Alter & Oppenheimer, 2006). According to the *hedonic fluency model*, these effects occur because easy processing elicits mild positive affect, which is then (mis)attributed to the target stimulus (Winkielman, Schwarz, Fazendeiro, & Reber, 2003). This positive affect presumably emerges because fluency reflects (or probabilistically indicates) lower conflict and cost in processing, greater coherence, as well as higher stimulus familiarity. Note that all this may occur early in stimulus processing, coloring the initial impression of a fluent stimulus with positivity.

Given these findings and theoretical assumptions, it is surprising that fluency's motivational consequences have thus far received limited attention. There are indications that mere exposure (which increases fluency, though also familiarity) augments neural electroencephalogram (EEG) indices of approach motivation (Harmon-Jones & Allen, 2001). However, no study has yet tested whether fluency influences motivationally related *action.* This is especially surprising given the availability and popularity of various methods to study action-tendencies associated with approach and avoidance, as discussed shortly.

There are several important reasons for exploring fluency's consequences on motivation-relevant action. First, it is not obvious that fluency should impact approach-avoidance action. After all, fluency effects on preference judgments and affective reactions are typically found with mild, inherently neutral stimuli. In contrast, effects on motivation-related action are typically found with strongly valenced stimuli (i.e., highly emotion-laden pictures, faces, or words). This raises a question of whether any fluency effects on valence of initially neutral stimuli are strong, enduring, or pervasive enough to impact more "basic" action. This question relates to the debates about the limits of weak (as opposed to strong) evaluative objects to spontaneously trigger action-related processes (e.g., Fazio, 2001). Second (and more generally), note that there is no obligatory or straightforward connection between affect and motivated-action. For instance, factors that increase stimulus liking do not always increase stimulus wanting (Aharon et al., 2001; Litt, Khan, & Shiv, 2010; Winkielman & Berridge, 2003). In another example, factors that decrease stimulus evaluation can sometimes increase approach behavior, as is the case with anger (Harmon-Jones, Harmon-Jones, & Price, 2013). Finally, if there are any fluency effects on action, they are probably subject to important boundary conditions. One key issue here is their possible automaticity. Fluency effects on approach-related action could be relatively unconditional, as has been previously argued for inherently valenced stimuli (e.g., Chen & Bargh, 1999). However, recent reviews suggest that approach-avoidance action effects even to strongly valenced stimuli are robustly observed *only* when such action is embedded in an affective classification tasks (see Phaf, Mohr, Rotteveel, & Wicherts, 2014, for a meta-analysis). As an example, positive valence facilitates approach action when participants classify emotional faces into affective categories, such as "positive" or "negative," but not into nonaffective categories, such as "male" or "female" (Rotteveel et al., 2015; Rotteveel & Phaf, 2004).

To address these questions, four experiments investigated how fluency impacts affect and approach-avoidance actions. The general logic of all the studies was to present novel and neutral stimuli (pseudowords) in the context of a "word judgment" task. Fluency was manipulated using a standard procedure of varying font readability. We assessed hedonic effects of fluency with self-report measures of liking and physiological reactivity—facial electromyography (fEMG). Critically, we also gauged fluency's consequences on motivated action using a method that taps into the perceiver's readiness to perform approach- and avoidance-related movements, as explained next.

There are important debates about the relative strengths of various approach-avoidance methods and paradigms (see Krieglmeyer & Deutsch, 2010). Here, we chose a robust method for which the available data suggest that approach motivation facilitates flexion movements (see Phaf, Mohr, Rotteveel, & Wicherts, 2014). However, as elaborated in the discussion, our hypothesis is committed to the fluency-approach link, rather than fluency-flexion link, with this particular paradigm providing a good way of measuring approach with flexion. More specifically, we used a vertical button-stand where participants pressed either a top or bottom response-button, which map onto approach (bicep contraction—resulting in arm flexion) and avoidance (tricep contraction—resulting in arm extension) movements, respectively (Figure 1; Rotteveel & Phaf, 2004). Note that this device keeps the spatial distance of each response type consistent, while providing two different dependent measures—*release time* (*RelT*, or time to initiate a response) and

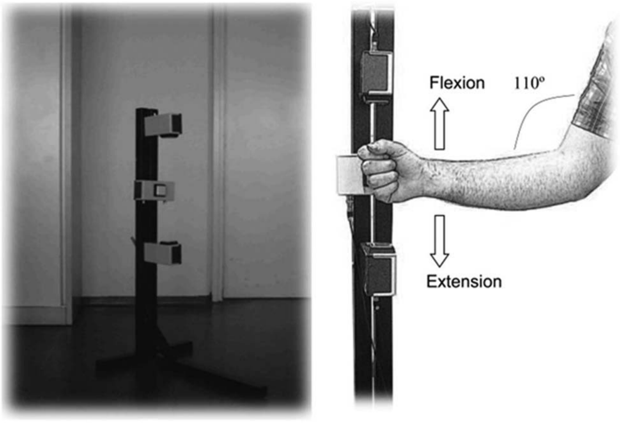

Figure 1. Experimental apparatus used for all four experiments in the approach-avoidance task (AAT). Three button boxes are affixed vertically on a metal stand. The middle box is the "home" button, where participants would rest the back of their hand and wait to respond. The two boxes above and below serve as response buttons, where participants would either flex or extend their arm to make a decision, respectively.

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movement time (*MovT*, or time to actually move the arm). Affective influences are typically found in RelT and not MovT (Phaf & Rotteveel, 2009; Rotteveel & Phaf, 2004), perhaps because emotion is about action-preparation, rather than action-performance (Frijda, 2010). Given this, we will not focus on exploratory MovT analyses here, because we had no specific predictions (but see footnotes for each individual experiment).

We hypothesized that fluency (compared with disfluency) would elicit faster flexion responses, indicating approach (Experiments 1 and 3). Note that flexion responses may be particularly sensitive to processing facilitation, given earlier research suggesting that fluency manipulations tend to influence positive rather than negative affect (as discussed later). Furthermore, as mentioned, fluency-action effects should be limited to when movements are embedded in affective classification tasks (whether the stimulus is "good" or "bad"; Experiments 1 and 3) rather than *non*-affective classifications (whether stimulus is "living" or "nonliving"; Experiments 2 and 4).

Finally, in all four experiments, we measured affective consequences of fluency. We predicted that fluency will lead to higher reports of liking for the stimulus. We also predicted that high fluency would elicit physiologically detectable positive response (increased smiling activity and reduced frowning activity, via fEMG over the *zygomaticus major* and *corrugator supercilii,* respectively), as measured in Experiments 3 and 4.

Experiment 1

Experiment 1 had two goals. First, we wanted to test how fluency influences rapid flexion movements (via reaction times [RTs], using the vertical button-stand; Figure 1). Second, we wanted to assess how fluency influences overt evaluations (liking ratings and classification decisions).

Method

Participants. Thirty-two University of California, San Diego (UCSD) undergraduates participated for course credit. All participants were right-handed English speakers.

