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When My Actions Shape Your Looks: Experience-Based Properties of Approach/Avoidance Bias the Visual Representation of Others

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The literature on the approach/avoidance training (AAT) effect has focused on its evaluative consequences (with approached stimuli evaluated as more positive than avoided ones). Building on a grounded cognition framework, we investigated AAT effects on the visual representation of stimuli (here, neutral faces). We formulated specific predictions regarding the facial features that should be the most biased and the conditions under which the effect should be the strongest. We tested these predictions in five preregistered experiments using a reverse correlation paradigm. In Experiments 1–2, the facial representations resulting from an AAT looked more "approachable" and "avoidable," respectively. Specifically, we observed more bias on facial traits related to approach/avoidance (e.g., trustworthiness) than on traits less relevant for these actions (e.g., cleverness). Experiment 2 additionally tested the unique contribution of both approach and avoidance as compared to control actions. Experiments 3A–4 showed that this effect depends on experiencing the AAT (compared to the mere instructions of approach/avoidance) and on the sensory aspects of approach/avoidance that are mimicked in the AAT. Finally, Experiment 5 supported the idea that the AAT effect still emerges in the absence of explicit instructions of approach/avoidance (i.e., by only leaving the sensory aspects of approach/avoidance). The present research enriches the literature by revealing AAT effects that extend beyond mere evaluative consequences to the visual representation of the target stimuli. Our results also inform existing theoretical views on AAT effects.

Keywords: approach/avoidance training, VAAST, face representation, reverse correlation, grounded cognition

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Approach and avoidance behaviors stand among the most adaptive reactions for survival and are strongly linked to beneficial (i.e., approach) or threatening (i.e., avoidance) perceptions of the environment. Although it is notorious that positive and negative evaluations potentiate approach and avoidance tendencies, respectively (Chen & Bargh, 1999; Solarz, 1960), there is also evidence for the reverse effect of action on evaluation. Training individuals to approach/avoid stimuli influences their evaluation, with approach actions fostering a more positive evaluation as compared to avoidance (Cacioppo et al., 1993). Relying on a grounded cognition framework, we investigated another consequence of the approach/avoidance training (AAT), namely its influence on the multimodal—here, visual—representation of stimuli (Barsalou, 1999, 2008; Damasio, 1989; Versace et al., 2014). Specifically, we propose that an AAT toward neutral faces should distort the visual representation of the approached/avoided groups of faces, as measured by a reverse correlation paradigm (Dotsch & Todorov, 2012). Beyond predicting an AAT effect on face representation, a grounded cognition approach also comes with two other crucial predictions. First, it predicts that the facial distortion should mostly emerge on the physical features that are routinely associated with approach/avoidance, ultimately making the faces look more approachable or avoidable (Experiments 1 and 2). Second, this effect should be the largest when the experiential and sensory properties of approach/avoidance actions—that is, enacting approach/avoidance actions together with the sensory feedback generally associated to them—are implemented in the AAT (Experiments 3A–5).

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Approach/Avoidance Training in Current Explanations

There is clear empirical evidence for a strong bidirectional link between approach/avoidance actions and positive/negative evaluations. Approach/avoidance paradigms sometimes served as a measure of evaluations (Paladino & Castelli, 2008) and sometimes as a training tool to create or to modify evaluations (Cacioppo et al., 1993; Kawakami et al., 2007). For instance, approaching African American faces by pulling a joystick and avoiding European American faces by pushing back a joystick led to more positive evaluations of the former than the latter (Experiments 1–3) and increased immediacy behaviors toward an African American confederate (Experiment 4), as compared to the reverse configuration (Kawakami et al., 2007).

Earlier work reveals AAT effects across various types of stimuli, such as unknown (Cacioppo et al., 1993; Laham et al., 2014; Van Dessel et al., 2015, Van Dessel, De Houwer, Gast, et al., 2016), social (Phills et al., 2011; Woud, Becker, et al., 2013; Woud, Maas, et al., 2013), addiction-related (alcohol, Wiers et al., 2010; tobacco, Wittekind et al., 2015), food-related (Becker et al., 2015), and pathology-related stimuli (phobia, Jones et al., 2013; social anxiety, Rinck et al., 2013; Taylor & Amir, 2012). Moreover, consequences of AATs on evaluation have also been shown on various direct or indirect measures (evaluative priming task, Fazio et al., 1995; Implicit Association Test, Greenwald et al., 1998; self-report—see also investigations on behavioral consequences—Kawakami et al., 2007; Wiers et al., 2010). Recent work even revealed that AAT effects also show on specific attributes of the approached/avoided stimuli (color) such that these attributes acquire an evaluative meaning (Hütter & Genschow, 2019). Alongside other kinds of paradigms (e.g., evaluative conditioning; Baeyens et al., 1992), AATs thus seem to be promising tools to create or change evaluations.

At the theoretical level, researchers traditionally interpret AAT effects through the prism of associative learning—although several associative subexplanations coexist in the literature (operant evaluative conditioning effect, Woud et al., 2008; common-coding account, Eder & Klauer, 2009; self-anchoring account, Phills et al., 2011; motivational-systems accounts, Neumann & Strack, 2000). According to this general view, AAT effects result from the repeated association between approach/avoidance actions and categories of stimuli. Given that approach is positively valenced and avoidance is negatively valenced, the coactivation of the mental representations—that of the stimulus and that of the evaluative components of approach/avoidance actions—automatically derives in a change of stimulus evaluation (Kawakami et al., 2007).

Recent results, however, question this traditional view. For instance, AAT effects do not seem to be automatic (Van Dessel, De Houwer, Roets, & Gast, 2016), can be produced without repeated associations between approach/avoidance (Hütter & Genschow, 2019; Van Dessel et al., 2015), and depend on the awareness of stimulus-action contingencies (Van Dessel, De Houwer, & Gast, 2016; see also Van Dessel, De Houwer, & Smith, 2018). Van Dessel et al. (2019) theorized that AAT effects rely on inferential processes resting on the propositional relations between stimuli and approach/avoidance actions (see also Corneille & Stahl, 2019; De Houwer, 2009, 2014).[1] Specifically, previous knowledge about approach/avoidance actions ("I generally approach positive things") mixed with propositional information related to the instructions ("I have to approach Stimulus A"/"I approached Stimulus A") would be responsible of the typical evaluative bias on the to-be-approached (more positive) and to-be-avoided stimuli (more negative).

Interestingly, both the associative and propositional approach predict that the evaluative connotation of approach (positive) and avoidance (negative) drives AAT effects. It is therefore not surprising that researchers primarily focused on whether the stimulus will become more positive (negative) after being approached (avoided). Also, neither an associative nor a propositional approach allow deriving clear-cut predictions regarding AAT effects on other aspects of a stimulus, such as its visual representation (i.e., the internal image about how the stimulus should look like). Interestingly, however, such predictions follow in a rather straightforward manner from a parallel theoretical approach of memory, the so-called grounded cognition approach (Barsalou, 1999, 2008; Damasio, 1989; Versace et al., 2014).

Although a grounded cognition approach does not stand in sharp opposition to an associative or a propositional view (Barsalou, Simmons, et al., 2003; De Houwer, 2014), it specifically emphasizes the role of sensorimotor processes in memory and cognition. Crucially for our purpose, a grounded cognition approach allows for fine-grained predictions regarding the nature of the biased representation that would result from an AAT and the conditions under which AAT effects should be most likely to emerge.

Multimodal Aspects of Face Representation

According to a grounded cognition framework, the activations within the various sensorimotor modalities (visual, auditory, olfactory, motor, etc.) resulting from past interactions with stimuli end up encoded in memory (Barsalou, 2008; Niedenthal, 2007). Presumably, these activations then contribute to the generation of a multimodal representation such that the representation contains the most prototypical activation of each modality involved during the interaction (Barsalou, 1999; Barsalou, Niedenthal, et al., 2003; Niedenthal, 2007; Niedenthal et al., 2005; Versace et al., 2014). These multimodal representations can code for various concepts such as objects, persons, emotions, social categories, behaviors, and so forth. Importantly, multimodal representations would contain the sensorimotor information pertaining to both perception and action (Barsalou, 2008; Niedenthal, 2007). For instance, the multimodal representation of threatening people should contain sensorimotor information about how a threatening face generally looks like but also about how we generally react (e.g., avoidance). In the same vein, the multimodal representation of avoidance actions should contain sensorimotor aspects pertaining to the action itself (e.g., visual information of moving backward) and to what is generally avoided.

Multimodal representations are reactivated from memory based on their similarity with the present sensorimotor activity: The higher the similarity, the stronger the reactivation of multimodal representations. To form an integrated piece of knowledge, multimodal components within a representation would be strongly integrated such that activating one multimodal component (e.g., the visual aspects of threatening people) should also reactivate the other components of the representation (e.g., avoidance reaction; Versace et al., 2014). This idea is consistent with the well-known "compatibility effect": Displaying the perceptual aspects of a stimulus reactivates the associated reaction and facilitates the corresponding action in an approach/avoidance task (Chen & Bargh, 1999; Slepian et al., 2012). This idea also has implications in the

[1] In a similar vein, Hütter and Genschow (2019) recently proposed to interpret AAT effects with the self-perception theory (Bem, 1972). Consistently, they found AAT effects only when participants performed (or imagined performing) approach/avoidance actions. Yet their effort remains the only one adopting this perspective and, as Hütter and Genschow (2019) acknowledged, their findings are consistent with an inferential account. Accordingly, we will not develop this account and will rather focus on the associative and inferential accounts.

case of AAT effects: Performing approach and avoidance actions in an AAT should reactivate their respective multimodal representations and the perception generally associated as facial information. In the case of approach, this should likely be an approachable face (e.g., a trustworthy, friendly face) and, in the case of avoidance, an avoidable face (e.g., a threatening, angry face).

Crucially for the present work, this past perception of approach/avoidance reactivated from memory could distort how perceivers encode the current perception. Indeed, as suggested by some grounded cognition models (e.g., MINERVA II, Hintzman, 1984; Act-In, Versace et al., 2014), perceptual and memory mechanisms operate simultaneously within the same memory system. This means that the multimodal representation of *past* sensorimotor activity triggered by the *present* sensorimotor activation will overlay in the same areas of the memory system. These two activations will then combine as a unit and will be reinjected in the memory system for later reemergence (see Rey et al., 2015). This new encoded information is thus partly objective (i.e., reflects the reality of the environment) and subjective (i.e., builds on past multimodal representations of approach and avoidance). The subjectivity thus depends on the personal traces of past similar experience or knowledge of approach and avoidance. Accordingly, we expect that when approaching or avoiding neutral faces, the ongoing actions will reactivate the visual information generally associated with approach/avoidance (i.e., the physical traits that relate to the approachability/avoidability of a person), ultimately influencing the way the neutral faces are represented in memory.

Grounded cognition models do not only suggest a main AAT effect on visual representations. They also have two significant implications regarding (a) the specific effects on the visual representations we should expect and (b) the characteristics of the AAT that should moderate the emergence of this effect.

Implications of Multimodal Representations for Approach/Avoidance Trainings

A first implication of multimodal representations is that the visual representation of the approached/avoided groups should become not only more pleasant or unpleasant (i.e., evaluative consequences) but also more approachable or avoidable. In other words, there should be more bias on facial features that specifically relate to these actions. It should be the case because this visual information initiated approach/avoidance actions in the first place. Past research on approach/avoidance compatibility effects can thus help determine the kind of physical traits that prove sensitive to approach/avoidance actions.

Approach/avoidance generally emerges as a function of the pleasantness of emotions (e.g., happy/angry) or personality traits (e.g., trustworthiness/aggressiveness; Oosterhof & Todorov, 2008; Rotteveel & Phaf, 2004; Slepian et al., 2012). For instance, individuals are faster to approach trustworthy faces and to avoid untrustworthy faces rather than the reverse (Slepian et al., 2012). Having said this, some pleasant/unpleasant traits activate approach/avoidance more than other traits, depending on their "relevance." A first category of traits called "possessor relevant" carry unconditional positive/negative consequences for the trait holder (e.g., intelligent, depressed).[2] These traits relate to the competence/agency dimension because they favor self-interest in denoting the ability or motivation to carry out goals (for a review, see Abele et al., 2020). A second category, the "other-relevant" traits, carry unconditional consequences for others living or interacting with the trait holder (e.g., generous, aggressive; Peeters, 1983). These traits relate to the warmth/communion dimension because they pertain to the nature of the relationship with others (Abele et al., 2020). Because the other-relevant traits signal a clear behavioral disposition/intention on the part of the trait holder, they inform on how perceivers should behave toward the target (Beauvois & Dubois, 2000). For instance, other-relevant traits signal that we can trust (generous) or should be wary of (aggressive) the trait holder.[3] Clearly, positive/negative other-relevant traits should be more relevant to behavioral reactions, such as approach and avoidance, than positive/negative possessor-relevant traits (Peeters et al., 2003).

The impact of possessor- and other-relevant traits on approach/avoidance has been shown in self-report measures of approach/avoidance (Ric et al., 2013) and in approach/avoidance tasks (Wentura et al., 2000). For instance, Wentura et al. (2000) found a compatibility effect as a function of the positive/negative connotation of traits but also as a function of their relevance (but see Degner et al., 2021): The compatibility of approach/avoidance toward positive/negative traits (faster response times to approach positive and to avoid negative traits than the reverse) was larger for other-relevant than possessor-relevant traits, that is, for stimuli having potential consequences for oneself.

Because the multimodal representation of approach and avoidance should contain (facial) features coding for the other-relevance information, the AAT should produce a larger face distortion on other-relevant traits, such as trustworthiness or friendliness, than on possessor-relevant traits, such as intelligence or laziness (see Wentura et al., 2000). To our knowledge, no research to date has examined this possibility. Such a pattern would suggest that the perception associated with approach/avoidance, and reactivated by the AAT, spontaneously biases the representation of the approached/avoided faces.

A second implication of multimodal representations is that the AAT effect on face representation should rely on the experiential and sensorimotor properties implemented in the training. Indeed, the AAT effect would depend on the extent to which the multimodal representations of approach and avoidance are activated in memory. As explained earlier, greater similarity between the current sensorimotor activation (i.e., in the AAT) and the one in the multimodal representation should induce more reactivation. Experiencing the sensorimotor activity that is the most prototypical of approach/avoidance behaviors should thus play a central role in producing AAT effects—in our case, a biased representation.

According to Rougier et al. (2018), the visual aspects associated with whole-body movements, that is, the visual impression of moving forward/backward, constitute the sensory(motor)

[2] We use the labels possessor/other-relevant instead of self/other-profitable that were originally proposed by Peeters (1983). Indeed, as suggested in Wentura et al. (2000), the term "profitability" can be confusing given that negative traits (e.g., depressed) are not profitable.

[3] Although possessor- and other-relevant traits should *most of the time* carry consequences that are more relevant for the possessor versus for others, respectively, the relevance aspect of a trait should still be context dependent. For instance, even if intelligence is possessor-relevant, it should become more desirable for those people interacting with the possessor in the case of outcome dependency (Abele & Wojciszke, 2007; Carrier et al., 2019; Wojciszke & Abele, 2008).

information most prototypical of approach/avoidance. Forward/backward movements unequivocally evoke approach/avoidance actions, which is not the case for all approach/avoidance action (e.g., arm movements of flexion/extension; Seibt et al., 2008). Moreover, the visual modality is more prevalent than the other modalities (e.g., Nørretranders, 1998) and can override the motor information (Rinck & Becker, 2007). In line with their reasoning, these authors created an approach/avoidance task reproducing these visual aspects (i.e., the Visual Approach/Avoidance by the Self Task [VAAST]). In an experiment contrasting the visual with the semantic aspects of approach/avoidance, the visual component alone (i.e., without any mention of approach/avoidance in the instructions) sufficed to produce a compatibility effect (Rougier et al., 2018, Experiment 6). This work established the key role of the sensory (here, visual) aspects in reactivating approach/avoidance tendencies from memory. Applying the same reasoning to AAT effects leads to predict that the core aspects of approach/avoidance (i.e., the experience of the action and the sensory features of these actions) should also be central in producing AAT effects on visual representation. As it turns out, empirical results on this matter are mixed.

Regarding AAT effects on evaluation, some empirical work suggests that the motor aspects of approach/avoidance are sufficient to change the evaluation of stimuli (Cacioppo et al., 1993; Kawakami et al., 2007; Phills et al., 2011; Priester et al., 1996; Slepian et al., 2012). For instance, Kawakami et al. (2007, Experiment 3) found an AAT effect independent of any semantic information and by implementing only the motor aspects of approach/avoidance actions (here, pulling/pushing a joystick toward African American/European American faces). In contrast, across six experiments, Nuel et al. (2019) failed to produce AAT effects with various operationalization of approach/avoidance relying on their sensorimotor features (e.g., body posture, walking). Similarly, other authors showed that performing an AAT does not have any additional effect compared to the mere instructions of approach/avoidance (Smith et al., 2019; Van Dessel, De Houwer, Gast, et al., 2016). Overall, the importance of the sensorimotor components and of experiencing approach/avoidance actions (i.e., in comparison with having the mere instructions of approach/avoidance) remains unclear.

Still, the fact that AAT experiments relied on nonprototypical/too subtle sensory information (Nuel et al., 2019; Van Dessel, De Houwer, Gast, et al., 2016) or on more symbolic approach/avoidance actions (Smith et al., 2019) may account for these inconsistencies. If the visual information associated with moving forward/backward is the most prototypical of approach/avoidance, this information should be of great importance in producing AAT effects. Accordingly, when using a task maximizing these prototypical visual aspects, both experiential and sensory information should have unique contribution in the emergence of AAT effects.

To summarize, the present work's primary aim was to test whether approach/avoidance actions shape the facial representation of others. We adopted a grounded cognition perspective and tested two specific predictions deriving from this view: whether an AAT specifically biases the visual representations on approach/avoidance-related (i.e., other-relevant) traits and whether the AAT effect depends on the experiential and sensory aspects of approach/avoidance during the training. To do so, we relied on a set of promising tools to assess the face representation and to manipulate the core aspects of approach/avoidance actions.

Assessing the AAT Effect on Face Representation

A noteworthy limitation of previous studies on AAT effects is that they relied on constrained measurements—that is, measures with preestablished sets of responses. For instance, participants may be asked to rate a face on predefined scales (Hütter & Genschow, 2019; Slepian et al., 2012; Woud et al., 2013) or to categorize faces by using predefined response labels (e.g., positive vs. negative; Van Dessel et al., 2015; Woud et al., 2013). Both methods constrain the projection of AAT effects instead of letting participants select their own criteria of interest, which can strongly influence the results (Michalak & Ackerman, 2020). A major contribution of the present research is to rely on an unconstrained measure, namely the reverse correlation paradigm (also called the "classification image technique"; Dotsch & Todorov, 2012; Dotsch et al., 2008; Mangini & Biederman, 2004) to capture people's facial representation of a social target. Specifically, this data-driven method does not draw any prior assumption on how the representation may look like (Dotsch & Todorov, 2012).

In a typical reverse correlation paradigm, participants see two noisy faces (i.e., faces with superimposed random noise) and have to choose which one best matches the to-be-measured representation (e.g., "Which one is the most Moroccan-looking face?"; Dotsch et al., 2008). A key aspect is that the pattern of noise randomly applied on the face can slightly distort the face so that it approaches, by chance alone, the participants' internal image (Brinkman et al., 2017). By capitalizing on a large number of trials, it is possible to obtain the visual outcome (also known as a "classification image" or CI) produced by participants or a sample of participants (i.e., the average noise of all the selected faces). The CIs thus constitute a proxy to "internal representations that determine how social stimuli are perceived" (Brinkman et al., 2017, p. 352). The first advantage of this method is that participants' responses are not constrained in any direction (e.g., with labeled response options), allowing individuals to spontaneously use any criteria of interest to select the face. The second advantage is that this technique can capture a complex mixture of traits (e.g., intelligent, trustworthy) or even specific features that may be ineffable to the participant (Mangini & Biederman, 2004).

The reverse correlation paradigm has proven very efficient in measuring evaluative biases on face representation (e.g., Dotsch et al., 2008, 2011, 2013; Imhoff et al., 2013; Ratner et al., 2014; Schmitz & Yzerbyt, 2020; Young et al., 2014). For instance, when participants had to select the most Moroccan-looking face, the average face resulting from the reverse correlation procedure came across (as assessed by independent judges) as being more negative as participants' prejudice proved stronger (Dotsch et al., 2008, 2011). Importantly, the reverse correlation method also captures information that goes beyond the mere valence dimension (e.g., Dotsch et al., 2011). Dotsch et al. (2011) showed that selecting a Moroccan-looking face led to more negative stereotype-relevant traits (i.e., criminal-looking face) but did not contain stereotype-irrelevant traits of the same valence (i.e., stupid-looking face). In our case, it should be possible to capture facial traits spontaneously reactivated by the AAT, that is, traits that we expect to be relevant for approach/avoidance actions (i.e., other relevant).