Materials and apparatus. Targets were 100 neutral pseudowords (i.e., pronounceable strings of letters that appear to be real words but have no actual meaning; all between 5 and 7 letters). These stimuli were selected out of a set of 200 pseudowords, generated using the ARC Nonword Database (Rastle, Harrington, & Coltheart, 2002). To select our neutral targets, we conducted an online survey using a separate sample of 72 UCSD undergraduates, where they rated all 200 pseudowords using a 1 to 7 scale on both valence (1 = *very negative* to 7 = *very positive*) and arousal (1 = *not arousing at all* to 7 = *very arousing*). Results showed that all 200 pseudowords were rated as relatively neutral in valence ($M_{valence} = 3.71$, $SD_{valence} = 0.27$) and low to medium in arousal ($M_{arousal} = 2.83$, $SD_{arousal} = 0.22$). For the final targets, we selected the 100 most neutral pseudowords on both scales ($M_{valence} = 3.92$, $SD_{valence} = 0.17$; $M_{arousal} = 2.87$, $SD_{arousal} = 0.23$).

Participants were instructed to respond using a vertical button-stand (for this setup and procedure, see Figure 1 and Rotteveel & Phaf, 2004). All participants were right-handed and sat to the left of the button-stand. To trigger the start of a trial, participants pressed and held the "home" button (fixed in the middle of the tower, 10 cm between the top and bottom buttons—adjusted to each individual participant to maintain the 110° angle between the upper and lower arm) with the back of their right hand, while they were waiting to respond. As they pressed one of two response buttons with the top or bottom side of their hand, they did not turn their hand when responding (Figure 1) and either flexed or extended their arm (revealing their "approach" vs. "avoidance" responses, respectively).

All stimuli were presented on a 17-inch Dell flat-screen from a PC running Windows XP and E-Prime 2.0.

Design and procedure. The experiment was introduced as "a language study where [participants would make] timed judgments of different words." After eight practice trials, participants were told to "make fast, intuitive judgments of whether the different words [were] *good* or *bad*—even though they [were not] in English, and [they would] not know their true meaning" (recall that the "non-English" pseudowords had no actual meaning and were selected as being neutral on both valence and arousal).

Each participant progressed through four blocks of 25 randomized trials, totaling 100 trials in the approach-avoidance task (AAT). As shown in Figure 2, each trial began with a 3,000-ms fixation, followed by the 300-ms presentation of a pseudoword in either fluent text (easy-to-read, black Arial font that was bolded) or disfluent text (difficult-to-read, silver Script font that was italicized). After 300 ms of target presentation, a decision screen appeared that said "GOOD -or- BAD," where these labels were paired with either the top or bottom response buttons (response labels were randomized across trials). Participants would release the middle "home" button to hit either the top or bottom button (thereby flexing or extending their arm). After logging the AAT response, participants would then would rate how much they liked the pseudoword on a 1 (*not at all*) to 4 (*very much*) scale, using their left hand on the keyboard (Figure 2).

Note that previous research with this paradigm has used facial expressions as stimuli, where the buttons can be labeled as "positive" versus "negative" or "male" versus "female"—thus allowing the responses to be evaluated on accuracy (e.g., Rotteveel & Phaf, 2004). However, in the current experiments, there was no explicit instruction regarding the association between high or low perceptual fluency and the specific arm movements. Participants responded only according to the instruction regarding their own affective evaluation of the targets on each trial, pressing the upper or lower buttons (i.e., arm flexion and arm extension). As a result, responses could not be evaluated according to accuracy (because no response could be regarded as incorrect).

Throughout the experiment, no explicit references were made to anything related to approach-avoidance movements (the response device was simply referred to as a "button-stand"), arm flexion versus arm extension, or positive versus negative emotion. After the session concluded, each participant was given an exit interview and asked for a brief statement on what they thought the experiment was investigating. None of the participants for any of the experiments reported anything linking fluency (font readability) to the type of arm movement (flexion vs. extension).

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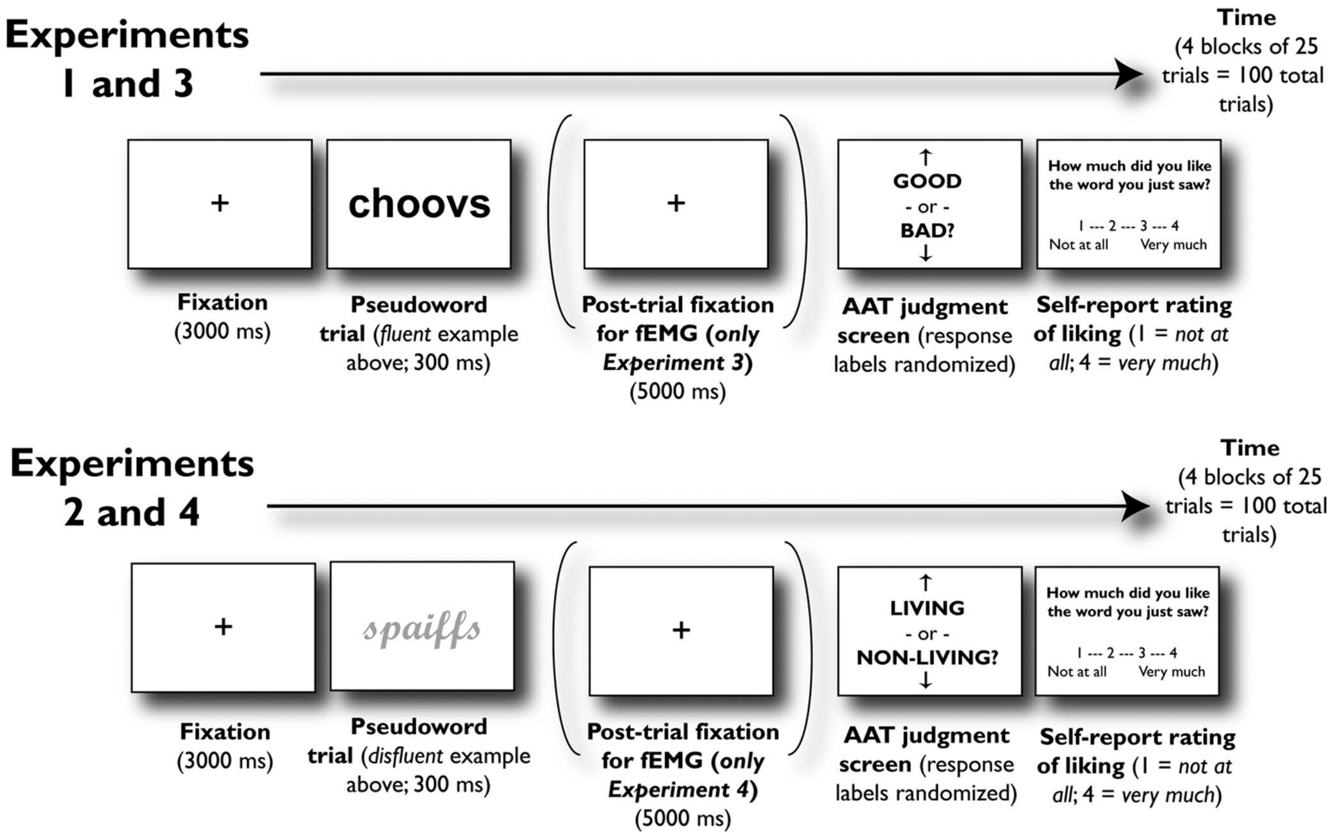

Figure 2. Design and procedure used for Experiments 1, 2, 3, and 4. AAT = approach-avoidance task.

Results

Analysis strategy. All repeated-measures analyses used mixed-effects modeling via maximum likelihood, because this method offers numerous analytical advantages—including more effective handling of unbalanced data with missing observations, reliance on fewer assumptions regarding covariance structures, and increased parsimony and flexibility between models (Bagiella, Sloan, & Heitjan, 2000). All models were built with the *lme4* (Bates, Maechler, Bolker, & Walker, 2015) and *lmerTest* (Kuznetsova, Brockhoff, & Christensen, 2014) packages in R (R Core Team, 2014), using a maximal random-effects structure appropriate for the data (Barr, Levy, Scheepers, & Tily, 2013). To obtain p value estimates for fixed-effects, we used Type III Satterthwaite approximations, which can sometimes result in decimal degrees of freedom, based on the number of observations (West, Welch, & Galecki, 2014).

RelTs. RTs were analyzed with a Fluency (2: fluent, disfluent) × Movement (2: flexion, extension) fixed-effects structure. To normalize the RelT distribution and reduce the impact of outliers, we removed all RelTs greater or less than 3 SDs from each subject's total average RelT (which constituted 3.44% of all trials), and all remaining RelTs were $\log_{10}$-transformed.

Recall that affective influences are typically found in RelT and not MovT (Phaf & Rotteveel, 2009; Rotteveel & Phaf, 2004), so we will not focus on exploratory MovT analyses here, because we had no specific predictions (see footnote 1 for Experiment 1 MovT results summary; MovTs were analyzed using the same methods as RelTs).

On RelTs, we found a Fluency × Movement interaction, $F(1, 3057.16) = 5.79$, $p = .02$ (independent from the actual "good" or "bad" classification made by the participants). Post hoc analysis of this interaction showed that participants initiated flexion movements quicker to fluent pseudowords, significant when compared with disfluent flexion, $b = .05$, $t = 4.16$, $p < .001$, $d_Z = 0.74$, and marginal when compared with fluent extension, $b = .02$, $t = 1.67$, $p = .09$, $d_Z = 0.30$. Note that we also observed a fluency main effect, $F(1, 29.94) = 11.25$, $p < .01$, $d_Z = 0.59$, such that overall, subjects initiated all movements more quickly in response to fluent pseudowords (Figure 3).

Liking judgments. Scale ratings for self-report liking (1 = *not at all*; 4 = *very much*) were analyzed in the same way as RelTs, using mixed-effects modeling according to a Fluency (2: fluent, disfluent) × Movement (2: flexion, extension) fixed-effects structure.

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[1] With MovTs for Experiment 1, we found main effects for both fluency, $F(1, 67.46) = 8.76$, $p < .01$, and movement, $F(1, 32.23) = 48.92$, $p < .001$. Post hoc breakdowns of these effects showed that participants had quicker MovTs in response to disfluent pseudowords, and overall, they were faster to perform extension movements. Outliers (greater or less than 3 SDs from each individual subject's total average MovT) constituted 3.75% of all trials, which were removed before $\log_{10}$-transforming the remaining valid MovTs.

We only observed a main effect of fluency, $F(1, 32.04) = 15.21$, $p < .001$, $d_Z = 0.69$, where participants reported greater liking for fluent pseudowords ($M = 2.55$; $SD = .83$) than disfluent pseudowords ($M = 2.38$; $SD = .76$; Figure 3).

Classification decisions. We also evaluated whether or not fluency impacted participants' classification decisions ("good" or "bad") of the different pseudoword targets. To do this, we constructed a mixed-effects model on the binary decision outcome ("good" or "bad" classification), according to a Fluency (2: fluent, disfluent) × Movement (2: flexion, extension) fixed-effects structure.

We found a main effect of fluency, $F(1, 31.23) = 9.41$, $p < .01$, such that fluent pseudowords predicted a greater likelihood for subjects to log a "good" classification compared with disfluent pseudowords, after both flexion movements, $b = .09$, $t = 2.62$, $p = .01$, $d_Z = 0.46$, and extension movements, $b = .09$, $t = 2.72$, $p < .01$, $d_Z = 0.48$ (Table 1). To gauge whether or not participants were more likely to just classify the pseudowords as "good" or "bad" overall, we tested subjects' mean proportions against a 50% chance level (0 = "*bad*"; 1 = "*good*"). This showed no effect, $t(31) = 1.13$, nonsignificant (*ns*), demonstrating that participants generally were not more or less likely to classify pseudowords as "good" or "bad."

Experiment 2

Experiment 1 established the basic effect that perceptual fluency facilitates flexion (but not extension) RelTs, along with more positive classifications and evaluative ratings of liking. Experiment 2 aimed to examine the boundary conditions of the RelT effect. Recall that participants in Experiment 1 made movements to classify the different pseudowords as either "good" or "bad," which embeds the action in an affective categorization task. Therefore, the only change in Experiment 2 was that the AAT classification task was *non*-affective (i.e., classifying each pseudoword as "living" or "nonliving"). If action effects of fluency require embedding them in an affective context, then the RelT effects should disappear, just as they do in approach-avoidance studies that use facial expressions as stimuli (Rotteveel & Phaf, 2004). Critically, fluency effects on affect should remain and still influence the self-report ratings of liking. As such, we kept the later preference judgment the same, to assess any changes in the simple liking component of fluency (Figure 2).

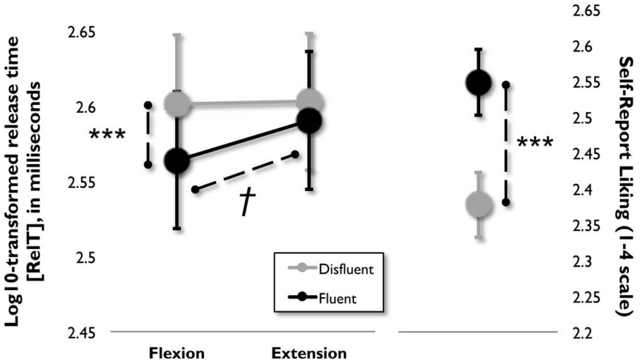

Figure 3. In Experiment 1, we observed a Fluency × Movement interaction for release times (RelTs). Participants initiated flexion (but not extension) movements quicker in response to fluent compared with disfluent pseudowords (left panel). Participants also reported greater liking for fluent compared with disfluent pseudowords (right panel). Error bars represent ± 1 *SEM* ($^{***}\ p < .001$; $^{**}\ p < .001$; $^{*}\ p < .05$; † $p < .10$).

Table 1
Percentage of Classification Decisions According to Fluency (Fluent vs. Disfluent), Classification ("Good" vs. "Bad"), and Movement (Flexion vs. Extension) for Experiment 1

Fluency	Classification	Movement		Total
		Flexion	Extension	
Disfluent	"Good"	11.20	10.18	21.38
	"Bad"	15.00	13.92	28.92
Fluent	"Good"	13.09	12.74	25.83
	"Bad"	12.00	11.87	23.87
	Total	51.29	48.71	100.00

Note. As evidenced by a main effect of fluency on the binary classification decision ("good" or "bad"), participants made more "good" classifications when responding to fluent pseudowords, along with more "bad" classifications when responding to disfluent pseudowords. Overall, participants showed relatively even proportions for total "good" versus "bad" classifications. Note that the split between fluent and disfluent trials may not be exactly 50-50, given that a very small number of error trials did not record any AAT classification response (e.g., subjects releasing the "home" button before pseudoword onset).