The approach/avoidance tasks used in the AAT literature, such as the manikin task (De Houwer et al., 2001) or the joystick task (Rinck & Becker, 2007), fail to reproduce the core sensorimotor aspects of approach/avoidance actions. First, because the manikin task relies on symbolic approach/avoidance actions (i.e., moving a small character toward or away from words), this task does not involve the sensorimotor aspects of approach/avoidance actions. Second, a task implementing arm movements, like the joystick task (e.g., Rinck & Becker, 2007), does not reproduce the relevant sensorimotor aspects of approach/avoidance because arm flexion/extension are ambiguous regarding their relationship with approach/avoidance actions. Indeed, arm flexion can represent approach (bringing a cake to the self) or avoidance (removing one's hand from a spider), and the same ambiguity holds for arm extension (e.g., Markman & Brendl, 2005; Seibt et al., 2008). In sharp contrast, a forward/backward movement of the entire body constitutes a more prototypical experience of approach/avoidance because (a) these movements are not ambiguous regarding approach/avoidance (i.e., moving forward = approach; moving backward = avoidance) but also because (b) they can occur in almost every situation (e.g., approaching a car), compared to arm movements (Rougier et al., 2018).

In light of this, we decided to use the VAAST because this task reproduces the visual impression of the whole self moving forward or backward. To the extent that the VAAST is a powerful tool in producing large compatibility effects (see Rougier et al., 2018), we would expect this also to be the case when it comes to manipulating approach/avoidance actions, that is, when the VAAST is used as an AAT (see Batailler et al., 2021).

The Current Research

We aimed to investigate the effect of approach/avoidance actions on facial representations. Building on a grounded cognition approach, we derived two predictions about the facial features that should be influenced and the experiential and sensory moderators of this effect. Empirical evidence for such effects would greatly contribute to the approach/avoidance literature. First, it would provide evidence that AAT effects go beyond evaluative consequences and spontaneously apply to face representations. Second, it would suggest that a grounded cognition approach has some predictive power in forecasting the moderators of AAT effects on the visual representation.

In a first set of experiments (Experiments 1–2), we tested if an AAT built on the VAAST could bias facial representations in such a way that these representations embed relevant traits for approach/avoidance actions. In Experiment 1, we investigated if the AAT could lead to more approachable versus avoidable facial representations, that is, representations with facial features that carry more information related to other- than possessor-relevant traits. Experiment 2 aimed at replicating these results, additionally comparing approach and avoidance actions by the means of a control condition. In a second set of experiments (Experiments 3A–5), we investigated whether the core aspects of approach/avoidance actions were important in producing these biased representations. In Experiments 3A and 3B, we examined whether removing the experience of approach/avoidance action (but leaving the approach/avoidance instructions) led to a smaller effect on face representations. In Experiment 4, we tested whether the sensory aspects of approach/avoidance contributed to the emergence of AAT effects. Finally, in Experiment 5, we tested whether the AAT effect on the face representation still emerged when the explicit instructions of approach/avoidance were removed but when the sensory aspects of approach/avoidance were still present.

Open Practices, Power Estimations, Analytical Strategy, and Diversity of Samples

We preregistered all our experiments on Open Science Framework. Preregistrations include *a priori* theoretical reasoning, hypotheses, power estimations, procedures, and statistical analyses. The main document signals any major deviation from the initial preregistration, and a separate file reports minor deviations. The preregistration files, deviations from preregistrations file, materials, data, and data analyses (R scripts) for all experiments are available at the following link: https://urlz.fr/eGqm. This research project received approval from the local ethic committee (institutional board).

Regarding power estimations, all experiments except Experiment 3B required two independent power analyses: one for the participants who underwent the AAT and the reverse correlation task (hereafter "face creators") and one for the judges who rated the resulting CIs (hereafter "judges"). Chances to detect an effect (differences between CIs) depend on both samples. The higher the number of face producers in the first sample, the better the CIs' quality (i.e., the signal/noise ratio) and thus their "readability" for the judges. At the same time, the higher the number of judges, the higher the statistical power to detect differences between the CIs if any. We report our power estimations within each experiment.

Regarding our analytical strategy, we settled for the more conservative tests whenever our design allowed doing so—that is, ordinary least squares (OLS) regression analyses (Experiments 1 [Part 2a] and 3A–5) and/or mixed-model analyses (Experiments 1 [Part 2b], 2, 3B, 4, and 5). Furthermore, we tested for the potential effect of control factors (i.e., color background and block order) on our effects of interest depending on the level at which we computed the CIs (condition or individual level). Accordingly, we estimated the impact of these factors in Experiment 1 (condition-level effect) and 3A (individual-level effect). None of these analyses yielded significant effects—that is, from $t(140) = 1.47$, $p = .14$, $d = .12$, 95% CI [−0. 21, 1.46] to $t(70) = 1.64$, $p = .11$, $d = .19$, [−.28, 1.67] for the background color and from $t(70) = .03$, $p = .98$, $d = .01$, [−.48, .48] to $t(140) = 1.54$, $p = .12$, $d = .12$, [−0. 20, 0.46] for the block order. We thus excluded these control factors from the analyses presented in the remainder of this article.

Finally, although we had no theoretical reason to expect that the nature of our samples would moderate our effects, we aimed at diversifying them for generalizability purposes. We conducted two experiments in the lab (Experiments 3A and 4) relying on French-speaking undergraduate students from a Belgian university, thus a homogeneous and Western, educated, industrialized, rich, and democratic sample (Henrich et al., 2010; Rougier et al., 2019). In contrast, we conducted the other experiments online using a crowdsourcing platform (here, Prolific Academic; www.prolific.co). Relying on prescreening criteria available on Prolific Academic, we recruited U.S. participants speaking English as a first language (both because we used the American norms in English speaking), allowing us to reach naive participants (potentially) varying on age, gender, religion, and belonging to various ethnic and racial groups, social class, and so forth (Gleibs, 2017; Peer et al., 2017).

Experiment 1

The goal of Experiment 1 was twofold. First, we aimed at establishing the AAT effect on the visual representation of faces. By using the VAAST, we tested whether training individuals to repeatedly approach (vs. avoid) neutral faces belonging to novel groups (i.e., blue-background faces vs. yellow-background faces) influences the visual representation of each group's face, as measured by a reverse correlation procedure. In Part 1, we collected the visual representations (i.e., CIs resulting from the training) on a first sample of participants (i.e., the face creators). In Part 2a, we asked another sample of participants (i.e., the judges) to rate the CIs on a series of traits known to relate to approach/avoidance (i.e., other-relevant traits). We expected the CIs resulting from approach actions to be rated, on average, as more approachable than the CIs resulting from avoidance actions.

Second, we tested whether the CIs differed more on other-relevant traits than on possessor-relevant traits as the latter should be less related to approach/avoidance (for a similar reasoning with the evaluative vs. normative fit hypothesis; see Dotsch et al., 2011). We tested this hypothesis in Part 2b in which we asked another pool of judges to rate the CIs on other- and possessor-relevant groups of traits that were equivalent on the dimension of valence. To facilitate the understanding of our methodology and results, we describe Parts 1, 2a, and 2b in separate sections.

Method

Part 1: Creation of CIs Resulting From Approach Versus Avoidance Actions

Participants and Design. We planned our sample size of face creators relying on past AAT and reverse correlation effects with the aim to achieve enough power to detect an AAT effect in a reverse correlation paradigm. Regarding the AAT effect, we relied on the smallest effect size (d = .59) obtained in similar recent experiments (using instruction-based AATs on fictional groups; Van Dessel et al., 2015), and we thus estimated that we needed a minimum of 100 participants to achieve a power of 80%. Regarding reverse correlation effects, previous studies established that a sample size of 20 participants per condition-level CI suffices to derive reliable (i.e., readable) visual representations (Dotsch & Todorov, 2012; see also Oliveira, Garcia-Marques, & Dotsch, 2019). Clearly, our projected sample of 100 participants largely fulfilled the minimum criteria required for this technique.

A total of 110 Prolific Academic users (M_{age} = 35.73, SD_{age} = 13.52; 55 male)[4] took part in exchange for USD $3.22. In line with the preregistration criteria, we removed the data from 17 participants who had an error rate of 30% or greater in the VAAST training, leaving a sample of 93 participants (M_{age} = 35.16, SD_{age} = 13.37; 50 male). The experiment relied on a 2 (Movement: approach vs. avoidance) × 2 (Background Color: blue vs. yellow) × 2 (Group of Faces: Group 1 vs. Group 2) × 2 (Group Order in the Reverse Correlation: Group 1 first vs. Group 2 first) mixed design with the last control variable varying between participants.

For the approach/avoidance task, participants performed 192 trials with 16 faces (eight belonging to Group 1 and eight to Group 2) presented 12 times in a random order. All faces were White male faces selected from the CaNAFF face database (Courset et al., 2018). Following the information available in the CaNAFF database, we selected the faces to have homogeneous groups on several dimensions. Specifically, the two groups of faces did not differ significantly in terms of emotional neutrality (M_{gp1} = −.96, SD_{gp1} = 8.28; M_{gp2} = −2.56, SD_{gp2} = 7.99; scale ranging from −50 = *positive* to +50 = *negative*), $t(14)$ = 1.26, p = .23, d = .63, 95% CI [−.47, 1.73], approach/avoidance tendencies (M_{gp1} = 3.38, SD_{gp1} = 19.68; M_{gp2} = 2.48, SD_{gp2} = 21.97; −50 = *avoid* to +50 = *approach*), $t(14)$ = .46, p = .65, d = .23, [−.85, 1.30], and attractiveness (M_{gp1} = −10.91, SD_{gp1} =19.57; M_{gp2} = −10.90, SD_{gp2} = 18.85; −50 = *unattractive* to +50 = *attractive*), $t(14)$ = .001, p = .99, d = .29, [−1.07, 1.07]. In order to make the faces even more neutral, we slightly blurred them (Gaussian blur of 3.5 radius). We randomized the background color (blue vs. yellow) associated to the group (Group 1 vs. Group 2) and the instruction relative to the color (i.e., approach blue-background faces vs. avoid blue-background faces). For the reverse correlation task, participants performed two blocks of 200 trials each, with block order randomized across participants.

Procedure. We programmed the experiment on Psytoolkit (www.psytoolkit.org; Stoet, 2010, 2017) and administered it online (Prolific Academic platform). We recruited participants with an approval rate of 90% or more (i.e., to improve data quality; Peer et al., 2014). Participants were informed that the study aimed to investigate the way people categorize others before giving their consent (box-checking format).

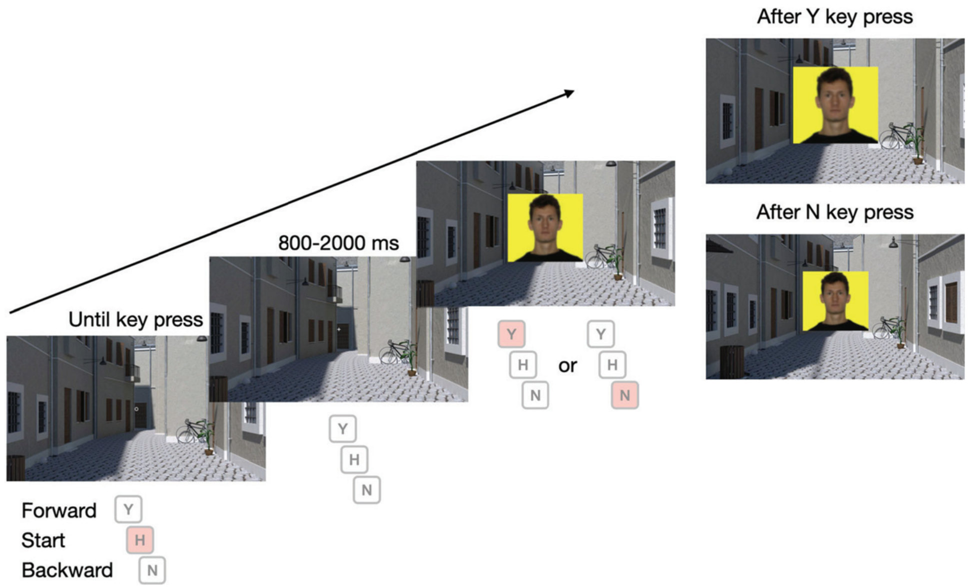
Approach/Avoidance Training. We used a modified version of the VAAST in its online variant (Aubé et al., 2019; Rougier et al., 2018), and we adapted the procedure to use it as an AAT (Batailler et al., 2021). This task reproduces the visual aspects associated with movements of the self in a virtual environment (i.e., a regular street view giving an impression of depth; see Figure 1).

Before the task, we told participants that they were about to see a virtual environment in which they would move forward (by pressing the Y key) or backward (by pressing the N key). Specifically, half of participants received the instruction to move forward (to approach) when blue-background faces appeared on the screen and to move backward (to avoid) when yellow-background faces appeared; the other half received the reverse instructions (i.e., to move forward for yellow-background faces and to move backward for blue-background faces).

For each trial, a white circle first appeared at the center of the screen, informing participants that they could start. When participants pressed the start button (the H key), a fixation cross replaced the circle (for a random duration between 800 and 2,000 ms), followed by a target face (see Figure 1). As soon as the target face appeared, participants had to categorize it as a function of its background color as quickly and as accurately as possible. Depending on the participants' approach/avoidance action, the entire visual environment changed (i.e., the background image and the target face). Specifically, the face was zoomed in/out (by approximately 13%), and the visual background was replaced by another one (i.e.,

[4] Eight participants did not answer the demographic questions.

Figure 1
Time Course of a Trial in the VAAST



Note. The street image and the (yellow vs. blue) background area of the face are originally colored. The photograph is from the Caucasian and North African French Faces database (Courset et al., 2018). See the online article for the color version of this figure.

another screenshot taken in front of or behind the initial position in the street), giving participants the visual impression that they were moving toward or away from the face in the street environment. For each trial, we recorded the response accuracy. In case of an inaccurate response, the "ERROR!" message (60-point Arial font in red) appeared on the screen during 500 ms before the next trial.

Reverse Correlation. After the VAAST, participants underwent the reverse correlation procedure adapted from Dotsch et al. (2008; see also Dotsch & Todorov, 2012; Dotsch et al., 2013). The task consisted in a forced-choice categorization task: Two noisy faces appeared side by side on the screen, and participants had to choose the one that best corresponded to the target group (e.g., the yellow group).

Before the task, participants read that each group of faces presented in the VAAST (i.e., with a yellow vs. blue background) was very different from the other group. They also learned that within each group, the faces also shared a series of physical characteristics, making them similar to each other. For each trial, participants had to "select the face that you think is the most similar to the group of faces that had a blue [yellow] background (. . .) (i.e., the faces that you avoided [approached])." Participants selected the blue-background face in one block and the yellow-background face in the other. They selected the face on the left by using the S key and the face on the right by using the L key.

Each block comprised 200 trials. We thus generated 400 pairs of noisy faces using the R package rcirc Version 0.3.4.1 (Dotsch, 2015) with the default settings. Noisy faces (512 × 512 grayscale pixels) consisted of a base image with superimposed random noise. Regarding the base images, we used two separate base images that were the average faces (i.e., the morph) of the two groups presented in the VAAST: One base image (Base Image 1) was the average face from Group 1, and the other base image (Base Image 2) was the average face from Group 2 (see Figure 2).[5] We then added a gray background to each base image, converted them to a grayscale, and slightly blurred them (using a radius of 5 pixels and a Laplacian standard deviation of 5 pixels).[6] Within a block, the base image always corresponded to the target group—for example, when participants had to select the blue-background face, the base image was a morph of the blue-background faces seen in the VAAST.

Regarding the noise applied on the base image, we generated a different noise pattern for each trial, the set of noise patterns being the same for the two blocks and for all participants. For each pair, one stimulus consisted in the base image along with the original random noise, and the other was the base image with the negative (opposite) pattern of noise (see Figure 2). We always presented images as pairs, and the images within a pair appeared randomly either on the right or on the left side. We showed the pairs in a random order within each block. At the end of the experiment, participants answered demographic questions (age and gender).

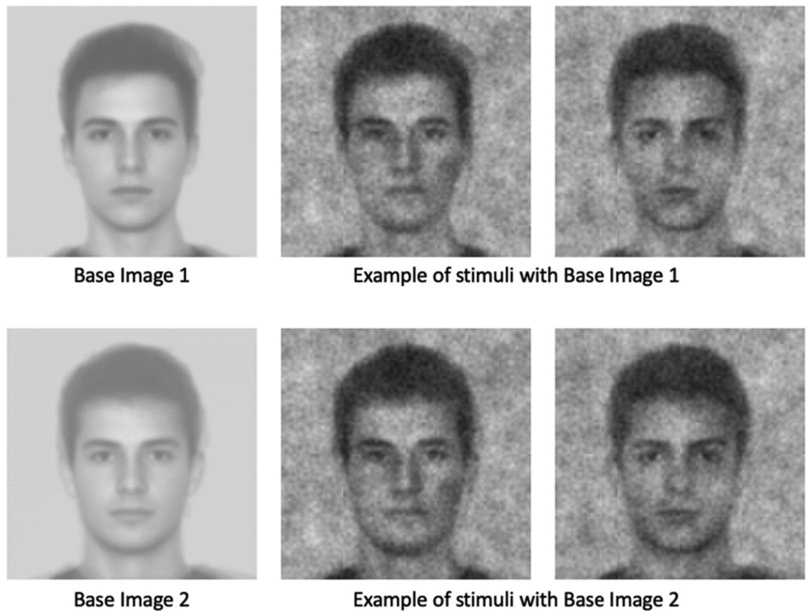
CIs Processing. We expected the AAT to bias the visual representations of the approached/avoided groups. If so, the CIs from the approach versus avoidance condition (for both Base Images 1 and 2) should be rather dissimilar (e.g., more or less trustworthy). To test this prediction, we averaged CIs by condition (i.e., approach vs. avoidance) for each base image (Base Image 1

[5] We created the two average faces using the morphing technique with the Java Psychomorph software (Tiddeman et al., 2005; guidelines from Sutherland, 2015).

[6] This manipulation aimed at increasing the fit between the base image and the random noise.

Figure 2

Base Images (1 on the Top Left and 2 Bottom Left) and Associated Examples of Stimuli (Pairs With Images Having the Opposite Patterns of Noise) for a Given Noise in the Reverse Correlation Task



Note. For each example of pairs of stimuli, the left (right) stimulus is the base image with the original (negative, i.e., opposite).

vs. 2).[7] Specifically, we averaged all the selected noises for all the participants within each condition, and we then superimposed this average noise to the corresponding base image, resulting in four condition-level CIs (see Figure 3; scaling constant = .008). To test whether background color (blue vs. yellow) and block order (first vs. second) affected our results, we also computed CIs for each of these conditions (in addition to group and movement), resulting in 16 CIs. Visual inspection of the four CIs presented in Figure 3 suggests that the AAT influenced the visual representation of the approached/avoided group: Condition-level CIs associated with approach seem overall more approachable than those associated with avoidance do. We tested in Part 2a whether a pool of independent judges supported these visual impressions.

Part 2a: CIs Ratings by Independent Judges on Other-Relevant Traits

In Part 2a, we tested whether the condition-level CIs obtained in Part 1 elicited different judgments. Specifically, we expected the two visual representations associated with approach to elicit more favorable evaluations than those associated with avoidance. Importantly, we turned to traits (trustworthiness, aggressiveness, and criminality) directly informative on the trait holder's intentions toward people in their environment (Abele & Wojciszke, 2007) and, as such, belonging to the other-relevant category of traits (Ric et al., 2013). These traits should thus typically relate to the approachability/avoidability of a person.

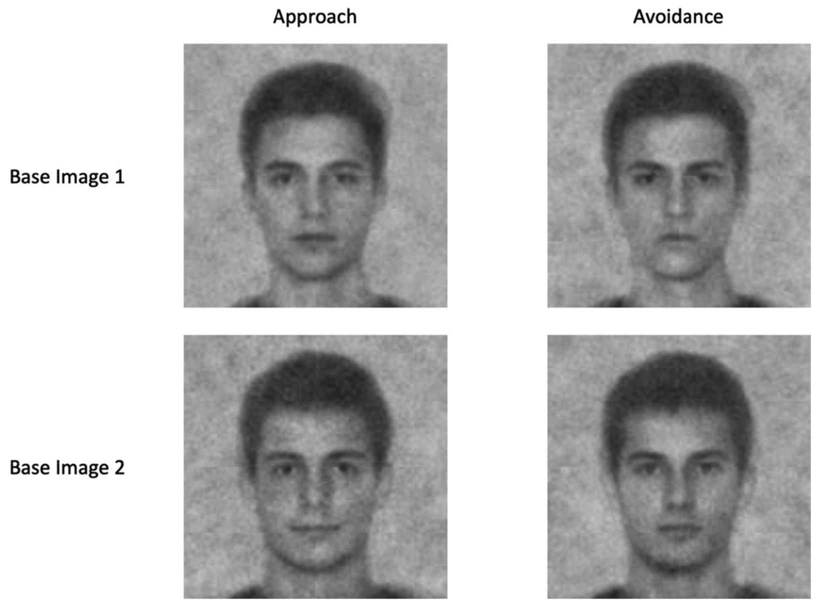
Participants. In order to settle on the sample size for the judges, we relied on a high estimate of the samples generally used in the reverse correlation literature (i.e., N = 31–101; Brinkman, Dotsch, et al., 2019; Dotsch et al., 2008, 2013; Dotsch & Todorov, 2012; Oliveira, Garcia-Marques, & Dotsch, 2019; Oliveira, Garcia-Marques, et al., 2019; Ratner et al., 2014). With a sample of 71 participants, we had 80% of power to detect a movement (approach vs. avoidance) effect of d = .70 at minimum (OLS regression). Our participants were Prolific Academic users (M_{age} = 31.22, SD_{age} = 10.86; 34 male and one other—i.e., self-categorizing as neither male nor female) who took part in exchange for USD $0.54.