Method

Participants. Thirty-five UCSD undergraduates participated for course credit. All participants were right-handed English speakers.

Materials and apparatus. We used the same stimuli and setup as Experiment 1 (Figures 1 and 2).

Design and procedure. To investigate boundary conditions, we only made one change to the Experiment 1 design. Instead of an affective classification ("good" or "bad"), Experiment 2 used a *non*-affective classification ("living" or "nonliving"). As before, participants were asked to make fast, intuitive decisions and were told that the words are not in English. All other task parameters were the same (Figures 1 and 2).

Results

RelTs. As with Experiment 1, after removing outliers greater or less than 3 *SD*s from each subject's total mean RelT (which constituted 4.51% of all trials), valid RelTs were then $\log_{10}$-transformed and analyzed using mixed-effects modeling, according to a Fluency (2: fluent, disfluent) × Movement (2: flexion, extension) fixed-effects structure. Once again, we will not focus on exploratory MovT analyses here, because we had no specific predictions (see footnote 2 for Experiment 2 MovT results summary; MovTs were analyzed using the same methods as RelTs).

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[2] Our analysis of Experiment 2 MovTs only showed a main effect of movement, $F(1, 34.92) = 49.23$, $p < .001$, such that subjects were faster at performing extension movements. Outliers (greater or less than 3 *SD*s from each individual subject's total average MovT) constituted 4.86% of all trials, which were removed before $\log_{10}$-transforming the remaining valid MovTs.

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In contrast to Experiment 1, we did *not* observe a Fluency × Movement interaction, $F(1, 67.24) = 1.92$, *ns* (independent from the "living" or "nonliving" classification). Our analysis only yielded a significant main effect of fluency, $F(1, 34.97) = 9.61$, $p < .01$, $d_Z = 0.52$, which revealed that subjects initiated movements more quickly in response to fluent pseudowords (Figure 4).

Liking judgments. Liking judgments were analyzed with the same methods as Experiment 1, using mixed-effects modeling. Here, we replicated the fluency main effect from Experiment 1, $F(1, 35.19) = 4.98$, $p = .03$, $d_Z = 0.38$, where participants reported greater liking for fluent ($M = 2.52$, $SD = .88$) compared with disfluent ($M = 2.35$, $SD = .86$) pseudowords (Figure 4).

Classification decisions. Classification decisions ("living" or "nonliving") were analyzed with the same methods as Experiment 1, using mixed-effects modeling. Here, we also did *not* observe any fluency or movement effects on the binary classification outcome, $F\text{s} < 1.36$, *ns*. As with Experiment 1, we also assessed whether or not participants were more likely to just classify the pseudowords as "living" or "nonliving" overall, by testing subjects' mean proportions against a 50% chance level (0 = "*nonliving*"; 1 = "*living*"). This test was significant, $t(34) = 5.38$, $p < .001$, $d_Z = 0.91$, demonstrating that generally, participants were more likely to classify the pseudowords as "nonliving" over "living" (Table 2).

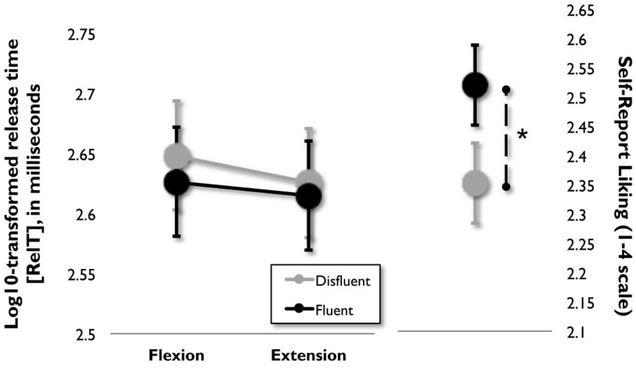

Figure 4. For Experiment 2, we did not observe any interactive effects for release times (RelTs; left panel). However, similar to Experiment 1, participants still reported greater overall liking for fluent compared with disfluent pseudowords (right panel). Error bars represent ± 1 *SEM* ($^{***}p < .001$; $^{**}p < .001$; $^{*}p < .05$; † $p < .10$).

Experiment 3

To recap, Experiment 1 showed that higher fluency enhances flexion RelTs (but not extension). Fluency also increases "good" classifications, along with later liking judgments. Experiment 2 found that when movements are embedded in a nonaffective decision, fluency effects on action disappear, but remain in the later liking judgments.

Considering these findings, we had three main goals with Experiment 3. First, we aimed to replicate the action effect from Experiment 1, again embedding the movement in an affective classification. Second, we wanted to see whether fluency effects on movement generation are observed even if the classification action is not immediate, but delayed for several seconds. The presence of the effect despite the delay would argue for at least a temporary change in the evaluative perception of the stimulus. Third, we wanted to further explore the nature of the underlying affective response to fluency with a measure that is unobtrusive (noninvasive), valence-specific (able to distinguish between positive and negative reactions), continuous (high temporal resolution), and nonverbal (independent of self-reports). All of this is possible with fEMG, which is an ideal measure for these purposes (Tassinary, Cacioppo, & Vanman, 2007). We expected a rapid increase in *zygomaticus major* ("smiling muscle") activity and a rapid decrease in *corrugator supercilii* ("frowning muscle") activity to fluent stimuli, indicating that fluency-preference effects reflect a genuine affective change (Cannon, Hayes, & Tipper, 2010; Harmon-Jones & Allen, 2001; Topolinski, Likowski, Weyers, & Strack, 2009; Topolinksi & Strack, 2015; Winkielman & Cacioppo, 2001). It is important that this effect should occur before participants make any overt evaluation of the stimulus, highlighting the rapid and spontaneous unfolding of the affective process.

Table 2
Percentage of Classification Decisions According to Fluency (Fluent vs. Disfluent), Classification ("Living" vs. "Nonliving"), and Movement (Flexion vs. Extension) for Experiment 2

		Movement		
Fluency	Classification	Flexion	Extension	Total
Disfluent	"Living"	10.68	11.21	21.89
	"Nonliving"	13.84	14.46	28.30
Fluent	"Living"	8.85	11.04	19.89
	"Nonliving"	13.93	15.99	29.92
	Total	47.30	52.70	100.00

Note. No effects of fluency or movement were observed on the binary classification decision. Overall, participants were more likely to classify the pseudowords as "nonliving" over "living." Note that the split between fluent and disfluent trials may not be exactly 50-50, given that a very small number of error trials did not record any AAT classification response (e.g., subjects releasing the "home" button before pseudoword onset).

Method

Participants. Twenty-nine UCSD undergraduates participated for course credit. All participants were right-handed English speakers.

Materials and apparatus. We used the same stimuli and experimental setup as Experiments 1 and 2 (Figures 1 and 2).

Design and procedure. The task for Experiment 3 was the same as Experiment 1, but we also incorporated fEMG acquisition for 5,000 ms after stimulus presentation, to evaluate the spontaneous affective responses to fluency with a physiological measure (before any self-report) and whether fluency effects on movement generation are expressed in a *delayed* action (Figure 2).

After receiving task instructions, bipolar surface electrodes were placed unilaterally on the left side of the face over the *zygomaticus major* ("smiling muscle") and *corrugator supercilii* ("frowning muscle") to gauge fEMG responses, in accordance with past research (Tassinary, Cacioppo, & Vanman, 2007). All other methods were the same as Experiment 1 (Figures 1 and 2).