Procedure. As in Part 1, we recruited participants via Prolific Academic (same prescreening criteria). We programmed and administered the experiment online via Qualtrics. Before giving their informed consent, participants learned that the study was about face perception and that their task would be to evaluate 22 faces on aggressiveness, trustworthiness, and criminality. We presented the faces one by one and the aggressive, trustworthy, and criminal scales (on a continuous scale from 0 = *not at all* to 100 = *very much*) adjacent to each other, in this order. We first showed the 20 CIs (the four condition-level CIs and the 16 CIs relative to control factors) in a random order. We then presented the two base images in a random order in a second block. We encouraged participants to answer as honestly and as spontaneously as possible. Finally, participants answered to the same demographics as in Part 1.

Results. We tested whether the two condition-level CIs associated with approach resulted in more favorable evaluations than those associated with avoidance. Overall, aggressiveness and

[7] Data from different base images cannot be averaged together.

Figure 3
Condition-Level (Approach vs. Avoidance) CIs as a Function of the Base Image (Base Image 1 vs. 2)



criminality scores were highly correlated, $r = .70$, $t(211) = 14.29$, $p < .001$, while trustworthiness was correlated more modestly with aggressiveness, $r = -.26$, $t(211) = 3.88$, $p < .001$, and criminality, $r = -.25$, $t(211) = 3.67$, $p < .001$. In line with our preregistration, we computed an "approachability score," indicating to what extent the judges perceived a face as being, on average, more trustworthy and less aggressive and criminal. Our main analysis revealed a movement (approach vs. avoidance) effect: Judges rated the two condition-level CIs associated with approach ($M = 67.65$, $SE = 1.57$) higher on the approachability score than those associated with avoidance ($M = 50.46$, $SE = 1.52$), $t(70) = 10.68$, $p < .001$, $dz = 1.27$, 95% CI [.75, 1.79].[8] This effect was significant for both Base Image 1, $t(70) = 9.52$, $p < .001$, $dz = 1.13$, [.62, 1.64], and Base Image 2, $t(70) = 6.42$, $p < .001$, $dz = .76$, [.27, 1.25].

These results are consistent with the idea that repeatedly performing approach/avoidance actions toward groups of neutral faces can bias their visual representation. However, we cannot exclude that approach versus avoidance actions triggered a visual representation that is generally positive versus negative, regardless of whether it is associated with approach/avoidance *per se* (i.e., other relevant). Indeed, the traits we used were positively (trustworthiness) or negatively (aggressiveness and criminality) valenced. In Part 2b, we addressed this limitation and tested whether the visual representations from Part 1 contained not only positive versus negative facial traits but also traits specifically associated with approach/avoidance actions.

Part 2b: CIs Ratings by Independent Judges on Other- and Possessor-Relevant Traits

We argue that performing approach/avoidance actions should bias the visual representation of the approached/avoided groups so that they become more approachable/avoidable. Wentura et al. (2000) showed that other-relevant traits (e.g., trustworthy, cruel) are more strongly associated with approach/avoidance tendencies, as compared to possessor-relevant traits (e.g., intelligent, lazy). If the CIs obtained in Part 1 contain a unique facial information relative to approach/avoidance actions, these CIs should be more likely biased on other- than on possessor-relevant traits.

Participants. In this part, we performed mixed-model analyses with both participants and traits as random factors (Judd et al., 2017). We opted for 101 participants and increased the number of traits for the judges' ratings (i.e., 20 instead of three) to maximize power, resulting in 80% power to detect a movement (approach vs. avoidance) by trait relevance (other vs. possessor relevant) interaction effect of $d = .32$.[9] Participants were Prolific Academic users ($M_{age} = 34.54$, $SD_{age} = 11.59$; 55 male and one other) who took part in exchange for USD $0.78.

Procedure. The procedure was similar to Part 2a. After providing their consent, participants evaluated the four condition-level CIs on a series of 20 traits.

We selected 10 other-relevant traits (i.e., aggressive, antisocial, brutal, cooperative, cordial, cruel, friendly, tolerant, understanding, and vicious) and 10 possessor-relevant traits (i.e., bored, clever, cowardly, independent, lonely, persistent, powerless, skillful, smart, and weak) from the overall pool of traits used in Wentura et al. (2000). Relying on Warriner et al.'s (2013) lemmas norms database, we selected traits so that the two groups of traits did not differ on several dimensions. Specifically, other- and possessor-relevant traits did not significantly differ on the overall valence extremity ($M_{other} = 6.92$, $SD_{other} = .54$; $M_{poss} = 7.02$,

[8] Analyses for each trait taken separately were also significant. Results for each trait and for Experiments 1, 3A, 4, and 5 (using condition-level CIs and OLS regression) are presented in the online supplemental materials.

[9] We computed power estimations for mixed-model analyses using the PANGEA application (Westfall, 2015; https://jakewestfall.shinyapps.io/pangea/).

SD_{poss} = .53; from 1 = *happy* to 9 = *unhappy*), $t(18) = .43$, $p = .67$, $d = .19$, 95% CI [−.75, 1.13]. Moreover, negative traits of the two groups were not significantly different on valence (M_{other} = 2.94, SD_{other} = .25; M_{poss} = 2.86, SD_{poss} = .11), $t(8) = .65$, $p = .53$, $d = -.41$, [−1.88, 1.06], nor were positive traits (M_{other} = 6.78, SD_{other} = .74; M_{poss} = 6.90, SD_{poss} = .76), $t(8) = .26$, $p = .80$, $d = .17$, [−1.29, 1.63]. These traits also did not differ on arousal (M_{other} = 4.44, SD_{other} = 1.19; M_{poss} = 4.78, SD_{poss} = .95; from 1 = *excited* to 9 = *calm*), $t(18) = .71$, $p = .49$, $d = .31$, [−.63, 1.26], or dominance (M_{other} = 5.81, SD_{other} = 1.12; M_{poss} = 5.47, SD_{poss} = 1.61; from 1 = *controlled* to 9 = *in control*), $t(18) = .55$, $p = .59$, $d = -.24$, [−1.19, .70].

Before the rating phase, we first briefly displayed the four condition-level CIs (automatically paced for 2 s each) for participants to better gauge the similarities and differences between them. Participants then rated each CI on each trait on a continuous scale (from 0 = *not at all* to 100 = *very much*). Traits appeared separately from each other, and participants rated the four CIs on a given trait before taking another trait. For each participant, we randomized the order of presentation of the faces as well as the trait order.

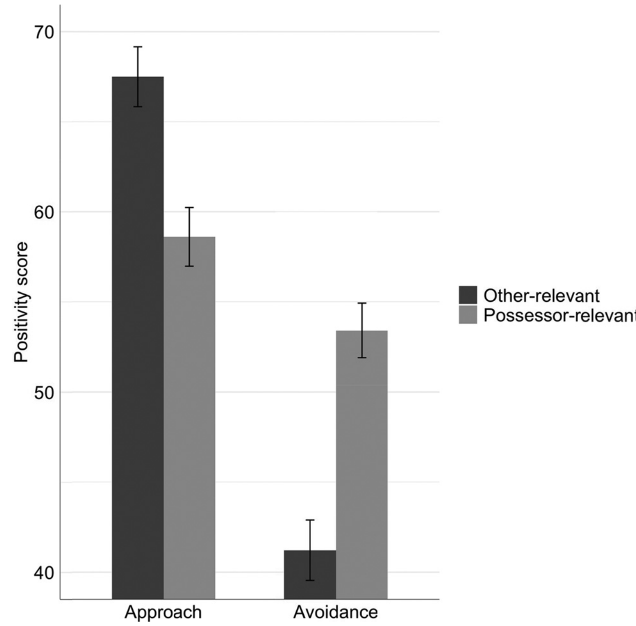
Results. We tested whether the evaluation of approach/avoidance CIs was more sensitive for (i.e., differed more on) other- than for possessor-relevant traits. Instead of relying on traditional analyses treating only participants as a random factor (e.g., OLS regression), we relied on a mixed-model analysis using both judges and traits as random factors so as to maximize the robustness and the generalizability of the findings (Judd et al., 2012; Westfall et al., 2014). In other words, our analytical strategy allows generalizing the results not only to other judges but also to other samples of other- and possessor-relevant traits.

Overall, traits within the other- (α = .94) and possessor-relevant (α = .75) groups were highly correlated. As in Part 2a, we computed a score comprising the ratings relative to all other- and possessor-relevant traits (negative traits were reversed) as a dependent variable—named "positivity" score because it does not only relate to approachability (i.e., for possessor-relevant traits). We estimated the movement (approach vs. avoidance) and the trait relevance (other vs. possessor relevant) as main effects as well as the interaction as fixed effects. We also estimated the related relevant random intercepts and slopes for participants (movement, relevance, and their interaction slopes) and traits (movement slope).

The crucial interaction between movement and relevance was significant, $t(22.53) = 6.45$, $p < .001$, $dz = 1.44$, 95% CI [.99, 1.88],[10] indicating that the difference between the condition-level CIs associated with approach versus avoidance was larger for other- than for possessor-relevant traits (see Figure 4). Of note, this effect remained significant, $t(20.28) = 6.73$, $p < .001$, and was not significantly moderated by traits' valence extremity, $t(5.56) = .94$, $p = .36$, when we introduced this factor in interaction with the other factors in the model. Simple-effects analyses revealed that the results for the other-relevant traits replicated those of Part 2a, with CIs associated with approach ($M = 67.50$, $SE = .84$) rated as more positive than those associated with avoidance ($M = 41.22$, $SE = .84$), $t(24.65) = 11.10$, $p < .001$, $dz = 2.27$, [1.77, 2.77]. For the possessor-relevant traits, this effect was also significant, $t(24.05) = 2.20$, $p = .04$, $dz = .46$, [.06, .86], with condition-level CIs associated with approach being more positive ($M = 58.60$, $SE = .82$) than those associated with avoidance ($M = 53.42$, $SE = .76$).

Figure 4

Positivity Score (Average Score of All Traits With Negative Traits Being Reversed) as a Function of Movement (Approach vs. Avoidance) and Relevance (Other vs. Possessor Relevant)



Note. Error bars represent 95% confidence intervals.

As predicted, the CIs obtained in Part 1 proved more biased on other- than on possessor-relevant traits. These data thus replicate and extend the results observed in Part 2a by showing that CIs are not only biased in a positive/negative way but that this bias is also accentuated on information uniquely related to approach/avoidance. Importantly, because we used mixed-model analyses, these results generalize not only to other participants but also to different other- and possessor-relevant traits.

However, one account of our findings may reside in a variable confounded with trait relevance, namely the "face readability"—that we define as the ease with which a given personality trait can be inferred from a face. One might argue that because other-relevant traits are more functional—in informing on the trait holder's intentions—these traits should be more strongly linked to facial features than possessor-relevant traits. Close inspection of other-relevant traits (e.g., aggressiveness) suggests that these traits may relate more to emotions (e.g., anger) than possessor-relevant traits (e.g., intelligence), which are again face-readable information. Therefore, it would be easier for the judges to infer positive (approach CIs) and negative (avoidance CIs) other- rather than possessor-relevant traits.

To address this alternative hypothesis, we conducted another study (see Study 1 in the online supplemental materials) in which we asked participants to indicate, for each other- and possessor-relevant trait, to what extent the trait can be read off a face. We

[10] Given that there is yet no consensual effect size measure for mixed-models analyses (Judd et al., 2017), and to facilitate the comparison with other experiments, we computed effect sizes (dz) with regular by-participant analyses when possible. We did so for all mixed-model analyses reported in this article.

then ran previous analyses anew by adding the face readability factor as a fixed effect in our mixed model. The mixed model was the same as before except that we additionally estimated the main effect of face readability as well as all its interactions with the other variables (Yzerbyt et al., 2004). Results showed that other-relevant traits are more face readable than possessor-relevant traits, $t(38) = 4.73$, $p < .001$, $dz = .76$, 95% CI [.09, 1.43]. More importantly, however, the movement by relevance interaction was not significantly moderated by the face readability of traits, $t(16.04) = 1.09$, $p = .29$, while the crucial movement by relevance interaction remained significant, $t(20.05) = 5.59$, $p < .001$. Overall, these results suggest that, although people indeed read other-relevant traits more easily from faces than possessor-relevant traits, face readability cannot account for the observed movement by relevance interaction.

Discussion

Experiment 1 establishes the effect of an AAT on the visual representation of others. This effect applied for traits known to be associated with approach and avoidance actions (Part 2a), and it was larger for these traits than for traits of the same valence but lacking this feature (Part 2b). Importantly, the differential face readability of other- compared to possessor-relevant traits, that is, the ease of inferring a personality trait from a face, failed to account for the observed pattern. These findings are thus consistent with the idea that the AAT reactivates the visual information routinely associated when performing these actions, ultimately biasing the visual representation of the approached/avoided groups.

Our results are also consistent with previous work showing that AATs can bias the evaluation of the stimuli (e.g., Huijding et al., 2009; Kawakami et al., 2007; Van Dessel et al., 2015; Woud et al., 2008, 2013; but see Vandenbosch & De Houwer, 2011). However, the present efforts extend these findings in two ways: first, by showing that an AAT can also distort the visual representation of faces even when the measure does not prime participants toward an evaluative bias (e.g., with valenced response options; Hütter & Genschow, 2019; Woud et al., 2008, 2011, 2013). Second, we extended the findings by showing for the first time that AAT effects can go beyond evaluative consequences and apply on physical features that are specific to the approach/avoidance actions that participants performed. Of note, we not only obtained these results in Part 2b but also replicated the movement by trait relevance interaction in an independent study (see Study 2 in the online supplemental materials) when using CIs of the VAAST condition in Experiments 3 ($dz = 1.03$) and 4 ($dz = 1.46$)—at that time, we had not yet conducted Experiment 5.

Nevertheless, Experiment 1 has two main limitations. First, Part 2b relied on a limited set of other- and possessor-relevant traits (i.e., 20 in total). It could thus be that other- and possessor-relevant traits in fact differed on one or several of the controlled dimensions (valence, arousal, or dominance) but that we were unable to detect the difference because of a low-powered test. In addition, the sets of traits could have differed on a series of dimensions not taken into account in the present selection (e.g., emotional connotation). For instance, other-relevant traits could relate more to happiness than possessor-relevant traits do. Second, we only compared the visual representation of the approached group with that of the avoided group. This prevents disentangling the potentially distinct effects of approach and avoidance actions on the visual representations. We addressed these two limitations in Experiment 2.

Experiment 2

The goal of Experiment 2 was twofold. First, we wanted to replicate the effect observed in Experiment 1 (Part 2b), namely, a larger difference between the visual representations of approach and avoidance for other- than for possessor-relevant traits. We used broader (i.e., 40) and more controlled sets of traits to increase the robustness and the generalizability of our findings. Second, we wanted to compare the visual representations resulting from approach and avoidance actions with a third visual representation resulting from control actions (right/left movements not implying approach/avoidance; e.g., Kawakami et al., 2007; Phills et al., 2011). On the one hand, if both approach and avoidance actions reactivate their associated perception of others from memory—ultimately biasing the visual representation—both visual representations of the approached and avoided groups should distinguish from the one of the control condition. On the other hand, it is possible that the perceptions in the multimodal representations of approach and avoidance are not equally extreme. In other words, only one of these two representations may differ from the one resulting from control actions, leading to asymmetrical effects. Addressing this question is important at the theoretical level because most current theoretical accounts would predict that both approach and avoidance have an effect of their own. As a notable exception, the self-anchoring account (Phills et al., 2011) predicts that approach (and not avoidance) actions drive AAT effects. A closer examination of this issue is also critical at the practical level, especially when the ambition is to change a problematic representation only with approach (e.g., prejudiced attitudes; Kawakami et al., 2007) or with avoidance (e.g., alcohol consumption; Wiers et al., 2010).

Method

Part 1: Creation of CIs Resulting From Approach Versus Avoidance Versus Control Actions

Participants and Design. We based our sample size estimation on Experiment 1 given that the design was the same, except for the between-participants manipulation of movement (approach vs. avoidance vs. control). We thus relied on 319 Prolific Academic users ($M_{age} = 31.79$, $SD_{age} = 11.43$; 166 male and two other) who took part in exchange for USD \$2.30. In line with our preregistration criteria, we excluded nine participants having at least 30% of incorrect trials in the VAAST and 16 participants having at least 30% of their response time inferior to 200 ms in the reverse correlation procedure, leaving 294 participants ($M_{age} = 31.85$, $SD_{age} = 11.36$; 150 male and two other). We used a 3 (Movement: approach vs. avoidance vs. control) × 2 (Background Color: blue vs. yellow) × 2 (Group of Faces: Group 1 vs. Group 2) × 2 (Group Selected in the Reverse Correlation: Group 1 vs. Group 2) design with the first and last variables varying between participants.

For participants performing approach and avoidance actions, the design of the VAAST was the same as in Experiment 1. For participants performing control actions, the design of the control task was the same as for the VAAST, except that participants pressed left/right control keys as a function of the background color of the faces (i.e., press the S key for blue-background faces vs. press the F key for blue-background faces) instead of approach/avoidance actions. For the reverse correlation, participants went through only one block of 150 trials each. Depending on whether participants performed approach/avoidance or control actions and depending on the color of the randomly selected group (blue- vs. yellow-background), we measured the visual representation of the approached group, the avoided group, or the group associated with control actions.

Procedure. We programmed the experiment on jsPsych and administered it online via the Prolific Academic platform (same prescreening criteria as in Experiment 1). The procedure was similar to Experiment 1 except for changes relative to the use of a control condition and a different reverse correlation procedure.

Approach/Avoidance Versus Control Training. We mimicked the design used by Kawakami et al. (2007, Experiment 1). We randomly assigned participants to either the approach/avoidance training condition (two thirds of the participants) or the control condition (one third of the participants). In the approach/avoidance training condition, the procedure was the same as in Experiment 1: Half of participants approached blue-background faces and avoided yellow-background faces; the other half performed the reverse actions. The only difference was that participants used the E key for approach, the C key for avoidance, and the D key as the start key.

Control participants had to categorize the same blue- and yellow-background faces as in the approach/avoidance training. To keep as many factors constant as possible, the visual environment of the control task was the same as the VAAST (e.g., same visual background; see Figure 1) except that participants did not perform any approach/avoidance actions. Following the same time course as in the VAAST, participants had to categorize the faces as a function of their background color by using either the S or the F key. No mention was made of approach/avoidance actions, and pressing the S or F keys was not associated with any visual feedback of approach/avoidance.

Reverse Correlation. Contrary to Experiment 1, we did not use a two-forced-choice task (e.g., Dotsch et al., 2008) but the brief reverse correlation (hereafter brief-RC; Schmitz et al., 2021). In the brief-RC, participants select one among 12 noisy faces (instead of two) at each trial. Schmitz et al. (2021) argued that with a larger number of faces, the selected face at each trial is more likely to carry diagnostic information of the to-be-measured representation. Supporting this hypothesis, these authors confirmed that the brief-RC led to better quality CIs (e.g., larger infoVal metric; Brinkman, Goffin, et al., 2019; see also Schmitz et al., 2020), even with a reduced number of trials.

We used the same instructions as in Experiment 1 except that there was no recall of which color group was associated with approach or avoidance. Participants had to select either the blue- or the yellow-background typical face. The group of faces thus corresponded to either approach, avoidance, or control actions. Participants performed 150 trials with 12 noisy faces (of 150 × 150 grayscale pixels each; with six pairs of faces having opposite patterns of noise) presented at each trial. Accordingly, we generated 900 pairs of noisy faces. For practical reasons, we used one base image (instead of two), namely the average face (i.e., the morph) of all the faces presented in the VAAST (see Figure 5). The faces and their positions on the screen in each trial remained fixed, but we randomized trial order across participants.

CIs Processing. We wanted to visualize the mental representations associated with approach, avoidance, and control actions. To do so, we averaged all the selected noises for all participants within each of these actions (see Figure 5; scaling constant = .003).