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Signals were recorded with MP150CE/EMG2-T BioNomadix wireless data acquisition system and AcqKnowledge Version 4.1.1 software (Biopac Systems Inc., Santa Barbara, CA). All channel sampling rates were 2,000 Hz. Analyses (calculation, cleaning, and standardization) used MindWare EMG 2.52 (MindWare Technologies Ltd., Gahanna, OH) and coding scripts in MATLAB (Version R2014a; MathWorks Inc, Natick, MA).

Results

RelTs. We assessed RelTs in the same way as Experiments 1 and 2. After removing outliers (i.e., RelTs greater or less than 3 SDs from each subject's total average RelT; 1.66% of all trials), the remaining valid RelTs were $\log_{10}$-transformed and analyzed using mixed-effects modeling, according to a Fluency (2: fluent, disfluent) × Movement (2: flexion, extension) fixed-effects structure. As before, we will not focus on exploratory MovT analyses here, since we had no specific predictions (see footnote 3 for Experiment 3 MovT results summary; MovTs were analyzed using the same methods as RelTs).

We replicated the Fluency × Movement interaction from Experiment 1, $F(1, 2794.72) = 4.05$, $p = .04$, such that participants initiated flexion movements more quickly in response to fluent stimuli, compared with fluent extension, $b = 0.01$, $t = 2.38$, $p = .02$, $d_Z = 0.44$. Similar to Experiment 1, fluent flexion RelTs were faster than disfluent flexion RelTs, but this did not quite reach significance, $b = 0.01$, $t = 1.21$, *ns*, $d_Z = 0.22$ (Figure 5).

Liking judgments. Liking judgments were analyzed with the same methods as Experiments 1 and 2, using mixed-effects modeling. Critically, we replicated the fluency main effect from Experiments 1 and 2, $F(1, 29.03) = 28.19$, $p < .001$, $d_Z = 0.99$, where participants reported greater liking for fluent ($M = 2.57$, $SD = .76$) compared with disfluent ($M = 2.34$, $SD = .69$) pseudowords (Figure 5).

Classification decisions. Classification decisions ("good" vs. "bad") were analyzed with the same methods as Experiments 1 and 2, using mixed-effects modeling on the binary AAT outcome.

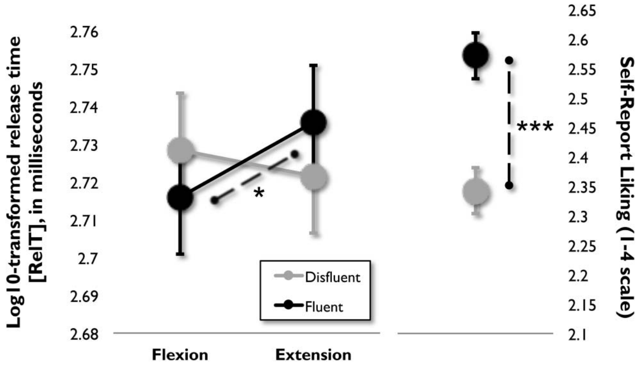

Figure 5. In Experiment 3, we replicated the Fluency × Movement interaction for release times (RelTs) from Experiment 1, where participants initiated flexion movements more quickly in response to fluent pseudowords (left panel). Also, as was the case with Experiments 1 and 2, participants reported greater overall liking for fluent compared with disfluent pseudowords (right panel). Error bars represent ± 1 *SEM* (*** $p < .001$; ** $p < .001$; * $p < .05$; † $p < .10$).

Here, we replicated the fluency main effect, $F(1, 29.02) = 26.66$, $p < .001$, from Experiment 1, such that more fluent stimuli predicted a greater likelihood for subjects to log a "good" classification, after both flexion movements, $b = .14$, $t = 4.26$, $p < .001$, $d_Z = 0.79$, and extension movements, $b = .15$, $t = 4.45$, $p < .001$, $d_Z = 0.83$ (Table 3). Also, as before, we tested subjects' mean proportions against a 50% chance level, to gauge whether or not they were more likely to just classify the pseudowords as "good" or "bad" overall (0 = "*bad*"; 1 = "*good*"). Similar to Experiment 1, this comparison showed no effect, $t(28) = 1.27$, *ns*, demonstrating that participants generally were not more or less likely to classify pseudowords as "good" or "bad."

fEMG. We also examined participants' fEMG data with mixed-effects modeling (using similar methods as RelT, MovT, and liking data), according to a Fluency (2: fluent, disfluent) × Muscle (2: corrugator, zygomaticus) × Time (10: 500 ms to 5,000 ms [in 500 ms groups]) fixed-effects structure.[4]

During each trial, the 3,000-ms fixation period was used as a baseline to which the subsequent 5,000-ms response period was compared. First, all EMG signals were filtered, rectified, and evaluated for movement artifacts. Second, to ensure that the data were properly cleaned and filtered, means and *SD*s were first calculated on each participant's raw dataset, and all trial points outside the ± 3 *SD* range from the mean signal for that participant were removed. Third, a new mean and *SD* for each participant was calculated based on the remaining valid trials, and all signals were *z*-scored. Finally, the median of the *z*-scored baseline for each participant was subtracted from each 500 ms *z*-scored trial point, and this process yielded a time-course of baseline-corrected, *z*-scored signals across 500-ms intervals for all trials. In sum, the final data (Figure 6) used for our analysis represent the *z*-scored change in muscle activity from baseline (standardized by each individual participant).

As expected, we found a Fluency × Muscle interaction, $F(1, 49.64) = 10.25$, $p < .01$, showing increased zygomaticus activity to fluent compared with disfluent pseudowords, $b = .04$, $t = 2.95$, $p < .01$, $d_Z = 0.59$. Participants also increased corrugator activity to disfluent compared with fluent pseudowords, but this effect did not reach significance, $b = .02$, $t = 1.57$, *ns*, $d_Z = 0.31$.

Note that we also observed a Muscle × Time interaction, $F(9, 225.00) = 9.66$, $p < .001$, which showed that the corrugator peaked very early, at the first 500-ms time point, which probably reflects an orienting response. The zygomaticus peaked later, at approximately 2,000 ms after stimulus onset, but still substantially before any overt liking judgments (Figure 6).

Experiment 4

As a quick review, in three experiments, we found that greater fluency leads to faster initiation of arm flexion during affective classification of initially neutral stimuli (Experiments 1 and 3). These

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[3] We did not observe any significant main effects or interactions on Experiment 3 MovTs. Outliers (greater or less than 3 *SD*s from each individual subject's total mean MovT) constituted 2.14% of all trials, which were removed before $\log_{10}$-transforming the remaining valid MovTs.

[4] Note that for all Experiment 3 fEMG analyses, we had $n = 25$ (instead of $n = 29$ with the behavioral data), because of computer errors in saving four participants' physiology files.

Table 3
Percentage of Classification Decisions According to Fluency (Fluent vs. Disfluent), Classification ("Good" vs. "Bad"), and Movement (Flexion vs. Extension) for Experiment 3

		Movement		
Fluency	Classification	Flexion	Extension	Total
Disfluent	"Good"	9.52	10.28	19.80
	"Bad"	14.72	15.48	30.20
Fluent	"Good"	12.83	14.17	27.00
	"Bad"	10.83	12.17	23.00
	Total	47.90	52.10	100.00

Note. Similar to Experiment 1, a main effect of fluency on the binary classification decision ("good" vs. "bad") showed that participants made more "good" classifications when responding to fluent pseudowords, along with more "bad" classifications when responding to disfluent pseudowords. Overall, participants showed relatively even proportions for total "good" versus "bad" classifications. Note that the split between fluent and disfluent trials may not be exactly 50-50, given that a very small number of error trials did not record any AAT classification response (e.g., subjects releasing the "home" button before pseudoword onset).

effects were accompanied by increased liking ratings and higher proportion of positive classifications for the fluent stimuli. Experiment 3 also found that these effects are accompanied by a low-level hedonic response, as shown by increased zygomaticus "smiling" activity to fluent pseudowords. It is interesting that when the same stimuli are placed in a *non*-affective decision context (i.e., "living" or "nonliving" classifications), these RelT effects disappear (Experiment 2).

With Experiment 4, we aimed to use fEMG to answer an important open question regarding the relationship between the hedonic response (physiology) and action-tendency (RelTs). Recall that in Experiment 3, we observed significantly increased smiling (zygomaticus) and a tendency toward reduced frowning (corrugator) to fluent pseudowords when the stimuli were embedded in an affective decision (i.e., "good" or "bad" classifications). This leaves unclear the role of the classification decision context for the relationship between fluency-elicited affect and action. Specifically, Experiment 2 showed that the fluency effect on approach action dissipates when the decision is *non*-affective (i.e., "living" or "nonliving" classifications). However, does this occur simply because no genuine hedonic response is elicited in that case? Or, perhaps more interestingly, an underlying hedonic state is elicited by high fluency, but it does not extend to modify the action?

We answered this question very simply in Experiment 4, by changing the affective classification task from fEMG Experiment 3 ("good" or "bad" classifications) to the same *non*-affective classification task from Experiment 2 ("living" or "nonliving" classifications). This simple change makes the results quite informative. Let us assume we *do* observe similar fEMG effects in Experiment 4 as Experiment 3 (i.e., increased zygomaticus and reduced corrugator activation to fluent pseudowords) *without* a RelT effect. This would suggest that RelT effects disappear for nonaffective classifications because the elicited hedonic reaction is not translated to a motor response (the fluency-based affect is somehow "gated" from the action-tendency). It would also mean that any RelT effects cannot simply be because of the global changes in the affective state itself. Conversely, let us assume we *do not* detect similar fEMG effects in Experiment 4 as Experiment 3 (i.e., no differences in zygomaticus or corrugator between fluent and disfluent pseudowords). This would suggest that RelT effects disappear for nonaffective classifications because fluency fails to elicit positive affect in the first place (nonaffective action context "switches off" early affective responding, which causes any downstream RelT effects to go away).

Method

Participants. Thirty-seven UCSD undergraduates participated for course credit. All participants were right-handed English speakers.

Materials and apparatus. We used the same stimuli and experimental setup as Experiments 1, 2, and 3 (Figures 1 and 2).

Design and procedure. To investigate the fEMG responses as a function of decision context, we only made one change to the Experiment 3 fEMG design. Instead of an affective classification ("good" or "bad"), Experiment 4 used the same *non*-affective

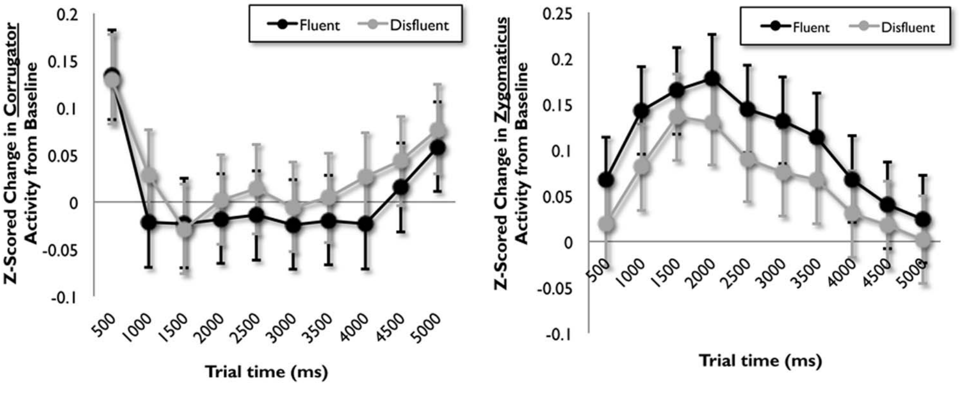

Figure 6. During Experiment 3, we measured facial electromyography (fEMG) over the corrugator (left panel) and zygomaticus (right panel) muscles. A Fluency × Muscle interaction indicated that participants recruited more zygomaticus (smiling) activation in response to fluent pseudowords. Subjects also recruited more corrugator (frowning) activation in response to disfluent pseudowords, but this effect did not reach significance. Error bars represent ± 1 *SEM*.

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classification as Experiment 2 (“living” or “nonliving”). All other task parameters were the same as Experiment 3 (Figures 1 and 2).

Results

RelTs. We evaluated RelTs in the same way as Experiments 1, 2, and 3. After removing outliers (i.e., RelTs greater or less than 3 SDs from each subject’s total mean RelT; 1.57% of all trials), the remaining valid RelTs were $\log_{10}$-transformed and analyzed using mixed-effects modeling, according to a Fluency (2: fluent, disfluent) × Movement (2: flexion, extension) fixed-effects structure. As was the case with previous experiments, we will not focus on exploratory MovT analyses here, because we had no specific predictions (see footnote 5 for Experiment 4 MovT results summary; MovTs were analyzed using the same methods as RelTs).

Here, we observed similar results to Experiment 2. We did *not* detect any evidence for a Fluency × Movement interaction, $F(1, 72.62) < .01$, *ns*. Our analysis only yielded a main effect of Movement, $F(1, 73.05) = 4.82$, $p = .03$, $d_Z = 0.36$, which showed that subjects initiated flexion movements faster than extension movements (Figure 7).

Liking judgments. Liking judgments were analyzed with the same methods as Experiments 1, 2, and 3, using mixed-effects modeling. Crucially, we replicated the fluency main effect from the three previous experiments, $F(1, 37.10) = 13.15$, $p < .001$, $d_Z = 0.60$, where subjects reported greater liking for fluent ($M = 2.53$, $SD = .75$) compared with disfluent ($M = 2.36$, $SD = .74$) pseudowords (Figure 7).

Classification decisions. Similar to previous experiments, we analyzed classification decisions (“living” or “nonliving”) using mixed-effects modeling. Here, we did observe a main effect of fluency, $F(1, 3663.10) = 7.57$, $p < .01$, $d_Z = 0.45$, which showed that participants were more likely to categorize fluent pseudowords as “nonliving,” compared with disfluent pseudowords. Furthermore, as with the previous three experiments, we also evaluated whether or not participants were more likely to just classify the pseudowords as “living” or “nonliving” overall, by testing subjects’ mean proportions against a 50% chance level (0 = “nonliving”; 1 = “living”). Similar to Experiment 2, this test was significant, $t(36) = 7.33$, $p < .001$, $d_Z = 1.21$, demonstrating that generally, participants were more likely to classify the pseudowords as “nonliving” over “living” (Table 4).