Part 2: CIs Ratings by Independent Judges on Other- and Possessor-Relevant Traits

Participants. As in Part 2b of Experiment 1, we performed mixed-model analyses with participants and traits as random factors. We recruited 101 judges and increased the number of traits (i.e., 40), ensuring 80% power to detect a movement by trait relevant effect of d = .33. Participants were Prolific Academic users (M_{age} = 26.79, SD_{age} = 7.87; 63 male and one other) who took part in exchange for USD $0.87.

Procedure. We recruited participants online via Prolific Academic, and the prescreening criteria were the same as Part 1 except that we recruited French participants. We did so in order to use the original other- and possessor-relevant traits from Ric et al. (2013) as these are validated in French. The procedure was similar to Experiment 1, Part 2b, except that participants evaluated the CIs on a series of 40 traits.

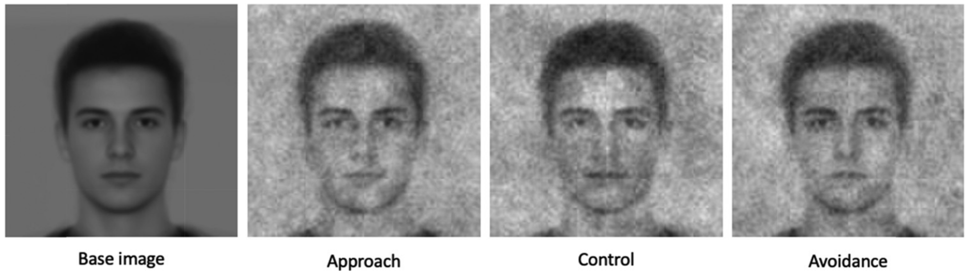
Our strategy regarding the controls on other- and possessor-relevant traits relied on recent work about conceptual and facial trait spaces. Following Stolier et al. (2018), lay theories about traits' relationship are substantially overlapping between the semantic level (e.g., using self-report) and the facial level (e.g., using reverse correlation). For instance, these authors showed that conceptual associations between traits (e.g., happiness and trustworthiness; i.e., the "conceptual trait space") measured at the semantic level shaped the facial representations (i.e., the "face trait space"), as measured in reverse correlation. Accordingly, if one controls other- and possessor-relevant traits in order to avoid any confound with happiness at the semantic level, there should also be no confound at the facial level.

We selected 20 other- and 20 possessor-relevant traits from the emotional norms database of Ric et al. (2013).[11] Following the ratings of the emotional norms database, other- and possessor-relevant traits did not significantly differ on the overall valence extremity (M_{other} = 1.57, SD_{other} = .57; M_{poss} = 1.53, SD_{poss} = .41; from 0 = *low extremity* to 3 = *high extremity*), $t(38)$ = .30, p = .76, d = −.09, 95% CI [−.74, .54]. Moreover, negative traits of the two groups were not significantly different on valence (M_{other} = −1.45, SD_{other} = .63; M_{poss} = −1.44, SD_{poss} = .41; from 0 = *extremely negative* to +3 = *extremely positive*), $t(18)$ = .04, p = .97, d = .02, [−.92, .96], nor were positive traits (M_{other} = 1.70, SD_{other} = .49;

[11] Other-relevant traits (English translation): harsh, difficult, authoritarian, compassionate, depressing, insistent, affectionate, humorous, unconcerned, cold, boorish, rude, faithful, steady, hospitable, adorable, impolite, understanding, polite, and loving. Possessor-relevant traits (English translation): artistic, mediocre, lazy, wasteful, rich, handy, decided, sluggish, talented, smart, sturdy, melancholic, determined, weak, scared, impotent, disturbed, meticulous, athletic, and fearful.

Figure 5

Base Image and Condition-Level CIs as a Function of Movement (Approach vs. Control vs. Avoidance)



M_{poss} = 1.62, SD_{poss} = .41), t(18) = .42, p = .68, d = −.19, [−1.13, .75]. The two groups of traits did not differ significantly on a series of emotions (from 1 = *does not convey this emotion at all* to 7 = *strongly conveys this emotion*), such as happiness (M_{other} = 2.66, SD_{other} = 1.66; M_{poss} = 2.22, SD_{poss} = 1.12), t(38) = .97, p = .34, d = −.31, [−.95, .33], anger (M_{other} = 2.34, SD_{other} = 1.32; M_{poss} = 1.93, SD_{poss} = .77), t(38) = 1.20, p = .24, d = −.38, [−1.02, .26], disgust (M_{other} = 1.93, SD_{other} = .92; M_{poss} = 1.81, SD_{poss} = .68), t(38) = .47, p = .63, d = −.15, [−.79, .48], fear (M_{other} = 1.88, SD_{other} = .67; M_{poss} = 2.23, SD_{poss} = 1.35), t(38) = 1.04, p = .31, d = .33, [−.31, .97], and sadness (M_{other} = 1.95, SD_{other} = 1.04; M_{poss} = 2.19, SD_{poss} = 1.16), t(38) = .70, p = .49, d = .22, [−.42, .86].

As in Experiment 1 (Part 2b), for arousal and dominance ratings, we relied on Warriner et al.'s (2013) database.[12] Again, traits did not differ on arousal (M_{other} = 4.19, SD_{other} = .90; M_{poss} = 4.38, SD_{poss} = 1.14), t(30) = .52, p = .61, d = .18, 95% CI [−.54, .91], or dominance, (M_{other} = 5.74, SD_{other} = 1.46; M_{poss} = 5.45, SD_{poss} = 1.20), t(30) = .62, p = .54, d = −.22, [−.94, .50]. Finally, we conducted a short study to collect the face readability ratings for each trait (i.e., "How easy is it to judge the face of others on this trait?"; scale from 0 = *not easy at all* to 10 = *very easy*; N = 30, M_{age} = 28.07, SD_{age} = 9.74, 20 male). The procedure was the same as the supplemental study of Experiment 1, Part 2b (see Study 1 in the online supplemental materials). The selected traits did not differ on facial readability (M_{other} = 4.83, SD_{other} = 1.14; M_{poss} = 4.48, SD_{poss} = 1.76), t(38) = .76, p = .45, d = −.24, [−.88, .40].

Results

The goal of Experiment 2 was twofold. We aimed to replicate the movement by trait relevance interaction found in Experiment 1 and to compare the visual representations of approach and avoidance with the one of the control condition. We relied on the same mixed-model analysis as in Experiment 1, Part 2b. We computed a positivity score comprising the ratings relative to all traits (negative traits were reversed) as a dependent variable and estimated the movement (approach vs. avoidance vs. control) and the trait relevance main effects as well as the interaction as fixed effects. Overall, traits within the other- (α = .91) and possessor-relevant (α = .72) groups were highly correlated. Yet given that other- and possessor-relevance ratings for each trait were available as continuous variables in Ric et al.'s (2013) database, we kept this format and computed a differential score indicating to what extent a trait was rather other or possessor relevant (from −3 = *other-relevant* to +3 = *possessor-relevant*).[13] Importantly, the valence, emotion (happiness, anger, disgust, fear, and sadness), arousal, dominance, and face readability of traits did not change the significance of the results when included in the models (including interaction effects).

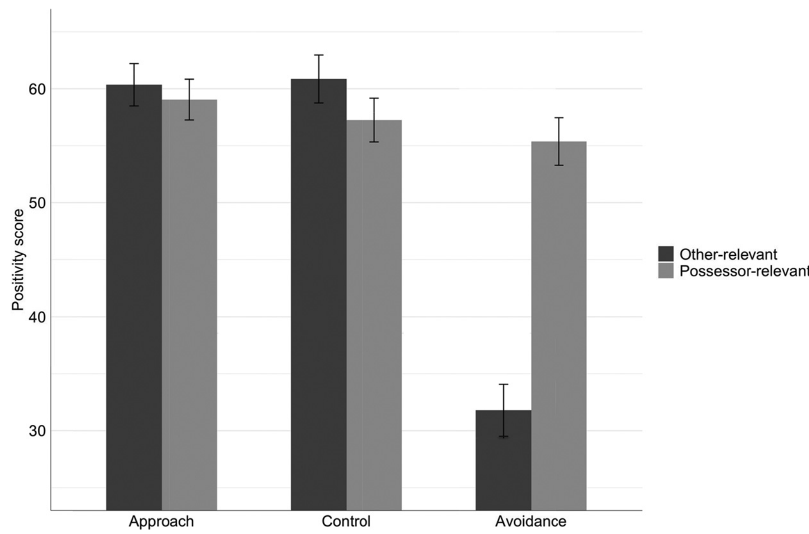
First, we tested whether the evaluation of approach, avoidance, and control CIs proved more sensitive to (i.e., differed more on) other- than to possessor-relevant traits. For the movement variable, we used two contrast codes: a linear contrast C1 (avoidance coded −1/2, control coded 0, and approach coded 1/2) and a quadratic contrast C2 (avoidance coded −1/3, control coded 2/3, and approach coded −1/3). As predicted, the interaction between the linear contrast C1 and trait relevance was significant, b = −4.80, t(46.88) = 4.71, p < .001, dz = −1.28, 95% CI [−1.71, −.85], indicating that the difference between CIs associated with approach versus avoidance was larger for other- than for possessor-relevant traits (see Figure 6). Simple-effects analyses showed that approach and avoidance CIs significantly differed on other-relevant traits (M_{app} = 60.35, SE_{app} = .94; M_{av} = 31.79, SE_{av} = 1.15), t(49.44) = 7.61, p < .001, dz = 1.88, [1.41, 2.36], but not on possessor-relevant traits (M_{app} = 59.05, SE_{app} = .90; M_{av} = 55.37, SE_{av} = 1.05), t(44.43) = 1.01, p = .32, dz = .30, [−.10, .69]. These results are in line with those of Experiment 1, suggesting that approach and avoidance actions influenced other- more than possessor-relevant traits. The interaction between C2 and trait relevance was also significant, b = −1.88, t(58.80) = 7.05, p < .001, dz = 1.15, [.72, 1.57], indicating that the difference between the control CI and the two CIs of approach and avoidance considered jointly was also larger for other- than for possessor-relevant traits. Simple-effects analyses indicated that this difference between the two approach/avoidance CIs and the control CI significantly differed on other-relevant traits ($M_{app/av}$ = 46.07, $SE_{app/av}$ = 1.04; M_{cont} = 57.25, SE_{cont} = 1.06), t(52.34) = 7.58, p < .001, dz = 1.29, [.86, 1.73], but not on possessor-relevant traits ($M_{app/av}$ = 57.21, $SE_{app/av}$ = .98; M_{cont} = 57.25, SE_{cont} = .97), t(48.77) = .02, p = .98, dz = .004, [−.39, .40].

[12] The values of eight traits (authoritarian, decided, determined, unconcerned, melancholic, boorish, loving, and disturbed) were missing in Warriner et al.'s (2013) database.

[13] Using trait relevance as a dichotomous variable does not alter the significance of the presented results.

Figure 6

Positivity Score (Average Score of All Traits With Negative Traits Being Reversed) as a Function of Movement (Approach vs. Control vs. Avoidance) and Trait Relevance (Other- vs. Possessor-Relevant)



Note. Error bars represent 95% confidence intervals.

Second, we tested the extent to which each CI of approach and avoidance taken separately differed from the control CI. We made the comparison for other-relevant traits on which differences are expected and have been shown to emerge. In accordance with the preregistration and in order to examine our hypothesis in a more focused way, we used two contrast codes: D1 opposing the control with the avoidance CI (avoidance coded 1, control coded 0, and approach coded 0) and D2 opposing the control with the approach CI (avoidance coded 0, control coded 0, and approach coded 1). The first contrast D1 was significant, $t(52.34) = 7.58$, $p < .001$, $dz = -1.76$, 95% CI [−2.23, −1.30], indicating that the avoidance CI ($M = 31.79$, $SE = 1.15$) was evaluated more negatively than the control CI ($M = 60.86$, $SE = 1.06$). However, the second contrast D2 was not significant, $t(100.02) = .50$, $p = .62$, $dz = -.05$, [−.44, .34], indicating that the approach CI ($M = 60.35$, $SE = .94$) did not significantly differ from the control CI, both being evaluated positively ($M = 60.86$, $SE = 1.06$).

Discussion

These results are entirely in line with Experiment 1, Part 2b. Again, the visual consequences of approach and avoidance actions seem to apply more on other- than on possessor-relevant traits. Of note, we also generalized our findings to a different base image and a different reverse correlation procedure (the brief-RC; Schmitz et al., 2021). The observed AAT effect, however, seemed to be mainly due to avoidance actions. Indeed, when taking into account other-relevant traits, the visual representation of avoidance, but not approach, significantly differed from the control one. Although informative, this result is also somewhat surprising in light of current theoretical approaches. We further discuss this finding in the "General Discussion" section.

Experiments 1 and 2 investigated the effect of approach and avoidance on participants' visual representation. Specifically, we wanted to examine whether the influence on the facial aspects of this visual representation showed mainly on those traits that are relevant for approach and avoidance actions. In the following experiments, we investigated the other set of predictions derived from a grounded cognition approach, namely the importance of experiencing approach/avoidance actions (Experiments 3A and 3B) and the importance of the sensory aspects of these actions in the emergence of a biased visual representation (Experiments 4 and 5).

Experiment 3A

Previous research has shown that the mere instructions of approach/avoidance have an impact on the subsequent evaluation of stimuli (e.g., Van Dessel et al., 2015, Van Dessel, De Houwer, Gast, et al., 2016). For instance, Van Dessel et al. (2015) told their participants that they would have to approach a novel and unknown group (e.g., the "Niffites") and to avoid another one (e.g., the "Luupites"). These instructions led to a more positive evaluation of the former group compared to the latter. Importantly, performing an AAT did not yield a larger effect on evaluation compared to mere instructions of approach/avoidance (Van Dessel, De Houwer, Gast, et al., 2016; see also Smith et al., 2019). As it turns out, several methodological reasons may account for the lack of difference between an experience- and an instruction-based AAT, such as the type of approach/avoidance task, the evaluative measure, and so forth. We therefore decided to test whether experiencing an AAT makes an additional contribution in the present experimental setting. To do so, we compared two conditions in a between-participants design. In the VAAST condition, the procedure was the same as in Experiment 1 (i.e., participants received approach/avoidance instructions and performed the VAAST training). In the instructions condition, participants merely received the approach/avoidance instructions (the same as in the other condition): They learned that they would perform the AAT, but they actually did not. This comparison allows testing the role of experiencing an AAT in the emergence of an effect on the face representation.

In addition to the subjective ratings provided by the judges, we investigated a more objective indicator (not preregistered), namely the pixel luminance correlation, which indicates the physical similarity between two CIs (also coined pixel-wise correlation; see Brinkman et al., 2017; Dotsch & Todorov, 2012). The more positive (negative) the correlation, the more physically similar (dissimilar) the CIs are, whereas a close to null correlation indicates that they have little in common (Dotsch & Todorov, 2012; Imhoff et al., 2013; Imhoff & Dotsch, 2013; Michalak & Ackerman, 2020; Oliveira, Garcia-Marques, et al., 2019). For instance, Imhoff et al. (2013) relied on this technique to show that the CI of a nursery teacher was (physically) more similar to the CI of a warm-looking person than to the CI of a competent-looking person, whereas the opposite was true for the CI of a manager, confirming the mixed nature of these stereotypes. Because we predicted the effect of approach/avoidance to be larger in the VAAST than in the instructions condition, CIs in the former condition should be less similar than in the latter. Importantly, in our case, the pixel luminance correlation value only informs about the strength of the similarity (dissimilarity) but not about its nature (i.e., on which traits the CIs are similar).

Method

Part 1: Creation of CIs Resulting From Approach Versus Avoidance Actions in the VAAST Versus Instructions Conditions

Participants and Design. Relying on Experiment 1 and considering our between-participants manipulation, we estimated that we needed between 150 and 200 face creators. One hundred sixty-one undergraduate students (M_{age} = 20.36, SD_{age} = 2.84; 11 male and one other)[14] took part in exchange for course credit. In line with our preregistration, we excluded 10 participants who failed to remember correctly the instructions (see also Van Dessel et al., 2015), leaving 151 participants (M_{age} = 20.36, SD_{age} = 2.90; 10 male and one other). We used a 2 (Condition: VAAST vs. instructions) × 2 (Movement: approach vs. avoidance) × 2 (Background Color: blue vs. yellow) × 2 (Group of Faces: Group 1 vs. Group 2) × 2 (Group Order in the Reverse Correlation: Group 1 first vs. Group 2 first) design with the first and last variables being between participants.

The design of the VAAST condition was the same as in Experiment 1. In the instructions condition, the design of the categorization task (i.e., a control task described hereafter) was the same as for the VAAST condition except that we presented instructions relative to the key press (i.e., press the E key for blue-background faces vs. press the I key for blue-background faces) instead of presenting the approach/avoidance instructions. For the reverse correlation, participants underwent two blocks of 100 trials each. We randomized the target group order across participants.

Procedure. We conducted the experiment in our social psychology lab and programmed the procedure on Psytoolkit (approach/avoidance induction) and jsPsych (reverse correlation). We recruited only French-speaking participants. When participants arrived at the lab, we informed them that the experiment was about face categorization and that they were about to perform several categorization tasks. Participants signed a consent form and sat in front of a computer in a 10-computer room (1,600 × 900 screen resolution).

Approach/Avoidance Induction. We randomly assigned participants to the VAAST or the instructions condition. In the VAAST condition, the procedure was the same as in Experiment 1: Participants received the approach/avoidance instructions and performed the VAAST accordingly.

In the instructions condition, participants began by performing a control categorization task. This task was similar to the control condition in Experiment 2, except that participants did not have to press the start key to begin a trial and they had to categorize the blue- and yellow-background faces with the E and I keys. Again, no mention was made of approach/avoidance actions, and pressing the E or I keys was not associated with any visual feedback of approach/avoidance. With this categorization task, participants saw the blue- and yellow-background faces the same number of times as in the VAAST. Moreover, the duration of the VAAST and the categorization task was similar. These features ensured that participants became equally familiar with blue- and yellow-background faces in both conditions, the only difference being that groups were associated with approach/avoidance experience only in the VAAST condition. After the control categorization task, participants received the same approach/avoidance instructions as in the VAAST condition. Specifically, we told participants that they were about to perform an approach/avoidance task and that their task will be to approach blue-background faces and to avoid yellow-background faces (or the reverse). As in the VAAST condition, we insisted on the importance of remembering these instructions. After the instructions, we told them that before the approach/avoidance task, they had to perform another task—namely, the reverse correlation task. In reality, they did not performed the AAT.

Reverse Correlation. After the approach/avoidance induction, all participants underwent the brief-RC, as in Experiment 2 (Schmitz et al., 2021). Participants went through two blocks of 100 trials (one for the yellow-background group and one for the blue-background group). To this end, we generated 600 pairs of noisy faces with the same base image as in Experiment 2.

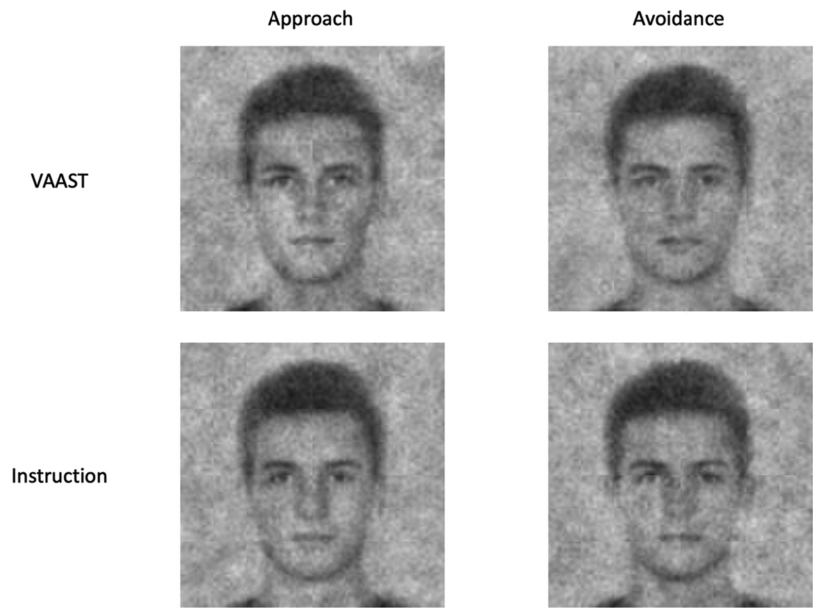
Instructions Check. After the reverse correlation task, participants reported the approach/avoidance instructions (three response options: "Approach blue-background and avoid yellow-background faces," "Approach yellow-background and avoid blue-background faces," and "I do not remember"). Then, they completed the same demographics as before.

CIs Processing. We computed the four CIs relative to each condition (see Figure 7; scaling constant = .004). In light of recent work showing that condition-level CIs sometimes lead to inflated Type-I error compared to individual-level CIs (Cone et al., 2020), we decided to test whether our effects replicated at the individual level (e.g., Degner et al., 2019). Accordingly, we computed the CIs relative to approach and to avoidance for each participant (scaling constant = .03). Additionally, we computed the pixel luminance correlation as the correlation between the noise layers from each CI. Specifically, each CI is composed of a noise layer (i.e., the average of all noise layers selected in the reverse correlation task by a single participant or a sample of participants) superimposed to the base image (512 × 512 pixels image). The noise

[14] Four participants did not answer to the demographic questions.

Figure 7

Condition-Level CIs as a Function of Movement (Approach vs. Avoidance) and Condition (VAAST vs. Instructions)



Note. VAAST = Visual Approach/Avoidance by the Self Task.

layer is a 512 × 512 luminance matrix with values indicating the opacity of each pixel ranging from 0 (opaque black) to 1 (opaque white) and values in between being translucent. We extracted an oval-shaped area covering the face region from the noise matrices of each condition-level CI (e.g., Dotsch & Todorov, 2012; Imhoff & Dotsch, 2013; Oliveira, Garcia-Marques, & Dotsch, 2019) and converted them into vectors. The pixel luminance correlation results from the correlation between these two vectors.

Part 2: CIs Ratings by Independent Judges on Other-Relevant Traits

Participants. Because we wanted to assess individual-level CIs in addition to condition-level CIs, which means a smaller effect, we increased our pool of judges compared to previous experiments. Two hundred participants (M_{age} = 41.38, SD_{age} = 12.80; 132 male) took part in exchange for USD $1.24, ensuring with 80% power to detect a movement (approach vs. avoidance) by condition (VAAST vs. instructions) interaction effect of d = .40 (OLS regression).

Procedure. We recruited participants via Foule Factory (a French crowdsourcing platform; www.foulefactory.com). We programmed the experiment online via Qualtrics. Before giving their informed consent, participants learned that the study was about face perception and that their task would be to evaluate two samples of faces. First, they evaluated a sample of 50 individual-level CIs on the same other-relevant traits as in Experiment 1, Part 2a (i.e., aggressiveness, trustworthiness, and criminality; continuous scale from 0 = *not at all* to 100 = *very much*). The 50 CIs were randomly selected among the pool of 302 individual-level CIs—each of the 151 face creators having one CI associated with approach and one CI associated with avoidance. Second, participants evaluated the four condition-level CIs (random order) on the same traits. Faces appeared one by one, and the three scales were adjacent to each other, always in the same order.

Results

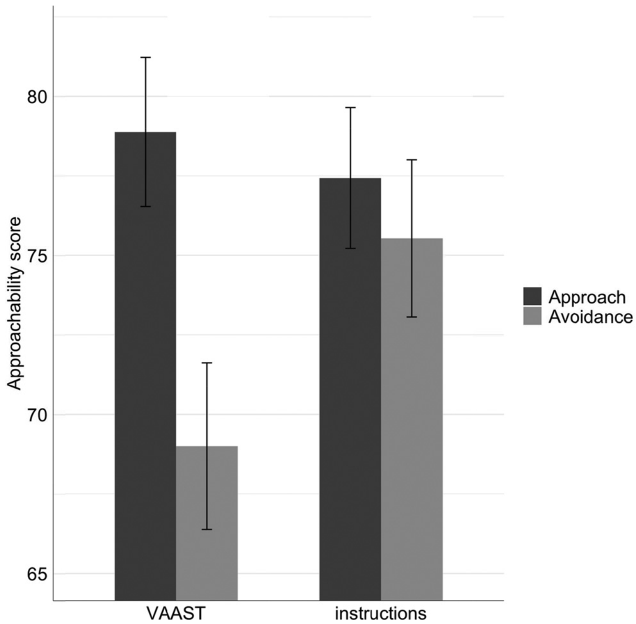
Aggressiveness and criminality scores were highly correlated, r = .73, t(10798) = 110.64, $p < .001$, while trustworthiness was correlated more modestly with aggressiveness, $r = -.44$, t(10798) = 50.70, $p < .001$, and criminality, $r = -.41$, t(10798) = 46.88, $p < .001$. As in Experiment 1, we computed an approachability score for each individual- and condition-level CI. We also investigated the objective similarity between condition-level CIs (pixel luminance correlations). Because experiencing the AAT should have a larger effect on the visual representations, we expected the two condition-level CIs to be less similar to each other in the VAAST than in the instructions condition.

Regarding condition-level CIs, the difference between approach and avoidance CIs in the judges' ratings was larger in the VAAST condition ($M_{diff} = -9.88$, SE_{diff} = 1.10) than in the instructions condition ($M_{diff} = -1.89$, SE_{diff} = .94), t(197) = 6.26, $p < .001$, dz = .44, 95% CI [.16, .73] (see Figure 8).[15] Simple-effects analyses revealed that the CI associated with approach was evaluated as being more approachable than the CI associated with avoidance in the VAAST condition (M_{app} = 79.21, SE_{app} = 1.19; M_{av} = 69.33, SE_{av} = 1.33), t(199) = 9.00, $p < .001$, dz = .64, [.35, .92]. This was not the case in the instructions condition (M_{app} = 77.76, SE_{app} =

[15] Some of the reported results required the exclusion of outliers (with an absolute value of the studentized residual > 4). We identified outliers for each regression model. Only one of these exclusions influenced the significance of the reported results, that is, when testing the movement effect for the instructions condition at the condition level.

Figure 8

Approachability Score (Average of Trustworthiness, Reversed Criminality, and Reversed Aggressiveness) as a Function of the Movement (Approach vs. Avoidance) and the Condition (VAAST vs. Instructions) Obtained for Condition-Level CIs



Note. Error bars represent 95% confidence intervals. VAAST = Visual Approach/Avoidance by the Self Task.

1.12; M_{av} = 75.87, SE_{av} = 1.25), $t(193) = 1.13$, $p = .26$, $dz = .08$, [−.20, .36]. The objective metric of pixel luminance was in line with judges' ratings. Specifically, approach and avoidance CIs were more strongly correlated (i.e., more similar) on pixel luminance in the instructions condition ($r = .25$) than in the VAAST condition ($r = .08$), $t(138790) = 25.35$, $p < .001$.

Regarding individual-level CIs, the more conservative (preregistered) mixed-model analyses yielded nonsignificant results as the effect of movement strongly varied between CIs.[16] In contrast, OLS regression analyses (not preregistered) revealed the same pattern as the one observed with the condition-level CIs. The approach-avoidance difference was larger in the VAAST (M_{diff} = −2.11, SE_{diff} = .40) than in the instructions condition (M_{diff} = .46, SE_{diff} = .41), $t(199) = 4.71$, $p < .001$, $dz = .33$, 95% CI [.05, .61]. Moreover, the simple effect of movement in the VAAST condition was significant (M_{app} = 71.25, SE_{app} = .94; M_{av} = 69.14, SE_{av} = 1.01), $t(199) = 5.29$, $p < .001$, $dz = .37$, [.09, .65], but not in the instructions condition (M_{app} = 70.07, SE_{app} = .98; M_{av} = 70.53, SE_{av} = .98), $t(199) = 1.34$, $p = .25$, $dz = −.08$, [−.36, .20].

Discussion

In Experiment 3A, we investigated whether experiencing approach/avoidance actions (VAAST condition) produced a larger effect on the facial representation of approached/avoided groups, compared to not experiencing these actions (instructions condition). As predicted, the difference of approachability between faces associated with approach versus avoidance was larger in the VAAST than in the instructions condition. The same pattern emerged with individual-level CIs when using OLS regression analyses and with the more objective metric of pixel luminance correlation. These results replicate and extend the message from Experiment 1 by showing that this effect can be—at least partly—due to the experience of approach/avoidance actions. Interestingly, our results contrast with some findings that failed to show an impact of experiencing an AAT (e.g., Smith et al., 2019; Van Dessel, De Houwer, Gast, et al., 2016), suggesting that our paradigm is robust enough to produce such effect (see the "General Discussion" section for further discussion).

Although these effects emerged both at the condition and individual level when using OLS regression, mixed-model analyses did not yield consistent results. Because mixed-model analyses consider more sources of variation (e.g., participants and stimuli) than OLS regression, they are more conservative (e.g., Judd et al., 2012; Westfall et al., 2014). In fact, our OLS regression analysis only included a single source of variance, that is, the judges, while ignoring the variation that may stem from the classification images, that is, the different ratings for the same individual-level CI. The variability of judgments on individual-level CIs (specifically, the variability of the movement effect, as reported in Footnote 17) appeared to be large enough that our effects of interest, evidenced with classical regression, were no longer significant in the mixed-model analysis.

The variation stemming from the evaluations of individual-level CIs may originate from several—and not necessarily exclusive—sources. On the one hand, the high variability between ratings of the same CIs may come from the variability in the judges' expectations about the to-be-rated facial features (e.g., criminality; Oliveira, Garcia-Marques, & Dotsch, 2019). On the other hand, individual-level CIs are considerably noisier and thus harder to read and rate by independent judges than averaged group-based CIs (Imhoff et al., 2013).[17] Both factors may have increased the interrating variability for the same individual CI. One way to address this issue is to improve the signal-to-noise ratio of the individual-level CIs. Experiment 3B sought to improve the CIs' quality by computing subgroup-level CIs averaged from a set of individual-level CIs (for a similar reasoning, see Cone et al., 2020).

Experiment 3B

Performing analyses of the CI's rating at the condition or individual level always comes with a trade-off. Indeed, condition-level CIs are of much better quality (i.e., improved signal-to-noise ratio) because they are composed of a very large number of trials (e.g., in the thousands), in comparison to individual CIs that are based on far fewer trials (e.g., in the hundreds). At the same time,

[16] Mixed-model analyses on individual-level CIs (for a similar design, see Degner et al., 2019) yielded nonsignificant results regarding the movement by condition interaction, $t(160.82) = 1.26$, $p = .21$, and the simple effect of movement both in the VAAST condition, $t(162.28) = 1.52$, $p = .13$, and in the instructions condition, $t(164.67) = 0.48$, $p = .80$. The variability of the movement effect for individual-level CIs was significant, $\chi^2 = 5570.1$, $p < .001$.

[17] The relatively low quality of individual-level CIs could come from creators' difficulty in mapping their facial representation of the approached/avoided group onto a face space (Oliveira, Garcia-Marques, & Dotsch, 2019) or from measurement errors (e.g., reduced number of trials; see Brinkman, Goffin, et al., 2019).

because condition-level CIs average all individual CIs from a given condition, they do not reflect potential between-individual variations captured by individual CIs (i.e., variations stemming from idiosyncratic visual representations of the target). As a result, they may lead to an increase in Type-I error (Cone et al., 2020). One strategy to handle the poor quality of individual-level CIs is to compute CIs at a subgroup level (rather than overall group CIs) based on a smaller set of individual-level CIs. Clearly, subgroup-level CIs benefit from an improved quality over individual CIs while retaining a large portion of the variability between individual CIs that condition-level CIs necessarily ignore. This means that one can model subgroup CIs with mixed-model analyses while avoiding an increase of Type-I error (Cone et al., 2020). Experiment 3B tested whether results of Experiment 3A could replicate when we improved the signal-to-noise ratio of the CIs by computing subgroup CIs (i.e., by averaging CIs of 10 randomly selected individual-level CIs) and using mixed-model analyses.

Method

Subgroup CIs Processing

We built each subgroup-level CI by using 10 randomly selected individual-level CIs within the same experimental condition. Specifically, we randomly selected 10 CI creators from Experiment 3A and generated (by averaging, as we did for previously for the other CIs) an approach subgroup-level CI from the 10 individual CIs associated with approach and an avoidance subgroup-level CI from the 10 individual CIs associated with avoidance. This means that these two approach and avoidance subgroup-level CIs came from the same sample of 10 creators (given that they performed two blocks in the reverse correlation task; one for the approach group and one for the avoided group). We repeated this process until we generated 800 subgroup-level CIs:[18] 400 for the VAAST and 400 for the instructions condition (200 associated with approach and 200 associated with avoidance within each condition).

Participants

We treated both participants and subgroups as random factors in a mixed-model analysis. We recruited 101 judges—at least five estimations per subgroup CI were sufficient given that we maximized the number of subgroup CIs (see Westfall et al., 2014)—giving us 80% power to detect a movement (approach vs. avoidance) by condition (VAAST vs. instructions) interaction effect of at least $d = .14$. Participants were Foule Factory users (M_{age} = 42.03, SD_{age} = 12.96; 42 male) who took part in exchange for USD $1.24.

Procedure

The experiment was programmed and administered online via JavaScript, and the procedure was similar to Experiment 3A, Part 2. After providing their informed consent, participants learned that the study was about face perception and that they had to evaluate 40 faces on the three same traits as in Experiments 1, Part 2a, and 3A (Likert scale from 0 = *not at all* to 100 = *very much;* with 10 as the incremental value). The 40 CIs were randomly selected among the pool of 800 subgroup-level CIs. For a given participant, 20 CIs came from the VAAST condition, and 20 CIs came from the instructions condition, with half of them from approach and the other half from avoidance. As before, we presented the CIs one by one in a random order, and the scales were adjacent to each other, always in the same order.

Results

As before, aggressiveness and criminality scores were highly correlated, $r = .78$, $t(4038) = 79.97$, $p < .001$, while trustworthiness correlated more modestly with aggressiveness, $r = -.48$, $t(4038) = 35.22$, $p < .001$, and criminality, $r = -.49$, $t(4038) = 35.98$, $p < .001$. We computed an approachability score for each subgroup-level CI. To test our hypothesis, we estimated a mixed model with movement (approach vs. avoidance), condition (VAAST vs. instruction), and their interaction as fixed effects, and we estimated the related relevant random intercepts and slopes for judges (i.e., movement, condition, and their interaction slopes) and subgroup-level CIs (i.e., movement slope). We report only the fixed effects.

First, the difference between approach and avoidance CIs was significantly larger in the VAAST condition ($M_{diff} = -3.23$, SE_{diff} = .67) compared to the instructions condition ($M_{diff} = .49$, SE_{diff} = .59), $t(265.81) = 2.89$, $p = .004$, $dz = .40$, 95% CI [.01, .79]. Second, our simple-effects analysis revealed that in the VAAST condition, the approach CIs were evaluated as more approachable than the avoidance CIs ($M_{app} = 68.44$, $SE_{app} = 1.48$; $M_{av} = 65.36$, SE_{av} = 1.54), $t(259.10) = 3.30$, $p = .001$, $dz = .48$, [.08, .88]. In the instructions condition, however, this effect was not significant (M_{app} = 66.36, $SE_{app} = 1.59$; $M_{av} = 66.85$, $SE_{av} = 1.52$), $t(267.18) = .80$, p = .42, $dz = -.08$, [−.48, .31].

Discussion

Experiment 3B aimed to replicate the OLS regression results obtained in Experiment 3A with a more conservative test. In the present experiment, we did not change the content of the data but simply increased the signal-to-noise ratio by creating subgroup CIs based on individual-level CIs. These results are in line with the idea that the nonsignificant findings obtained in Experiment 3A when using mixed-model analyses were likely due to the extreme weakness of the signal in the individual-level CIs. Accordingly, this subgroup technique seems promising because it produces CIs of higher quality—given that the subgroup-level rests on samples of individual-level CIs. At the same time, the analysis avoids the inflation of the Type-I error while allowing a finer-grained analysis than the condition-level CIs.

Taken together, Experiments 3A and 3B support our hypothesis that actually experiencing an AAT with the VAAST contributes to the effect on the visual representations compared to facing mere instructions about approach/avoidance. In other words, some aspects of the AAT contribute to leading to this effect. Given that the two conditions differed on several points (e.g., number of associations between approach/avoidance and groups of faces; Woud et al., 2011), however, we cannot single out any aspect in particular. At the same time, because a grounded cognition approach holds that our experiences of approach/avoidance are stored by

[18] The subgroup-level CIs were generated with a scaling constant = 0.012.

means of their sensorimotor aspects in memory, the sensory (here, visual) characteristics implemented in the AAT are likely to be a significant factor. In Experiment 4, we isolated the visual aspect (i.e., the visual feedback) associated with approach/avoidance actions and tested whether this aspect plays a role in leading to a biased perception.

Experiment 4

In Experiment 4, we tested the importance of one specific property of the AAT, namely its sensory (here, visual) aspects. We designed two between-participants conditions. The VAAST condition was the same as in Experiments 1 and 3A in that participants performed approach/avoidance actions and received the visual information associated with these actions. The without feedback (WF) condition eliminated the visual information of the self moving forward/backward in the visual environment. Consequently, both conditions involved approach/avoidance actions (i.e., explicit instructions and pressing the approach and avoidance keys), but these actions were associated with their sensory aspects only in the VAAST condition. Because approach/avoidance actions should be represented through their sensory(motor) activations in memory and cognition (e.g., Barsalou, 1999; Versace et al., 2014), the multimodal representations associated with approach and avoidance behaviors should be reactivated more strongly in the VAAST condition. Ultimately, this reactivation should lead to a larger effect on the visual representation of the approached/avoided groups of faces. To test this hypothesis, we relied on judges' ratings for both condition and subgroup levels, as well as on the pixel luminance correlations between condition-level CIs.

Method

Part 1: Creation of CIs Resulting From Approach Versus Avoidance Actions in the VAAST Versus WF Conditions

Participants and Design. We planned our sample size based on Experiment 3A. One hundred sixty-six undergraduate students (M_{age} = 21.40, SD_{age} = 4.97; 41 male) took part in exchange for course credit or for a lottery with the opportunity to win USD $28.19. This experiment used a 2 (Condition: VAAST vs. WF) × 2 (Movement: approach vs. avoidance) × 2 (Background Color: blue vs. yellow) × 2 (Group of Faces: Group 1 vs. Group 2) × 2 (Group Order in the Reverse Correlation: Group 1 first vs. Group 2 first) design with the first and the last variables being between participants. The design of both conditions was the same as in Experiments 1 and 3A. For the reverse correlation, the design was the same as in Experiment 3A except that participants went through two blocks of 150 trials (instead of 100) each.

Procedure. ***Approach/Avoidance Training.*** We randomly assigned participants to either the VAAST or the WF condition. In the VAAST condition, the procedure was the same as in Experiments 1 and 3A. The procedure in the WF condition was that of the VAAST condition with the only exception that no visual feedback was associated with approach/avoidance actions. Specifically, when participants pressed the approach (Y) or avoidance (N) keys, the face and the visual environment remained constant with no visual feedback simulating a forward/backward movement in the virtual environment. After a delay of 500 ms, the face disappeared, signaling to the participants that the trial ended.

Reverse Correlation. After the AAT, participants went through the brief-RC with the same procedure as in Experiment 3A (Schmitz et al., 2021). We generated 900 pairs of noisy faces.

CIs Processing. We processed CIs at both the condition and subgroup level. Regarding the four condition-level CIs, we relied on the same procedure as in Experiment 3A (see Figure 9). Regarding subgroup-level CIs, we relied on the same procedure as in Experiment 3B: Based on the 166 CI creators (thus 332 individual-level CIs), we generated 600 subgroup-level CIs: 300 for the VAAST condition and 300 for the WF condition (150 associated with approach and 150 associated with avoidance within each condition). Regarding the pixel luminance correlations of the condition-level CIs, we relied on the same procedure as in Experiment 3A.

Part 2: CIs Ratings by Independent Judges on Other-Relevant Traits

In Part 2, we tested whether the difference between approach and avoidance CIs differed as a function of the VAAST versus WF condition. We did so for both condition- and subgroup-level CIs.

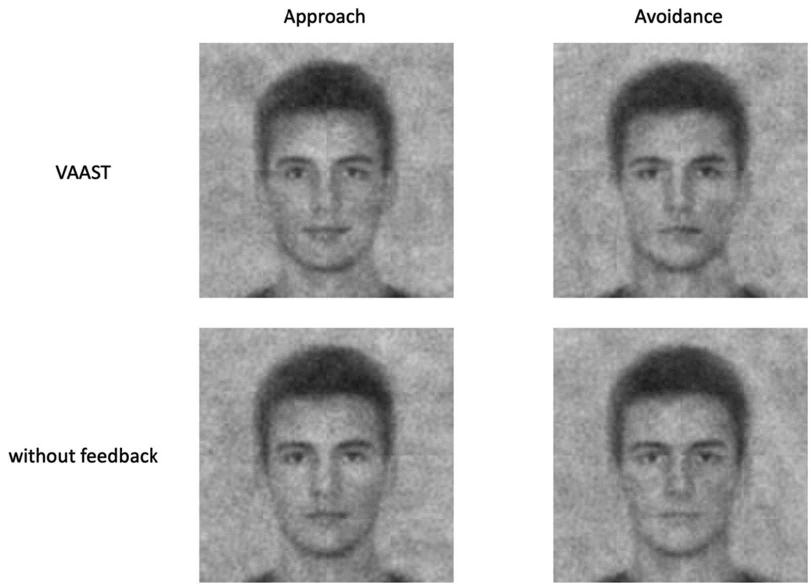
Participants. Relying on Experiment 3B, we recruited 99 judges to conduct a similar mixed-model analysis based on subgroup CIs. This provided us with 80% power to detect a movement (approach vs. avoidance) by condition (VAAST vs. WF) interaction effect of d = .14. Participants came from Foule Factory (M_{age} = 42.82, SD_{age} = 12.98; 31 male) and took part in exchange for USD $1.24.