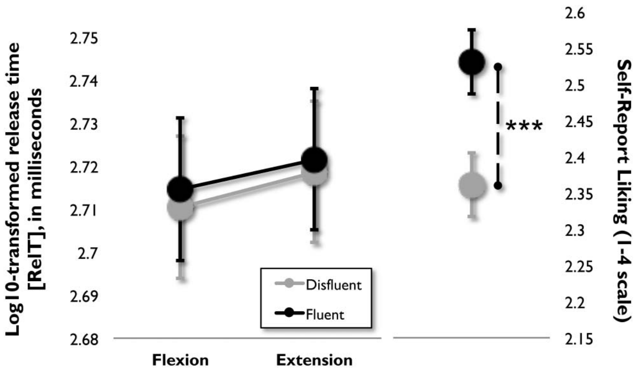

Figure 7. Similar to Experiment 2, we did not observe any interactive effects for release times (RelTs) in Experiment 4 (left panel). Also, as was the case with the previous three experiments, participants reported greater overall liking for fluent compared with disfluent pseudowords. Error bars represent ± 1 *SEM* (*** $p < .001$; ** $p < .001$; * $p < .05$; † $p < .10$).

fEMG. We assessed subjects’ fEMG data with the same preprocessing steps and analysis methods as Experiment 3, using mixed-effects modeling according to a Fluency (2: fluent, disfluent) × Muscle (2: corrugator, zygomaticus) × Time (10: 500 ms to 5,000 ms [in 500-ms groups]) fixed-effects structure.

Intriguingly, even though we did not detect any RelT effects (similar to Experiment 2), we *did* observe a similar pattern of fEMG effects as Experiment 3. Specifically, we saw a Fluency × Muscle interaction, $F(1, 72.32) = 4.55$, $p = .04$, where subjects exhibited less corrugator (frowning) muscle reactivity to fluent compared with disfluent pseudowords, $b = .04$, $t = 2.43$, $p = .02$, $d_Z = 0.40$. We also observed a similar pattern of zygomaticus activation as Experiment 3, with increased smiling to fluent compared with disfluent pseudowords, but this effect did not reach the level of significance, $b = .01$, $t = .56$, *ns,* $d_Z = 0.09$ (Figure 8).

Note also that the temporal dynamics of muscle activation was similar to Experiment 3, resulting in a similar Muscle x Time interaction, $F(9, 332.87) = 5.25$, $p < .001$. As shown in Figure 8, the corrugator peaked early at approximately 500 ms (probably an orienting response), while the zygomaticus peaked later at around 1,500 ms. Crucially though, fluency condition influenced the physiological measure of affect early in the trial.

General Discussion

In summary, the current research discovered a link between perceptual fluency and approach action. Experiments 1 and 3 found faster RelTs to initiate arm flexion to fluent stimuli. This effect occurred with actions that were rapid (Experiment 1) or delayed (Experiment 3) and was primarily observed in faster initiation of arm flexion to fluent stimuli, but not arm extension to disfluent stimuli. It is important that the fluency-flexion link required embedding the action within affective classification decisions and was absent in Experiments 2 and 4—which used the same action for nonaffective classification decisions. This is rather interesting, given that in all four experiments, fluency robustly enhanced self-reported liking ratings. We also found that fluency elicits early, spontaneous affective responses that are detectable on the physiological level using fEMG (i.e., increased smiling activity and reduced frowning activity; Experiments 3 and 4). These fEMG effects occurred across *both* affective and nonaffective decision contexts, before participants made any overt liking judgments. Finally, all these effects emerged without participants reporting a connection between fluency, movement, and affect.

Our findings suggest that, within a context of affective decision, perceptual fluency influences action-tendencies. This influence occurred particularly with respect to action-readiness, as suggested by the impact on RelT (Frijda, 2010)—which was particularly pronounced for flexion (i.e., associated with approach in our paradigm; Rotteveel & Phaf, 2004). To our knowledge, this is the

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[5] We did not observe any significant main effects or interactions on Experiment 4 MovTs. Outliers (greater or less than 3 SDs from each individual subject’s total average MovT) constituted 2.03% of all trials, which were removed before $\log_{10}$-transforming the remaining valid MovTs.

Table 4

Percentage of Classification Decisions According to Fluency (Fluent vs. Disfluent), Classification ("Living" vs. "Nonliving"), and Movement (Flexion vs. Extension) for Experiment 4

		Movement		
Fluency	Classification	Flexion	Extension	Total
Disfluent	"Living"	10.38	9.65	20.03
	"Nonliving"	15.35	14.62	29.97
Fluent	"Living"	7.73	10.19	17.92
	"Nonliving"	14.81	17.27	32.08
	Total	48.27	51.73	100.00

Note. We observed a main effect of fluency on the binary classification decision ("living or nonliving"), which demonstrated that subjects made more "nonliving" classifications when responding to fluent pseudowords. Overall, participants were more likely to classify the pseudowords as "nonliving" over "living." Note that the split between fluent and disfluent trials may not be exactly 50-50, given that a very small number of error trials did not record any AAT classification response (e.g., subjects releasing the "home" button before pseudoword onset).

first evidence for a link between fluency and approach behavior. Theoretically, this finding suggests an important revision to current fluency models, highlighting its previously neglected consequences for motivation-relevant action (Winkielman et al., 2003). This is particularly interesting given that our pseudoword stimuli were initially neutral and low in arousal. As such, our findings suggest that, at least under certain conditions, perceptual fluency can modify the valence of the stimulus with enough strength and duration (Experiment 3) to make it function like an intrinsically valenced stimulus (such as an emotional word or an emotional facial expression). Keep in mind, however, that our study did not directly compare different types of stimuli and manipulations; thus, future research may assess the relative size of the action effect elicited by fluency and other valence sources.

Our findings are consistent with earlier reports that the mere-exposure effect is related to neural indices of individual differences in approach motivation (Harmon-Jones & Allen, 2001). Because the mere-exposure effect involves both fluency and familiarity, future studies may explore the relative role of these closely related factors in the respective neural effects and consequences for action. Interestingly, because our study used completely unfamiliar pseudowords, it suggests that relatively "pure" enhancements of stimulus fluency (without familiarity) are sufficient to influence approach action.

It is worth acknowledging that our predictions, methods, and discussions of the results assumed that arm flexion indicates approach. This is consistent with other work using this particular button-tower paradigm (see Phaf et al., 2014). However, note that our main claim is about a link between fluency and approach, which in this specific paradigm manifests as a link between fluency and arm flexion. Future studies may examine whether similar results would be obtained with different approach-avoidance paradigms (for a review, see Krieglmeyer et al., 2013) or even with different framings of the same movement (e.g., framing extension as approach, as in reaching out to pet a cute animal; see Seibt, Neumann, Nussinson, & Strack, 2008).