Procedure. The procedure was similar to Experiment 3B except that each participant rated 60 subgroup-level CIs (instead of 40) along with the condition-level CIs. The 60 CIs were randomly selected from the pool of 600 subgroup-level CIs with the constraint that 30 CIs came from the VAAST condition and 30 from the WF condition and that half of these 30 CIs were composed of CIs associated with approach and the other half with avoidance. Participants evaluated the subgroup-level CIs before the condition-level CIs.

Results

Aggressiveness and criminality scores were highly correlated, r = .81, t(6334) = 109.30, p < .001, as well as trustworthiness with aggressiveness, r = −.60, t(6334) = 59.18, p < .001, and criminality, r = −.56, t(6334) = 54.04, p < .001. We computed an approachability score for each condition- and subgroup-level CI. Regarding condition-level CIs, we analyzed our results using OLS regression with movement (approach vs. avoidance), condition (VAAST vs. WF), and their interaction as factors. Regarding subgroup-level CIs, we analyzed our results using a mixed-model analysis. We estimated the same factors as fixed effects, and we estimated the relevant random intercepts and slopes for judges (i.e., movement, condition, and their interaction slopes) and subgroup-level CIs (i.e., movement slope). We expected the AAT effect on the visual representations to be larger in the VAAST condition compared to the WF condition, translating into more dissimilar CIs (i.e., larger difference on judge ratings and smaller pixel luminance correlation) in the VAAST condition.

Figure 9
Condition-Level CIs as a Function of Movement (Approach vs. Avoidance) and Condition (VAAST vs. Without Feedback)



Note. VAAST = Visual Approach/Avoidance by the Self Task.

First, the difference between approach and avoidance condition-level CIs for judges' ratings was significantly larger in the VAAST condition ($M_{diff} = -21.21$, $SE_{diff} = 1.83$) than in the WF condition ($M_{diff} = 9.02$, $SE_{diff} = 1.28$), $t(98) = 6.76$, $p < .001$, $dz = .68$, 95% CI [.27, 1.09] (see Figure 10). This interaction effect was also significant for subgroup-level CIs, with a larger approach-avoidance difference in the VAAST condition ($M_{diff} = -7.58$, $SE_{diff} = .80$) than in the WF condition ($M_{diff} = 2.79$, $SE_{diff} = .43$), $t(305.45) = 3.81$, $p < .001$, $dz = .64$, [.23, 1.04]. The objective metric of pixel luminance was in line with judges' ratings, with approach and avoidance CIs correlating more strongly on pixel luminance (i.e., being more similar) in the WF condition ($r = .25$) than in the VAAST condition ($r = .15$), $t(138790) = 17.15$, $p < .001$.

Second, our simple-effects analyses revealed that, in the VAAST condition, the CI associated with approach was evaluated as being more approachable than the CI associated with avoidance both at the condition ($M_{app} = 79.93$, $SE_{app} = 1.47$; $M_{av} = 58.51$, $SE_{av} = 1.97$), $t(98) = 11.71$, $p < .001$, $dz = 1.18$, 95% CI [.74, 1.61], and at the subgroup level ($M_{app} = 71.37$, $SE_{app} = 1.44$; $M_{av} = 63.79$, $SE_{av} = 1.62$), $t(254.88) = 7.25$, $p < .001$, $dz = .95$, [.53, 1.37]. In the WF condition, this effect was also significant both at the condition ($M_{app} = 69.12$, $SE_{app} = 1.62$; $M_{av} = 60.09$, $SE_{av} = 1.89$), $t(98) = 7.03$, $p < .001$, $dz = .70$, [.26, 1.12], and at the subgroup level ($M_{app} = 65.95$, $SE_{app} = 1.55$; $M_{av} = 63.16$, $SE_{av} = 1.66$), $t(302.80) = 3.46$, $p < .001$, $dz = .65$, [.24. 1.06].

Discussion

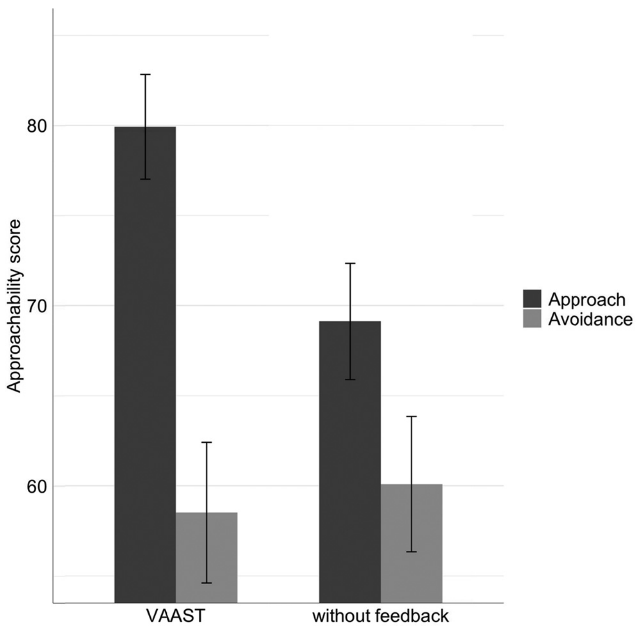
As predicted, the AAT yielded a larger bias on the visual representation in the presence of the sensory (here, visual) aspects of approach/avoidance. This effect emerged in judges' ratings for both condition and subgroup levels and in pixel luminance correlations for condition-level CIs. Importantly, we found this effect by comparing two conditions that were almost identical, that is, differing only with respect to the visual information of approach/avoidance. In line with Experiment 3A, these results highlight the importance of implementing the core properties of approach/avoidance experiences in the AAT.

One remaining question is whether the sensory information of approach/avoidance could lead to an effect on its own, that is, without the need for explicit approach/avoidance instructions. A grounded cognition approach would predict that the effect should emerge even in these circumstances. However, one possibility is that the impact of the visual aspects of approach/avoidance observed in Experiment 4 only shows in the presence of explicit approach/avoidance instructions. In other words, the sensory information could fuel the semantic information but would fail to have an impact as such. Experiment 5 directly tested whether an AAT that does not capitalize on explicit instructions could nevertheless produce an effect on the visual representation.

Experiment 5

Although our data are consistent with the idea that mimicking the core aspects of approach/avoidance actions in the AAT is important (cf. Experiments 3A–4), they remain silent as to whether the explicit instructions play a crucial role in and of themselves. Said otherwise, we do not know if a biased perception can emerge in the absence of semantic instructions about approach/avoidance actions. The message emanating from the literature is unclear. Some experiments showed that AAT evaluative consequences result from the mere activation of sensorimotor aspects of approach/avoidance (e.g., using flexion/extension of the arm; Cacioppo et al., 1993; Kawakami et al., 2007), whereas other efforts failed to find such effect (e.g., using body posture; Nuel et al., 2019). Experiment 5 tested whether our AAT procedure with

Figure 10
Approachability Score (Average of Trustworthiness, Reversed Criminality, and Reversed Aggressiveness) as a Function of the Movement (Approach vs. Avoidance) and the Condition (VAAST vs. Without Feedback) Obtained for Condition-Level CIs



Note. Error bars represent 95% confidence intervals. VAAST = Visual Approach/Avoidance by the Self Task.

the VAAST produces an effect on the visual representation under such minimal conditions (see Rougier et al., 2018, for a similar procedure).

Method

Part 1: Creation of CIs Resulting From Approach Versus Avoidance Actions

Participants and Design. Given that we had only one AAT condition in the present experiment, we estimated that we needed approximately the same number of face creators as in Experiment 1. One hundred twenty Prolific Academic users (M_{age} = 32.21, SD_{age} = 10.89; 60 male and three other) took part in exchange for USD $3.22. We removed one participant because of his error rate (greater than 30%) in the VAAST, leaving a sample of 119 participants (M_{age} = 32.25, SD_{age} = 10.92; 59 male and three other). We used a 2 (Movement: approach vs. avoidance) × 2 (Background Color: blue vs. yellow) × 2 (Group of Faces: Group 1 vs. Group 2) × 2 (Group Order in the Reverse Correlation: Group 1 first vs. Group 2 first) design with the last variable being between participants. The design was the same as in the VAAST condition of Experiment 4.

Procedure. ***Approach/Avoidance Training.*** The procedure was the same as in the VAAST condition of Experiments 3A and 4 except for a few changes relative to the version of the VAAST and the instructions. First, to maximize the visual feedback of approach/avoidance, we used the multiple-key-press version of the VAAST (as in Experiments 1–3 and 5–6 in Rougier et al., 2018) instead of the one-key-press version as in previous experiments. Instead of pressing the Y and N once, participants pressed each key three times to complete a trial. Each key press resulted in a visual feedback simulating a forward/backward movement in the environment. Second, we told participants that they had to categorize faces as a function of their background color by pressing the Y key or the N key. In other words, we made no mention of approach/avoidance actions.

Reverse Correlation. The reverse correlation procedure was the same as in Experiment 4 (brief-RC; Schmitz et al., 2021). The only difference was that we generated the 900 pairs of noisy faces with a different pattern of noise for generalizability purposes.

CIs Processing. We processed CIs at both the condition and subgroup level. Regarding the two condition-level CIs (see Figure 11) and subgroup-level CIs, we relied on the same procedure as in Experiments 3A and 4. Based on the 119 CI creators (thus 238 individual-level CIs), we generated 400 subgroup CIs: 200 CIs of approach and 200 of avoidance.

Part 2: CIs Ratings by Independent Judges on Other-Relevant Traits

Participants. Seventy Prolific Academic users (M_{age} = 33.91, SD_{age} = 12.16; 37 male) took part in exchange for USD $0.95, giving us 80% power to detect a movement (approach vs. avoidance) effect of d = .26 in our most conservative mixed-model analysis on subgroup CIs. They evaluated both condition-level CIs (OLS regression) and a subset of subgroup-level CIs (mixed model).

Procedure. The procedure was the same as in Experiment 4 except that participants rated 50 subgroup-level CIs (instead of 40) in addition to condition-level CIs. We randomly selected 50 subgroup-level CIs in the pool of 400 CIs such that, for a given participant, half of these CIs comprised CIs associated with approach and the other half CIs associated with avoidance. Participants evaluated subgroup CIs before the condition-level CIs.

Results

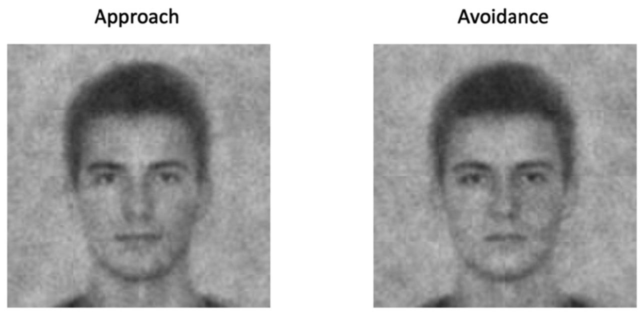
Aggressiveness and criminality scores were highly correlated, $r = .76$, $t(3638) = 71.35$, $p < .001$, while trustworthiness was again moderately correlated with aggressiveness, $r = -.38$, $t(3638) = 25.02$, $p < .001$, and criminality, $r = -.38$, $t(3638) = 24.53$, $p < .001$. We computed an approachability score for each condition- and subgroup-level CI. Regarding condition-level CIs, we analyzed our results using OLS regression with movement (approach vs. avoidance) as factor. Regarding subgroup-level CIs, we analyzed the results using mixed models and estimated the movement factor as a fixed effect and the related relevant random intercepts and slope for judges and subgroup-level CIs.

As expected, at the condition-level CIs, the approach CI (M = 70.05, SE = 2.08) was evaluated as more approachable than the avoidance CI (M = 44.38, SE = 2.38), $t(69) = 8.25$, $p < .001$, dz = .99, 95% CI [.48, 1.49]. This effect was also significant for subgroup-level CIs (M_{app} = 60.17, SE_{app} = 1.32; M_{av} = 53.95, SE_{av} = 1.45), $t(143.00) = 6.20$, $p < .001$, dz = .92, [.42, 1.42].

Discussion

As predicted, an AAT without any semantic aspects of approach/avoidance in the instructions still produced an effect on

Figure 11
Condition-Level CIs as a Function of Movement (Approach vs. Avoidance)



the visual representation. This experiment extends Experiments 3A and 4 by showing that instructions of approach/avoidance are not necessary for an AAT to alter the representation of others' faces. These results are thus difficult to reconcile with the idea that the VAAST produces this effect because it relies on an interplay between approach/avoidance sensory information and instructions about these actions. However, we cannot exclude that participants somehow reconstructed the semantic content of approach/avoidance from the sensory information in the AAT while performing the task (e.g., activation of the proposition "I am approaching blue-background faces"). It thus remains possible that the AAT was not completely devoid of sematic information, but participants had to generate this for themselves (see "General Discussion" section for further discussion). Still, taken together, the results of Experiments 3A–5 are all consistent with the hypothesized processes that the sensory (here, visual) information implemented in the VAAST contribute to the emergence of AAT effects.

General Discussion

AATs are widely considered as useful tools to create or change attitudes (e.g., Becker et al., 2015; Kawakami et al., 2007; Wiers et al., 2010). Past theoretical and empirical work on AAT effects, however, mainly focused on the evaluative aspects of this training technique. As a result, it was unclear whether AAT consequences could go beyond the mere evaluation of stimuli and actually distort their mental representation. Building on a grounded cognition framework (Barsalou, 1999; Versace et al., 2014), we investigated whether an AAT could alter the visual representation of faces in a way that is congruent with the action performed. Additionally, we examined two critical predictions. First, we expected the AAT effect to influence the facial features that are most relevant to approach/avoidance, independently of their evaluative connotation (Experiments 1–2). Second, we critically examined the role of the experiential and sensory aspects of approach/avoidance actions implemented during the training (Experiments 3A–5).

Experiment 1 confirmed our main assumption that an AAT can bias the visual representation of the approached and avoided groups. It also showed that the visual representations differed more on other-relevant traits—that is, the visual representations showed more bias on this category of traits—than on the possessor-relevant traits. Importantly, we replicated this effect for the VAAST condition of Experiments 3A and 4 (see Study 2 in the online supplemental materials), showing that it was not restrained to the visual representations of Experiment 1.

Experiment 2 replicated the effect found in Experiment 1, Part 2b, by relying on extended sets of other- and possessor-relevant traits. Importantly, we controlled our traits on a series of dimensions (valence, emotions, arousal, dominance, face readability), thereby excluding alternative explanations based on potential confounds. We also investigated the individual effect of both approach and avoidance on the visual representations, as compared to a control condition. When relying on other-relevant traits, only the visual representation resulting from avoidance actions differed from the control visual representation. This result suggests that the AAT effect on visual representations is mainly driven by avoidance.

In Experiment 3A, we tested whether experiencing approach/avoidance actions (i.e., performing the AAT) had an added contribution compared to mere instructions of approach/avoidance. In line with our predictions, the visual representations revealed more bias in the VAAST than in the instructions condition, signaling the importance of experiencing approach/avoidance actions. Experiment 3B showed that this effect is robust enough to emerge in a mixed-model analysis when using subgroups of participants instead of the visual representation aggregated at the condition level (which overlooks the interindividual variability) in an OLS regression.

Finally, Experiments 4 and 5 tested the unique contribution of the sensory aspects of approach/avoidance in the AAT. Using a between-participants design, Experiment 4 showed that the sensory information of approach/avoidance in the AAT (i.e., the visual information of the self moving forward/backward) accentuated the bias on the visual representations, compared to not having this information. Experiment 5 further suggested that the explicit information of approach/avoidance in the instructions was not necessary to create an AAT effect on the visual representation.

Overall, these experiments provide multiple replications that an AAT can bias the visual representation of approached/avoided groups of faces. Moreover, and in line with the grounded cognition framework, we found that (a) the bias seems to be more pronounced for the physical features that are most related to approach/avoidance and that (b) the strength of this bias seems to hang on the extent to which the AAT mimics the core properties of approach/avoidance actions (i.e., experiential and sensory properties). Of note, the predicted effects emerged in five preregistered experiments, using different methods (traditional vs. brief reverse correlation, one vs. two base images, condition- vs. subgroup-level CIs), statistics (OLS regression vs. mixed-models), experimental settings (lab and online), and populations (United States and Belgium, homogeneous vs. heterogeneous populations). Finally, and importantly, the large sample sizes used in our experiments further stress the reliability of our findings.

Empirical Contribution to Research on Approach/ Avoidance and Face Perception

A first empirical contribution is that, for the first time, these experiments show that AAT consequences can apply on physical traits in a spontaneous fashion (Experiments 1–5). Indeed, earlier work mainly assessed AAT consequences using constrained tools, that is, tools for which the set of available responses were limited and defined beforehand by the experimenter (valenced labels/traits). The results obtained with these tools thus very much depend on the expectancies of researchers about the nature of the (evaluative) bias (Michalak & Ackerman, 2020). In contrast, the reverse correlation used here allowed participants to produce almost an infinity of faces (e.g., neutral faces, attractive faces, stupid faces) and thus probe a vast array of hypotheses. In spite of this absence of constraints, the visual outcomes were in line with our hypotheses. Our experiments thus replicate the evaluative consequences of an AAT on faces as stimuli because approach led to an overall pleasant visual representation, as compared to avoidance (e.g., Van Dessel et al., 2015; Woud et al., 2013; Woud et al., 2013). They additionally show that this effect (a) can apply on the physical aspects of faces and (b) can emerge without any constraints (i.e., participants spontaneously produce a face that is congruent with their actions).

A second related contribution is that the visual representations resulting from approach/avoidance actions did not only reveal a bias on their pleasantness but a bias on (other-relevant) traits specifically related to approach/avoidance behaviors (see Experiment 1, Part 2b, and Experiment 2). This finding is consistent with those on approach/avoidance compatibility effects, showing that approach/avoidance tendencies are reactivated primarily as a function of the stimuli relevance to be approached/avoided (Alexopoulos & Ric, 2007; Kaltwasser et al., 2017; Krieglmeyer & Deutsch, 2013; Wentura et al., 2000; Wilkowski & Meier, 2010; but see Degner et al., 2021). Accordingly, we showed for the first time that the link between other-relevant traits and approach/avoidance is bidirectional: Performing approach/avoidance actions will activate in memory the associated facial perceptions (presumably holding other-relevant traits), ultimately shaping the visual aspects of approached versus avoided stimuli. It is worth mentioning that the reverse correlation technique proved useful to unveil this effect—in contrast to constrained measures—because it enables a complex mixture of traits (e.g., trustworthiness, sociability) or even ineffable features to appear on the faces (Mangini & Biederman, 2004).

A third contribution is to provide a robust procedure to probe AAT effects, as compared to past AAT research. First, past findings showed that AAT evaluative effects are not produced so easily when using faces as stimuli (e.g., Vandenbosch & De Houwer, 2011; Van Dessel, De Houwer, Roets, & Gast, 2016; Woud et al., 2013; but see Woud et al., 2013). For example, Vandenbosch and De Houwer (2011) failed to reproduce Woud et al.'s (2008) results when reanalyzing their data and failed to replicate their findings when using a similar procedure (see also Woud, et al., 2011). Remarkably, we produced our main AAT effect several times with effect sizes varying from medium (dz = .48 in Experiment 3B) to very large (dz = 2.27 in Experiment 1, Part 2b, for other-relevant traits). Second, results regarding the importance of experiencing an AAT (vs. having the mere instructions) as well as the sensory(motor) aspects of approach/avoidance are rather mixed (e.g., Cacioppo et al., 1993; Kawakami et al., 2007; Kurdi & Banaji, 2017, 2019; Nuel et al., 2019; Smith et al., 2019; Van Dessel, De Houwer, Gast, et al., 2016). With our procedure, we found that both experiential and sensory aspects of approach/ avoidance play a substantial role in producing the expected AAT effects (Experiments 3A–5).

Although our data might appear somehow inconsistent with recent AAT findings (e.g., Nuel et al., 2019; Van Dessel, De Houwer, Gast, et al., 2016), the most notable difference between past and present work concerns the approach/avoidance manipulation. As we argued, the VAAST maximizes what should theoretically be the most prototypical sensory information of approach/avoidance. In contrast, past AAT experiments did not rely on these prototypical sensory features (e.g., Nuel et al., 2019; Van Dessel, De Houwer, Gast, et al., 2016). In all likelihood, the use of the VAAST may account for the discrepancies between past and present results regarding the role of the experiential and sensory(motor) aspects in the AAT (Rougier et al., 2018; but see Batailler et al., 2021). Clearly, future work should investigate whether more prototypical sensory information leads to larger AAT effects, going beyond the impact of its mere presence as tested in the present contribution (see Experiments 3A and 4).

A fourth and final empirical contribution is to show that the visual representation of people's faces is not only a function of attitudes, stereotypes, or previous knowledge (Dotsch et al., 2008, 2011, 2013; Imhoff et al., 2013; Ratner et al., 2014; Young et al., 2014) but can also result from self-generated behaviors. Importantly, the visual bias depended on the behavioral experience and did not show up in the case of mere knowledge about approach/ avoidance actions (Experiment 3A). This suggests that, in our case, the face distortion mainly derived from the low-level aspects of one's behaviors (i.e., experiencing approach/avoidance with all the associated sensory information) rather than from the higher-level information associated (i.e., the knowledge that one approached/avoided or that one was supposed to do so; Experiments 3A and 4). Overall, the visual representation of others also depends on one's behavior: Without the need for any further information than our own reactions (e.g., goals), we can come up with a representation of how others look.

Theoretical Advances

The ambition of the present contribution was to test a series of specific predictions derived from a grounded cognition framework (Barsalou, 1999, 2008; Versace et al., 2014). As a set, the findings dove nicely with this theoretical approach, especially regarding the aspects of the visual representation that should be the most biased by the AAT and the experiential and sensory moderators of this effect. At the same time, our results may appear less easy to reconcile with other accounts and thus impose new constraints on current explanations of AAT effects.

First, the explanations falling under the general umbrella of the traditional associative learning account (operant evaluative conditioning account, Woud et al., 2008; common-coding account, Eder & Klauer, 2009; self-anchoring account, Phills et al., 2011; motivational-systems accounts, Neumann & Strack, 2000) have a hard time explaining some of our results. Indeed, these accounts hold that AAT effects are due to an associative transfer between the valence of approach (positive) and avoidance (negative) actions and the approached/avoided stimuli. However, if AAT effects only depend on the evaluative properties of approach/avoidance, other, nonvalenced aspects of approach/avoidance actions (here, trait relevance aspects) are not predicted to affect the representation of stimuli, as was the case in Experiments 1, Part 2b, and 2.

Additionally, because these views differ regarding the evaluative processes (i.e., how the valenced properties of approach/avoidance are represented and transferred onto the stimulus), they do not fully account for the results observed in Experiments 3A–5. Given that the motivational, self-anchoring, and operant conditioning accounts all confer a key role to experiencing approach/avoidance and/or the proprioceptive cues coming with these actions,[19] these explanations are consistent with results of Experiments 3A–4. In contrast, because the common-coding account relies on symbolic codes to represent the action more than on the actual behavior (Eder & Klauer, 2009; Van Dessel, Eder, & Hughes, 2018), this view is less well equipped to explain the importance of experiencing approach/avoidance actions or the importance of their sensory aspects.

Second, although the more recent inferential account is currently gaining support (Van Dessel et al., 2019; see also Corneille & Stahl, 2019), our results depart from this perspective by showing the unique contribution of the core properties of approach/avoidance in Experiments 3A–4. According to Van Dessel et al. (2019; see also De Houwer, 2009, 2014), AAT effects would result from a four-step inferential process: From the information given to participants (e.g., approaching Stimulus A) and their previous knowledge about approach/avoidance actions (e.g., “I generally approach positive things”), they would automatically draw inferences regarding the evaluative value of a stimulus (e.g., “Stimulus A must be positive”; “I like it”). Because propositional processes are central in the inferential account, this view is well suited to account for past findings showing that AAT effects can emerge from the mere instructions of approach/avoidance (e.g., Van Dessel et al., 2015). However, because experiencing an AAT and learning approach/avoidance instructions should be redundant information (because these are activating the same propositional structures), this account would not predict different effects between experience- and instruction-based AATs, as we found in Experiment 3A (Kurdi & Banaji, 2017, 2019). In the same vein, the presence/absence of the sensorimotor information of approach/avoidance should not moderate the activation of the propositional structures.

Overall, the grounded cognition framework emerges as the most comprehensive and parsimonious account when it comes to explaining the pattern of results obtained in the present experiments. This is the case for both the nonevaluative consequences of an AAT (cf. associative learning account) and the importance of the core properties of approach/avoidance in the training (cf. inferential account). Our results are indeed consistent with the idea that the sensory aspects of approach/avoidance actions reactivate the respective perceptions routinely associated with these actions from memory, ultimately biasing the visual representations of the two groups of faces seen during the AAT. Importantly, however, all of the current theoretical explanations would predict that both approach and avoidance should have an effect of their own (i.e., distinct from control actions)—except the self-anchoring account that would only predict an effect of approach actions (i.e., the opposite of what we found; Phills et al., 2011). As such, results of Experiment 2 seem at odds with current theoretical approaches, including a grounded cognition approach.

Limitations and Future Directions

Beyond the empirical and theoretical contributions of the present endeavor, Experiment 2 challenges not only current theoretical approaches of AAT but also a grounded cognition approach as depicted in the introduction section. Indeed, Experiment 2 showed that the AAT effect on visual representations mainly resulted from avoidance actions. These results depart from our expectations because we reasoned that if both approach and avoidance actions reactivate their respective associated perception in memory, both representations of the approached and avoided groups should be biased in a more approachable versus avoidable manner.

On the one hand, post hoc theoretical explanations based on a grounded cognition approach could reconcile these results. For instance, it is possible that the perception associated with approach is less clearly defined than the one of avoidance. Indeed, past work on approach/avoidance compatibility effects showed that approach actions can activate from drastically opposed goals. For instance, people may enact approach behaviors either to affiliate with or to attack/aggress another person (Bossuyt et al., 2014; Krieglmeyer & Deutsch, 2013). In comparison, avoidance refers less ambiguously to the goal of fleeing. Accordingly, whereas the multimodal representation of approach would be related to various—and sometimes opposed—perceptions of others (e.g., a trustworthy face in the case of affiliative approach or to a threatening face in the case of aggressive approach), this would be less the case for avoidance (avoidable face). Consistently, we did not provide any contextual information about the goal underlying approach in the current experiment (i.e., we just asked participants to “approach by moving forward” or we even did not provide any explicit information at all). Accordingly, various perceptions could have acted to bias the visual representation, leading to a relatively ambiguous visual representation. In line with this idea, the contextual framing of approach/avoidance seems to be an important component for AAT effects emergence (Laham et al., 2014). To address this possibility, future work should test whether inducing an affiliative versus an aggressive contextual goal influences the visual representation of approach.

On the other hand, these results call for some degree of caution, especially because past findings showed that approach plays a

[19] Due to a larger activation of the motivational systems of approach/avoidance for the motivational account (Neumann & Strack, 2000), the self-concept for the self-anchoring account (Phills et al., 2011), or the approach/avoidance state for the operant conditioning account (Woud et al., 2008).

distinct role in the evaluative consequences of AATs (e.g., Kawakami et al., 2008; Phills et al., 2011). Because our work is the first to use the reverse correlation method to assess AAT consequences, future work should seek to corroborate our findings with different methodologies. For instance, the average positivity of the base image that we used in Experiment 2 could have played a role. Indeed, in Experiment 1, the visual representations of the Base Image 2 were evaluated, on average, more positively than the ones of Group 1 (M_{base1} = 51.85, SE_{base1} = 1.53; M_{base2} = 66.06, SE_{base2} = 1.53), $t(70) = 9.27$, $p < .001$, $dz = -1.10$, 95% CI [−1.61, −.59], and the AAT effect was larger for the Base Image 1 than for the Base Image 2. Although we did not have a control condition to compare these visual representations, these results might indicate that the measure of the visual representation of approach and avoidance is sensitive to the base image used in the experiment and, possibly, to its average evaluation (see also Dotsch & Todorov, 2012).

A second limitation of the present work concerns the hypothesis that the sensory aspects of approach/avoidance are sufficient in and of themselves to produce an AAT effect. Indeed, our Experiment 5 is consistent with the idea that the sensory aspects alone (i.e., without explicit instructions) can produce this effect, but it does not constitute strong evidence (see also Rougier et al., 2018). As already mentioned, we cannot exclude the possibility that participants themselves generated a semantic content of approach/avoidance based on the visual information. However, it seems particularly challenging to design an experiment that would completely exclude any aspect of semantic activation. Whatever the sensorimotor aspects involved, an automatic activation of the semantic aspects of approach/avoidance is always a possibility. Still, it should be possible to limit potential controlled aspects of a semantic recategorization process, for instance, by reducing the awareness of the approach/avoidance visual feedback—for example, using parafoveal visual features of a forward/backward movement—and/or by measuring the contingency awareness of the visual feedback as being approach/avoidance and then test whether the AAT effect depends on this factor.

Third, because our results suggest that an AAT can bias the visual representations of unknown groups of faces, the next question is whether such an effect can also apply to visual representations that already exist in people's minds (e.g., social groups; Dotsch et al., 2008). As one would expect, the literature suggests that it is more difficult to modify existing attitudes than to create attitudes toward novel stimuli (Gregg et al., 2006; Hofmann et al., 2010; Van Dessel et al., 2015; Woud et al., 2013). Consistently, research on AAT evaluative consequences is mixed when it comes to this category of stimuli (Centerbar & Clore, 2006; Radke et al., 2018; Vandenbosch & De Houwer, 2011; Van Dessel et al., 2015; Woud et al., 2008, 2011, 2013). Yet, because of the obvious practical implications of such a question (e.g., changing a prejudiced visual representation), we deem it important for future work to investigate AAT effects on the visual representation of existing groups of stimuli.

Fourth, the present work raises the question of the special status of AATs as attitude change paradigms. Specifically, one may wonder whether an AAT with the VAAST would produce distinct effects compared to other attitude change paradigms relying on repeated evaluative pairings with valenced stimuli, such as in the evaluative conditioning procedure (Baeyens et al., 1992). One crucial aspect of the AAT is to reproduce real-life behaviors (moving forward/backward). In line with this idea, Experiments 1 and 2 suggests that the visual consequences are specific to the approach and avoidance actions performed in the AAT (i.e., leading to a more other-relevant visual representation). However, it remains unknown whether the behavioral aspects of approach/avoidance in the AAT are indeed necessary to obtain biased visual representations or if these effects can also emerge in a procedure that does not rely on these specific features such as an evaluative pairing procedure. We would expect that a task built on repeated pairing of faces (conditioned stimuli, initially neutral) with valenced stimuli (unconditioned stimuli, positive or negative) should result in a more positive/negative visual representation but would not replicate the effects observed in Experiments 1 and 2 (i.e., a larger bias on other-relevant traits). Conducting such an experiment would greatly contribute to establishing the AAT as an effective but also specific procedure in the kind of effects it produces.

Finally, in the present contribution, we focused on the AAT consequences on the visual aspects of the multimodal representation of others. We reasoned that approach/avoidance actions should reactivate the visual representation of others whom we usually approach/avoid—ultimately biasing the visual representations. Because our theoretical reasoning relies on the idea of multimodal representations in memory, we would expect this training to manifest its influence beyond the visual domain. For instance, an AAT could also modify the auditory representation of others (e.g., toward a more trustworthy voice in the case of approach). By using an adapted reverse correlation paradigm to capture the auditory representation (instead of this visual one, e.g., Ponsot et al., 2018), we could assess the auditory consequences of an AAT. This kind of work would strengthen the idea that AAT effects can apply to the entire multimodal representation and not only to its visual components.

Conclusion

Using state-of-the-art tools, the present research examined whether our own actions of approach/avoidance shape our mental image of others. Because classical (associative or propositional) approaches remain silent as to whether and how such an effect would emerge, we opted for a grounded cognition approach. This theoretical perspective led us to investigate various moderators of the AAT effect. Although our findings do not provide a definitive answer on the matter, the present efforts shed light on a series of important moderators of the AAT effect on the visual representation of social targets.

References

Abele, A. E., Ellemers, N., Fiske, S. T., Koch, A., & Yzerbyt, V. (2020). Navigating the social world: Toward an integrated framework for evaluating self, individuals, and groups. *Psychological Review*. Advance online publication. https://doi.org/10.1037/rev0000262

Abele, A. E., & Wojciszke, B. (2007). Agency and communion from the perspective of self versus others. *Journal of Personality and Social Psychology*, *93*(5), 751–763. https://doi.org/10.1037/0022-3514.93.5.751

Alexopoulos, T., & Ric, F. (2007). The evaluation-behavior link: Direct and beyond valence. *Journal of Experimental Social Psychology*, *43*(6), 1010–1016. https://doi.org/10.1016/j.jesp.2006.10.017

Aubé, B., Rougier, M., Muller, D., Ric, F., & Yzerbyt, V. (2019). The online-VAAST: A short and online tool to measure spontaneous approach and avoidance tendencies. *Acta Psychologica*, *201*, Article 102942. https://doi.org/10.1016/j.actpsy.2019.102942

Baeyens, F., Eelen, P., Crombez, G., & van den Bergh, O. (1992). Human evaluative conditioning: Acquisition trials, presentation schedule, evaluative style and contingency awareness. *Behaviour Research and Therapy*, *30*(2), 133–142. https://doi.org/10.1016/0005-7967(92)90136-5

Barsalou, L. W. (1999). Perceptions of perceptual symbols. *Behavioral and Brain Sciences*, *22*(4), 637–660. https://doi.org/10.1017/S0140525X99532147

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology*, *59*(1), 617–645. https://doi.org/10.1146/annurev.psych.59.103006.093639

Barsalou, L. W., Niedenthal, P. M., Barbey, A. K., & Ruppert, J. A. (2003). Social embodiment. In B. Ross (Ed.), *Psychology of learning and motivation: Advances in research and theory* (pp. 43–92). Academic Press. https://doi.org/10.1016/s0079-7421(03)01011-9

Barsalou, L. W., Simmons, W. K., Barbey, A. K., & Wilson, C. D. (2003). Grounding conceptual knowledge in modality-specific systems. *Trends in Cognitive Sciences*, *7*(2), 84–91. https://doi.org/10.1016/S1364-6613(02)00029-3

Batailler, C., Muller, D., Nurra, C., Rougier, M., & Trouilloud, D. (2021). Math approach training changes implicit identification with math: A close preregistered replication. *Journal of Experimental Social Psychology*, *92*, Article 104059. https://doi.org/10.1016/j.jesp.2020.104059

Beauvois, J.-L., & Dubois, N. (2000). Affordances in social judgment: Experimental proof of why it is a mistake to ignore how others behave towards a target and look solely at how the target behaves. *Swiss Journal of Psychology*, *59*(1), 16–33. https://doi.org/10.1024//1421-0185.59.1.16

Becker, D., Jostmann, N. B., Wiers, R. W., & Holland, R. W. (2015). Approach avoidance training in the eating domain: Testing the effectiveness across three single session studies. *Appetite*, *85*, 58–65. https://doi.org/10.1016/j.appet.2014.11.017

Bem, D. J. (1972). Self-perception theory. *Advances in Experimental Social Psychology*, *6*, 1–62. https://doi.org/10.1016/s0065-2601(08)60024-6

Bossuyt, E., Moors, A., & De Houwer, J. (2014). On angry approach and fearful avoidance: The goal-dependent nature of emotional approach and avoidance tendencies. *Journal of Experimental Social Psychology*, *50*, 118–124. https://doi.org/10.1016/j.jesp.2013.09.009

Brinkman, L., Dotsch, R., Zondergeld, J., Koevoets, M. G., Aarts, H., & van Haren, N. E. (2019). Visualizing mental representations in schizophrenia patients: A reverse correlation approach. *Schizophrenia Research: Cognition*, *17*, Article 100138. https://doi.org/10.1016/j.scog.2019.100138

Brinkman, L., Goffin, S., van de Schoot, R., van Haren, N., Aarts, H., & Dotsch, R. (2019). Quantifying the informational value of classification images. *Behavior Research Methods*, *17*, 1–15. https://doi.org/10.3758/s13428-019-01232-2

Brinkman, L., Todorov, A., & Dotsch, R. (2017). Visualising mental representations: A primer on noise-based reverse correlation in social psychology. *European Review of Social Psychology*, *28*(1), 333–361. https://doi.org/10.1080/10463283.2017.1381469

Cacioppo, J. T., Priester, J. R., & Berntson, G. G. (1993). Rudimentary determinants of attitudes: II. Arm flexion and extension have differential effects on attitudes. *Journal of Personality and Social Psychology*, *65*(1), 5–17. https://doi.org/10.1037/0022-3514.65.1.5

Carrier, A., Dompnier, B., & Yzerbyt, V. (2019). Of nice and mean: The personal relevance of others' competence drives perceptions of warmth. *Personality and Social Psychology Bulletin*, *45*(11), 1549–1562. https://doi.org/10.1177/0146167219835213

Centerbar, D. B., & Clore, G. L. (2006). Do approach-avoidance actions create attitudes? *Psychological Science*, *17*(1), 22–29. https://doi.org/10.1111/j.1467-9280.2005.01660.x

Chen, M., & Bargh, J. A. (1999). Consequences of automatic evaluation: Immediate behavioral predispositions to approach or avoid the stimulus. *Personality and Social Psychology Bulletin*, *25*(2), 215–224. https://doi.org/10.1177/0146167299025002007

Cone, J., Brown-Iannuzzi, J. L., Lei, R., & Dotsch, R. (2020). Type I error is inflated in the two-phase reverse correlation procedure *Social Psychological and Personality Science*. Advance Online Publication. https://doi.org/10.1177/1948550620938616

Corneille, O., & Stahl, C. (2019). Associative attitude learning: A closer look at evidence and how it relates to attitude models. *Personality and Social Psychology Review*, *23*(2), 161–189. https://doi.org/10.1177/1088868318763261

Courset, R., Rougier, M., Palluel-Germain, R., Smeding, A., Jonte, J. M., Chauvin, A., & Muller, D. (2018). The Caucasian and North African French Faces (CaNAFF): A face database. *Revue Internationale de Psychologie Sociale*, *31*, 1–10. https://doi.org/10.5334/irsp.179

Damasio, A. R. (1989). Time-locked multiregional retroactivation: A systems-level proposal for the neural substrates of recall and recognition. *Cognition*, *33*(1–2), 25–62. https://doi.org/10.1016/0010-0277(89)90005-X

Degner, J., Mangels, J., & Zander, L. (2019). Visualizing gendered representations of male and female teachers using a reverse correlation paradigm. *Social Psychology*, *50*(4), 233–251. https://doi.org/10.1027/1864-9335/a000382

Degner, J., Muller, D., Reichardt, R., Ric, F., & Rougier, M. (2021). *The interaction of valence and relevance in automatic approach-avoidance tendencies*. Unpublished manuscript.