A related theoretical issue is the potential role of response labeling in these effects—or the idea that action is facilitated by the match between stimulus valence and the evaluative meaning of the response labels that are used in the task instructions (Eder & Rothermund, 2008). Basically, an action to fluent (and thus, more positive) stimuli could be initiated faster when the action is paired with a more positive label, such as a "top button" (involving arm flexion) as opposed to a "bottom button" (involving arm extension). However, this account would need to explain several features of our data. First, this alternative "affective response mapping" account is well suited to explain the connection between clearly valenced stimuli (positive and negative pictures or words) and clearly valenced response labels. However, in our paradigm, the stimuli (pseudowords) do not have any intrinsic valence—their new and temporary value derives from fluency. As such, the affective-mapping account would need to clarify how such newly acquired value gets mapped onto affective responses. Second, it is not clear on this alternative account why the fluency-flexion effect only occurred with actions embedded in evaluative decisions ("good" vs. "bad"), but not with actions involving nonaffective

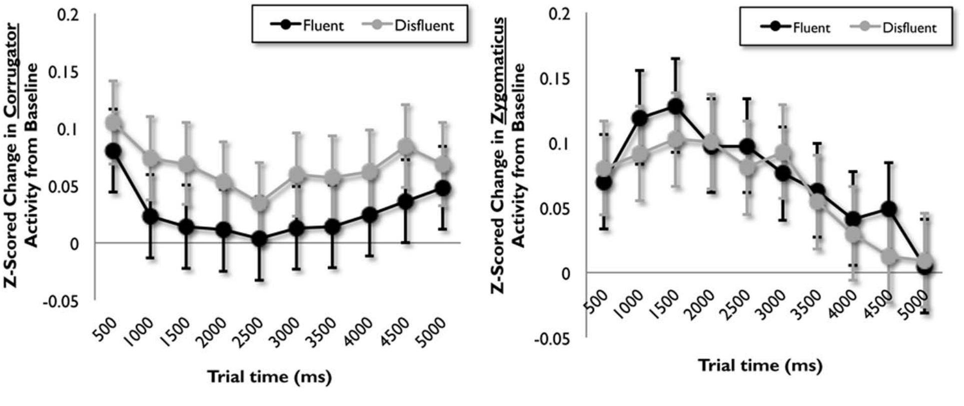

Figure 8. As with Experiment 3, we measured facial electromyography (fEMG) over the corrugator (left panel) and zygomaticus (right panel) muscles in Experiment 4. A Fluency × Muscle interaction indicated that participants recruited more corrugator (frowning) activation in response to disfluent pseudowords. While subjects also recruited more zygomaticus (smiling) activation in response to fluent pseudowords, this effect did not quite reach the level of significance. Error bars represent ± 1 *SEM*.

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classification (“living” vs. “non-living”). After all, in all experiments, the response buttons were labeled “top” and “bottom,” and fluent stimuli were still positive—as observed with positive fEMG responses and higher liking judgments (Experiment 4). Third, and perhaps most problematically for the affective-response mapping account, our facilitation effects were preferentially obtained on arm flexion to fluent stimuli, but not arm extension to disfluent stimuli. Nevertheless, future research should test our preferred motivational-direction versus the alternative response-labeling explanations of these action effects by, for example, reassigning button labels to the opposite response direction (i.e., labeling the “top” and “bottom” buttons as the “bottom-facing button” and “top-facing button,” respectively). Critically, however, note that our core conclusions about the ability of fluency to influence action embedded in an affective context do not hinge on this particular debate.

As mentioned, in Experiments 2 and 4, when the classification decision was embedded in *non*-affective decisions (“living” or “non-living”), fluency had no effects on the speed of flexion or extension action. Fluency also only clearly influenced affective decisions (“good” vs. “bad”), since it increased the likelihood of classifying a pseudoword as “good” over “bad” in Experiments 1 and 3 (with no consistent effects on nonaffective decisions [“living” vs. “non-living”] in Experiments 2 and 4). It is important that the absence of the fluency effect on nonaffective decisions is unlikely to be driven by a floor effect, given the relatively similar proportions of “good/bad” decisions and “living/nonliving” decisions across experiments (Tables 1–4). Furthermore, fluency effects on liking ratings and physiological indices of positive affect were obtained across *both* affective and nonaffective contexts of the initial classification decision.

These differences in the impact of fluency, as a function of action context and measure, are interesting for a number of reasons. First, they demonstrate the power of context in shaping the emergence of valence-action links. This is consistent with previous reports showing that action effects using even strong, intrinsically valenced stimuli (e.g., happy and angry faces) require embedding the action in an affective decision (Rotteveel & Phaf, 2004). Second, they are consistent with proposals that even genuinely “liked” stimuli require a particular context to facilitate motivated behaviors, presumably indicative of “wanting” (Winkielman & Berridge, 2003). This is especially clear when considering the RelT and fEMG findings from Experiments 3 and 4. We found similar patterns of zygomaticus and corrugator fEMG, regardless of the initial classification task, indicating genuine liking for the fluent stimulus. Yet, the effects on action initiation (RelTs) only emerged during the affective classification task. Overall, these findings suggest that fluency instantiates a low-level hedonic response across multiple contexts, but this affective response is only selectively translated to action-tendency based on the relevance to the task at-hand (i.e., ones that require emotionally based judgments). Still, we hesitate to make any claims about an unconditional link between fluency and valence, since all four experiments involved a self-report of liking at the end. Future experiments may test whether fluency effects on fEMG emerge even in the absence of any consideration for the affective nature of the stimulus. This is indeed a difficult question, as nonaffective judgments or classification tasks can serve as potential distractors from the affective nature of stimuli and can disturb even stronger effects (e.g., Pessoa, McKenna, Gutierrez, & Ungerleider, 2002).

Regardless, in the current paradigm, the psychophysiological findings (fEMG; Experiments 3 and 4) suggest that the basic hedonic response to fluency arises quickly, prior to any overt judgment. This response usually has primarily a positive component, as revealed via increased zygomaticus (smiling) activity to fluent stimuli, for instance (Winkielman & Cacioppo, 2001). It is interesting that this positive skew was evident in the RelT results during Experiment 3 (i.e., fluency was associated with faster approach RelTs, but *dis*fluency was not connected to quicker extension RelTs). At the same time, Experiment 4 (which found no RelT effects) observed more robust fEMG responses on the corrugator (frowning), with fluent pseudowords significantly *reducing* corrugator reactivity (zygomaticus reactivity in response to fluent vs. disfluent pseudowords was not quite significant, but in the predicted direction). While many studies have demonstrated increased zygomaticus (smiling) activity to fluent stimuli (Winkielman & Cacioppo, 2001), other studies with fluency manipulated via semantic coherence have reported effects on the corrugator, which likely arise from reduced negative affect and relaxed mental effort (Topolinski, Likowski, Weyers, & Strack, 2009). Again, future studies may further explore these differences.

Finally, it is worth highlighting some general connections of the current work to other research on the links between fluency, action, and affect. Several labs have shown that easier actions (either because of practice, priming, or compatibility) elicit more positive responses, even to unrelated stimuli (Beilock & Holt, 2007; Brouillet, Ferrier, Grosselin, & Brouillet, 2011; Cannon et al., 2010). Our work is clearly different in that we manipulated the ease of perception (not the ease of action) and measured the relative speed of specific actions related to approach (flexion) versus avoidance (extension). Considering this, both lines of research point to the affective nature of the links between fluency of perception and fluency of action. More generally, these areas of research emphasize the fundamental connection between the dynamics of mental processes and the embodied, action-based nature of emotion (Winkielman, Niedenthal, Wielgosz, Eelen, & Kavanagh, 2015).

In conclusion, we provided the first evidence of a link between processing fluency and approach-related action. These results reveal that high fluency is linked to faster initiation of flexion movements—a novel demonstration that smoothness of perceptual processing shapes motor responding within the environment.

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