De Houwer, J. (2009). The propositional approach to associative learning as an alternative for association formation models. *Learning & Behavior*, *37*(1), 1–20. https://doi.org/10.3758/LB.37.1.1

De Houwer, J. (2014). A propositional model of implicit evaluation. *Social and Personality Psychology Compass*, *8*(7), 342–353. https://doi.org/10.1111/spc3.12111

De Houwer, J., Crombez, G., Baeyens, F., & Hermans, D. (2001). On the generality of the affective Simon effect. *Cognition and Emotion*, *15*(2), 189–206. https://doi.org/10.1080/02699930125883

Dotsch, R. (2015). *rcicr:* Reverse-correlation image-classification toolbox (R Package Version 0.3.0) [Computer software]. https://rdrr.io/cran/rcicr/man/rcicr-package.html

Dotsch, R., Wigboldus, D. H. J., Langner, O., & van Knippenberg, A. (2008). Ethnic out-group faces are biased in the prejudiced mind. *Psychological Science*, *19*(10), 978–980. https://doi.org/10.1111/j.1467-9280.2008.02186.x

Dotsch, R., Wigboldus, D. H. J., & van Knippenberg, A. (2011). Biased allocation of faces to social categories. *Journal of Personality and Social Psychology*, *100*(6), 999–1014. https://doi.org/10.1037/a0023026

Dotsch, R., Wigboldus, D. H. J., & van Knippenberg, A. (2013). Behavioral information biases the expected facial appearance of members of novel groups. *European Journal of Social Psychology*, *43*(1), 116–125. https://doi.org/10.1002/ejsp.1928

Dotsch, R., & Todorov, A. (2012). Reverse correlating social face perception. *Social Psychological and Personality Science*, *3*, 562–571. https://doi.org/10.1177/1948550611430272

Eder, A. B., & Klauer, K. C. (2009). A common-coding account of the bidirectional evaluation–behavior link. *Journal of Experimental Psychology: General*, *138*(2), 218–235. https://doi.org/10.1037/a0015220

Fazio, R. H., Jackson, J. R., Dunton, B. C., & Williams, C. J. (1995). Variability in automatic activation as an unobtrusive measure of racial attitudes: A bona fide pipeline? *Journal of Personality and Social Psychology*, *69*(6), 1013–1027. https://doi.org/10.1037/0022-3514.69.6.1013

Gleibs, I. H. (2017). Are all "research fields" equal? Rethinking practice for the use of data from crowdsourcing market places. *Behavior Research Methods*, *49*(4), 1333–1342. https://doi.org/10.3758/s13428-016-0789-y

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. K. (1998). Measuring individual differences in implicit cognition: The Implicit Association

Test. *Journal of Personality and Social Psychology*, *74*(6), 1464–1480. https://doi.org/10.1037/0022-3514.74.6.1464

Gregg, A. P., Seibt, B., & Banaji, M. R. (2006). Easier done than undone: Asymmetry in the malleability of implicit preferences. *Journal of Personality and Social Psychology*, *90*(1), 1–20. https://doi.org/10.1037/0022-3514.90.1.1

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). Most people are not WEIRD. *Nature*, *466*(7302), 29. https://doi.org/10.1038/466029a

Hintzman, D. L. (1984). MINERVA 2: A simulation model of human memory. *Behavior Research Methods, Instruments, & Computers*, *16*, 96–101. https://doi.org/10.3758/BF03202365

Hofmann, W., De Houwer, J., Perugini, M., Baeyens, F., & Crombez, G. (2010). Evaluative conditioning in humans: A meta-analysis. *Psychological Bulletin*, *136*(3), 390–421. https://doi.org/10.1037/a0018916

Huijding, J., Field, A. P., De Houwer, J., Vandenbosch, K., Rinck, M., & van Oeveren, M. (2009). A behavioral route to dysfunctional representations: The effects of training approach or avoidance tendencies towards novel animals in children. *Behaviour Research and Therapy*, *47*(6), 471–477. https://doi.org/10.1016/j.brat.2009.02.011

Hütter, M., & Genschow, O. (2019). What is learned in approach-avoidance tasks? On the scope and generalizability of approach-avoidance effects. *Journal of Experimental Psychology: General*, *149*(8), 1460–1476. https://doi.org/10.1037/xge0000728

Imhoff, R., & Dotsch, R. (2013). Do we look like me or like us? Visual projection as self-or ingroup-projection. *Social Cognition*, *31*(6), 806–816. https://doi.org/10.1521/soco.2013.31.6.806

Imhoff, R., Woelki, J., Hanke, S., & Dotsch, R. (2013). Warmth and competence in your face! Visual encoding of stereotype content. *Frontiers in Psychology*, *4*, Article 386. https://doi.org/10.3389/fpsyg.2013.00386

Jones, C. R., Vilensky, M. R., Vasey, M. W., & Fazio, R. H. (2013). Approach behavior can mitigate predominately univalent negative attitudes: Evidence regarding insects and spiders. *Emotion*, *13*(5), 989–996. https://doi.org/10.1037/a0033164

Judd, C. M., Westfall, J., & Kenny, D. A. (2012). Treating stimuli as a random factor in social psychology: A new and comprehensive solution to a pervasive but largely ignored problem. *Journal of Personality and Social Psychology*, *103*(1), 54–69. https://doi.org/10.1037/a0028347

Judd, C. M., Westfall, J., & Kenny, D. A. (2017). Experiments with more than one random factor: Designs, analytic models, and statistical power. *Annual Review of Psychology*, *68*, 601–625. https://doi.org/10.1146/annurev-psych-122414-033702

Kaltwasser, L., Moore, K., Weinreich, A., & Sommer, W. (2017). The influence of emotion type, social value orientation and processing focus on approach-avoidance tendencies to negative dynamic facial expressions. *Motivation and Emotion*, *41*(4), 532–544. https://doi.org/10.1007/s11031-017-9624-8

Kawakami, K., Phills, C. E., Steele, J. R., & Dovidio, J. F. (2007). Close distance makes the heart grow fonder: Improving implicit racial attitudes and interracial interactions through approach behaviors. *Journal of Personality and Social Psychology*, *92*(6), 957–971. https://doi.org/10.1037/0022-3514.92.6.957

Kawakami, K., Steele, J. R., Cifa, C., Phills, C. E., & Dovidio, J. F. (2008). Approaching math increases math = me and math = pleasant. *Journal of Experimental Social Psychology*, *44*(3), 818–825. https://doi.org/10.1016/j.jesp.2007.07.009

Krieglmeyer, R., & Deutsch, R. (2013). Approach does not equal approach: Angry facial expressions evoke approach only when it serves aggression. *Social Psychological and Personality Science*, *4*, 607–614. https://doi.org/10.1177/1948550612471060

Kurdi, B., & Banaji, M. R. (2017). Repeated evaluative pairings and evaluative statements: How effectively do they shift implicit attitudes? *Journal of Experimental Psychology: General*, *146*(2), 194–213. https://doi.org/10.1037/xge0000239

Kurdi, B., & Banaji, M. R. (2019). Attitude change via repeated evaluative pairings versus evaluative statements: Shared and unique features. *Journal of Personality and Social Psychology*, *116*(5), 681–703. https://doi.org/10.1037/pspa0000151

Laham, S. M., Kashima, Y., Dix, J., Wheeler, M., & Levis, B. (2014). Elaborated contextual framing is necessary for action-based attitude acquisition. *Cognition and Emotion*, *28*(6), 1119–1126. https://doi.org/10.1080/02699931.2013.867833

Mangini, M., & Biederman, I. (2004). Making the ineffable explicit: Estimating the information employed for face classifications. *Cognitive Science*, *28*(2), 209–226. https://doi.org/10.1207/s15516709cog2802_4

Markman, A. B., & Brendl, C. M. (2005). Constraining theories of embodied cognition. *Psychological Science*, *16*(1), 6–10. https://doi.org/10.1111/j.0956-7976.2005.00772.x

Michalak, N. M., & Ackerman, J. (2020). A multi-method approach to measuring mental representations of threatening others. *PsyArXiv*. https://doi.org/10.31234/osf.io/r3uea

Neumann, R., & Strack, F. (2000). Approach and avoidance: The influence of proprioceptive and exteroceptive cues on encoding of affective information. *Journal of Personality and Social Psychology*, *79*(1), 39–48. https://doi.org/10.1037/0022-3514.79.1.39

Niedenthal, P. M. (2007). Embodying emotion. *Science*, *316*(5827), 1002–1005. https://doi.org/10.1126/science.1136930

Niedenthal, P. M., Barsalou, L. W., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in attitudes, social perception, and emotion. *Personality and Social Psychology Review*, *9*(3), 184–211. https://doi.org/10.1207/s15327957pspr0903_1

Nørretranders, T. (1998). *The user illusion* (J. Sydenham, Trans.). Viking.

Nuel, I., Fayant, M.-P., & Alexopoulos, T. (2019). Science manipulates the things and lives in them": Reconsidering approach-avoidance operationalization through a grounded cognition perspective. *Frontiers in Psychology*, *10*, Article 1418. https://doi.org/10.3389/fpsyg.2019.01418

Oliveira, M., Garcia-Marques, T., & Dotsch, R. (2019). Combining traits into a face: A reverse correlation approach. *Social Cognition*, *37*(5), 516–545. https://doi.org/10.1521/soco.2019.37.5.516

Oliveira, M., Garcia-Marques, T., Dotsch, R., & Garcia-Marques, L. (2019). Dominance and competence face to face: Dissociations obtained with a reverse correlation approach. *European Journal of Social Psychology*, *49*(5), 888–902. https://doi.org/10.1002/ejsp.2569

Oosterhof, N. N., & Todorov, A. (2008). The functional basis of face evaluation. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(32), 11087–11092. https://doi.org/10.1073/pnas.0805664105

Paladino, M.-P., & Castelli, L. (2008). On the immediate consequences of intergroup categorization: Activation of approach and avoidance motor behavior toward ingroup and outgroup members. *Personality and Social Psychology Bulletin*, *34*(6), 755–768. https://doi.org/10.1177/0146167208315155

Peer, E., Brandimarte, L., Samat, S., & Acquisti, A. (2017). Beyond the Turk: Alternative platforms for crowdsourcing behavioral research. *Journal of Experimental Social Psychology*, *70*, 153–163. https://doi.org/10.1016/j.jesp.2017.01.006

Peer, E., Vosgerau, J., & Acquisti, A. (2014). Reputation as a sufficient condition for data quality on Amazon Mechanical Turk. *Behavior Research Methods*, *46*(4), 1023–1031. https://doi.org/10.3758/s13428-013-0434-y

Peeters, G. (1983). Relational and informational pattern in social cognition. In W. Doise & S. Moscovici (Eds.), *Current issues in European social psychology* (pp. 201–237). Cambridge University Press.

Peeters, G., Cornelissen, I., & Pandelaere, M. (2003). Approach-avoidance values of target-directed behaviours elicited by target-traits: The role of evaluative trait dimensions. *Current Psychology Letters: Behaviour, Brain & Cognition*, *2*(11), 1–10. https://doi.org/10.4000/cpl.396

Phills, C. E., Kawakami, K., Tabi, E., Nadolny, D., & Inzlicht, M. (2011). Mind the gap: Increasing associations between the self and blacks with approach behaviors. *Journal of Personality and Social Psychology*, *100*(2), 197–210. https://doi.org/10.1037/a0022159

Ponsot, E., Burred, J. J., Belin, P., & Aucouturier, J. J. (2018). Cracking the social code of speech prosody using reverse correlation. *Proceedings of the National Academy of Sciences*, *115*(15), 3972–3977. https://doi.org/10.1073/pnas.1716090115

Priester, J. R., Cacioppo, J. T., & Petty, R. E. (1996). The influence of motor processes on attitudes toward novel versus familiar semantic stimuli. *Personality and Social Psychology Bulletin*, *22*(5), 442–447. https://doi.org/10.1177/0146167296225002

Radke, S., Kalt, T., Wagels, L., & Derntl, B. (2018). Implicit and explicit motivational tendencies to faces varying in trustworthiness and dominance in men. *Frontiers in Behavioral Neuroscience*, *12*, Article 8. https://doi.org/10.3389/fnbeh.2018.00008

Ratner, K. G., Dotsch, R., Wigboldus, D. H. J., van Knippenberg, A., & Amodio, D. M. (2014). Visualizing minimal ingroup and outgroup faces: Implications for impressions, attitudes, and behavior. *Journal of Personality and Social Psychology*, *106*(6), 897–911. https://doi.org/10.1037/a0036498

Rey, A. E., Riou, B., Muller, D., Dabic, S., & Versace, R. (2015). “The mask who wasn’t there”: Visual masking effect with the perceptual absence of the mask. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*(2), 567–573. https://doi.org/10.1037/xlm0000051

Ric, F., Alexopoulos, T., Muller, D., & Aubé, B. (2013). Emotional norms for 524 French personality trait words. *Behavior Research Methods*, *45*(2), 414–421. https://doi.org/10.3758/s13428-012-0276-z

Rinck, M., & Becker, E. S. (2007). Approach and avoidance in fear of spiders. *Journal of Behavior Therapy and Experimental Psychiatry*, *38*(2), 105–120. https://doi.org/10.1016/j.jbtep.2006.10.001

Rinck, M., Telli, S., Kampmann, I. L., Woud, M. L., Kerstholt, M., Te Velthuis, S., Wittkowski, M., & Becker, E. S. (2013). Training approach-avoidance of smiling faces affects emotional vulnerability in socially anxious individuals. *Frontiers in Human Neuroscience*, *7*, Article 481. https://doi.org/10.3389/fnhum.2013.00481

Rotteveel, M., & Phaf, R. H. (2004). Automatic affective evaluation does not automatically predispose for arm flexion and extension. *Emotion*, *4*(2), 156–172. https://doi.org/10.1037/1528-3542.4.2.156

Rougier, M., Muller, D., Courset, R., Smeding, A., Devos, T., & Batailler, C. (2019). Toward the use of approach/avoidance tendencies as attitude measures: Individual-and group-level variability of the ingroup bias. *European Journal of Social Psychology*, *50*(4), 857–875. https://doi.org/10.1002/ejsp.2653

Rougier, M., Muller, D., Ric, F., Alexopoulos, T., Batailler, C., Smeding, A., & Aubé, B. (2018). A new look at sensorimotor aspects in approach/avoidance tendencies: The role of visual whole-body movement information. *Journal of Experimental Social Psychology*, *76*, 42–53. https://doi.org/10.1016/j.jesp.2017.12.004

Schmitz, M., Rougier, M., & Yzerbyt, V. (2020). Comment on “Quantifying the informational value of classification images”: A miscomputation of the infoVal metric. *Behavior Research Methods*, *52*, 1383–1386. https://doi.org/10.3758/s13428-019-01295-1

Schmitz M., Rougier M., & Yzerbyt V. (2021). *Introducing the brief reverse correlation: An improved tool to assess visual representations*. Unpublished manuscript.

Schmitz, M., & Yzerbyt, V. (2020). Direct and indirect dimensional compensation: Is there a difference between observers and group members? *Group Processes & Intergroup Relations*. Advance online publication. https://doi.org/10.1177/1368430220963176

Seibt, B., Neumann, R., Nussinson, R., & Strack, F. (2008). Movement direction or change in distance? Self- and object-related approach–avoidance motions. *Journal of Experimental Social Psychology*, *44*(3), 713–720. https://doi.org/10.1016/j.jesp.2007.04.013

Slepian, M. L., Young, S. G., Rule, N. O., Weisbuch, M., & Ambady, N. (2012). Embodied impression formation: Social judgments and motor cues to approach and avoidance. *Social Cognition*, *30*(2), 232–240. https://doi.org/10.1521/soco.2012.30.2.232

Smith, C. T., Calanchini, J., Hughes, S., Van Dessel, P., & De Houwer, J. (2019). The impact of instruction- and experience-based evaluative learning on IAT performance: A Quad model perspective. *Cognition and Emotion*, *34*, 21–41. https://doi.org/10.1080/02699931.2019.1592118

Solarz, A. K. (1960). Latency of instrumental responses as a function of compatibility with the meaning of eliciting verbal signs. *Journal of Experimental Psychology*, *59*, 239–245. https://doi.org/10.1037/h0047274

Stoet, G. (2010). PsyToolkit: A software package for programming psychological experiments using Linux. *Behavior Research Methods*, *42*(4), 1096–1104. https://doi.org/10.3758/BRM.42.4.1096

Stoet, G. (2017). A novel web-based method for running online questionnaires and reaction-time experiments. *Teaching of Psychology*, *44*(1), 24–31. https://doi.org/10.1177/0098628316677643

Stolier, R. M., Hehman, E., Keller, M. D., Walker, M., & Freeman, J. B. (2018). The conceptual structure of face impressions. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(37), 9210–9215. https://doi.org/10.1073/pnas.1807222115

Sutherland, C. A. M. (2015). *A basic guide to Psychomorph*. University of York. https://dlib.york.ac.uk/yodl/app/home/detail?id=york:847354&ref=browse

Taylor, C. T., & Amir, N. (2012). Modifying automatic approach action tendencies in individuals with elevated social anxiety symptoms. *Behaviour Research and Therapy*, *50*(9), 529–536. https://doi.org/10.1016/j.brat.2012.05.004

Tiddeman, B. P., Stirrat, M. R., & Perrett, D. I. (2005). Towards realism in facial image transformation: Results of a Wavelet MRF method. *Computer Graphics Forum*, *24*(3), 449–456. https://doi.org/10.1111/j.1467-8659.2005.00870.x

Vandenbosch, K., & De Houwer, J. (2011). Failures to induce implicit evaluations by means of approach–avoid training. *Cognition and Emotion*, *25*(7), 1311–1330. https://doi.org/10.1080/02699931.2011.596819

Van Dessel, P., De Houwer, J., & Gast, A. (2016). Approach–avoidance training effects are moderated by awareness of stimulus–action contingencies. *Personality and Social Psychology Bulletin*, *42*(1), 81–93. https://doi.org/10.1177/0146167215615335

Van Dessel, P., De Houwer, J., Gast, A., & Smith, C. T. (2015). Instruction-based approach-avoidance effects. *Experimental Psychology*, *62*(3), 161–169. https://doi.org/10.1027/1618-3169/a000282

Van Dessel, P., De Houwer, J., Gast, A., Smith, C. T., & De Schryver, M. (2016). Instructing implicit processes: When instructions to approach or avoid influence implicit but not explicit evaluation. *Journal of Experimental Social Psychology*, *63*, 1–9. https://doi.org/10.1016/j.jesp.2015.11.002

Van Dessel, P., De Houwer, J., Roets, A., & Gast, A. (2016). Failures to change stimulus evaluations by means of subliminal approach and avoidance training. *Journal of Personality and Social Psychology*, *110*(1), e1–e15. https://doi.org/10.1037/pspa0000039

Van Dessel, P., De Houwer, J., & Smith, C. T. (2018). Relational information moderates approach-avoidance instruction effects on implicit evaluation. *Acta Psychologica*, *184*, 137–143. https://doi.org/10.1016/j.actpsy.2017.03.016

Van Dessel, P., Eder, A. B., & Hughes, S. (2018). Mechanisms underlying effects of approach-avoidance training on stimulus evaluation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *44*(8), 1224–1241. https://doi.org/10.1037/xlm0000514

Van Dessel, P., Hughes, S., & De Houwer, J. (2019). How do actions influence attitudes? An inferential account of the impact of action performance on stimulus evaluation. *Personality and Social Psychology Review*, *23*(3), 267–284. https://doi.org/10.1177/1088868318795730

Versace, R., Vallet, G. T., Riou, B., Lesourd, M., Labeye, É., & Brunel, L. (2014). Act-in: An integrated view of memory mechanisms. *Journal of Cognitive Psychology*, *26*(3), 280–306. https://doi.org/10.1080/20445911.2014.892113

Warriner, A. B., Kuperman, V., & Brysbaert, M. (2013). Norms of valence, arousal, and dominance for 13,915 English lemmas. *Behavior Research Methods*, *45*(4), 1191–1207. https://doi.org/10.3758/s13428-012-0314-x

Wentura, D., Rothermund, K., & Bak, P. (2000). Automatic vigilance: The attention-grabbing power of approach- and avoidance-related social information. *Journal of Personality and Social Psychology*, *78*(6), 1024–1037. https://doi.org/10.1037/0022-3514.78.6.1024

Westfall, J. (2015). *PANGEA: Power analysis for general ANOVA designs*. Unpublished manuscript. http://jakewestfall.org/publications/pangea.pdf

Westfall, J., Kenny, D. A., & Judd, C. M. (2014). Statistical power and optimal design in experiments in which samples of participants respond to samples of stimuli. *Journal of Experimental Psychology: General*, *143*(5), 2020–2045. https://doi.org/10.1037/xge0000014

Wiers, R. W., Rinck, M., Kordts, R., Houben, K., & Strack, F. (2010). Retraining automatic action-tendencies to approach alcohol in hazardous drinkers. *Addiction*, *105*(2), 279–287. https://doi.org/10.1111/j.1360-0443.2009.02775.x

Wilkowski, B. M., & Meier, B. P. (2010). Bring it on: Angry facial expressions potentiate approach-motivated motor behavior. *Journal of Personality and Social Psychology*, *98*(2), 201–210. https://doi.org/10.1037/a0017992

Wittekind, C. E., Feist, A., Schneider, B. C., Moritz, S., & Fritzsche, A. (2015). The approach-avoidance task as an online intervention in cigarette smoking: A pilot study. *Journal of Behavior Therapy and Experimental Psychiatry*, *46*, 115–120. https://doi.org/10.1016/j.jbtep.2014.08.006

Wojciszke, B., & Abele, A. E. (2008). The primacy of communion over agency and its reversals in evaluations. *European Journal of Social Psychology*, *38*(7), 1139–1147. https://doi.org/10.1002/ejsp.549

Woud, M. L., Becker, E. S., Lange, W.-G., & Rinck, M. (2013). Effects of approach-avoidance training on implicit and explicit evaluations of neutral, angry, and smiling face stimuli. *Psychological Reports*, *113*(1), 199–216. https://doi.org/10.2466/21.07.PR0.113x10z1

Woud, M. L., Becker, E. S., & Rinck, M. (2008). Implicit evaluation bias induced by approach and avoidance. *Cognition and Emotion*, *22*(6), 1187–1197. https://doi.org/10.1080/02699930801906843

Woud, M. L., Becker, E. S., & Rinck, M. (2011). Induction of implicit evaluation biases by approach–avoidance training: A commentary on Vandenbosch and De Houwer (this issue). *Cognition and Emotion*, *25*(7), 1331–1338. https://doi.org/10.1080/02699931.2011.628300

Woud, M. L., Maas, J., Becker, E. S., & Rinck, M. (2013). Make the manikin move: Symbolic approach–avoidance responses affect implicit and explicit face evaluations. *Journal of Cognitive Psychology*, *25*(6), 738–744. https://doi.org/10.1080/20445911.2013.817413

Young, A. I., Ratner, K. G., & Fazio, R. H. (2014). Political attitudes bias the mental representation of a presidential candidate's face. *Psychological Science*, *25*(2), 503–510. https://doi.org/10.1177/0956797613510717

Yzerbyt, V. Y., Muller, D., & Judd, C. M. (2004). Adjusting researchers' approach to adjustment: On the use of covariates when testing interactions. *Journal of Experimental Social Psychology*, *40*(3), 424–431. https://doi.org/10.1016/j.jesp.2003.10.001

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