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What Is Learned in Approach-Avoidance Tasks? On the Scope and Generalizability of Approach-Avoidance Effects

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Previous research has shown that approaching a stimulus makes it more positive, while avoiding a stimulus makes it more negative. The present research demonstrates that approach–avoidance behaviors have the potential to charge stimulus attributes such as color with evaluative meaning. This evaluation carries over to other stimuli with that feature. We address the latter point by assessing the influence of colors that were approached or avoided on the perceived attractiveness of persons wearing those colors. We show that wearing a certain color makes people appear more attractive when this color is associated with approach rather than avoidance. In line with a self-perception account of these effects, we obtained approach–avoidance effects on stimulus attributes only when participants carried out approach–avoidance behaviors toward these colors or imagined doing so. This set of experiments adds to the evaluative learning literature by demonstrating approach–avoidance effects on stimulus attributes and that these effects carry over to new classes of stimuli and new tasks. Moreover, we systematically investigated boundary conditions for these effects. Finally, with this research we introduce an ontogenetic perspective to research into colors and their influence on psychological functioning.

Keywords: attitudes, approach-avoidance, generalization, color, interpersonal attraction

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Previous research has demonstrated a close link between approach-avoidance behaviors and liking as well as attractiveness (Neumann, Förster, & Strack, 2003). Approach behaviors typically increase the attractiveness of an object or person, while avoidance behaviors decrease it. In consumer psychology, it is well documented that the attractiveness of chosen alternatives relative to rejected alternatives increases (Ariely & Norton, 2008; Brehm & Cohen, 1962) and that a higher effort involved in acquiring a commodity increases liking of that commodity (Kim & Labroo, 2011). Likewise, in interpersonal contexts, it has been demonstrated that when individuals signal approach toward a person, their attitudes toward that person become more positive (Chen, Minson, & Tormala, 2010; Lambert, Clark, Durtschi, Fincham, & Graham, 2010; Lambert & Fincham, 2011).

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This quasi-experimental work has been complemented with approach-avoidance paradigms that demonstrate the role of approach and avoidance behaviors experimentally. For example, Kawakami, Steele, Cifa, Phills, and Dovidio (2008) demonstrated the positive impact of approach training on the evaluation of mathematics. Specifically, they used a joystick task in which they prompted participants to perform an approach behavior toward images that represent mathematics and an avoidance reaction toward unrelated stimuli, and vice versa in the control condition. Participants who pulled mathematics-related stimuli toward themselves identified themselves more strongly with mathematics, acquired a more positive attitude toward mathematics, and attempted more tasks in a difficult mathematics quiz than participants in the control condition. A first line of research has also illuminated the positive effects of approach tendencies in the interpersonal context. Specifically, approach trainings have been shown to improve interracial attitudes and interactions (Kawakami, Phills, Steele, & Dovidio, 2007). That is, training participants to approach photographs of black individuals and to avoid photographs of white individuals improved attitudes and behavior toward black individuals as compared to a condition in which participants approached white and avoided black individuals. In the health context, avoidance training has been shown to change the approach bias toward alcohol in alcoholic patients (Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011). In this training, patients were instructed to use a joystick to push away stimuli related to alcohol. As a consequence of this procedure, patients' approach bias toward alcohol turned into an avoidance bias. Moreover, compared to a control group that did not receive this training, patients reported weaker cravings for alcohol and demonstrated better treatment outcomes one year later.

Recent research shows that actually performing approach versus avoidance actions is not a necessary condition for obtaining the reported effects. Van Dessel, De Houwer, Gast, and Smith (2015) demonstrated that the mere instruction to perform approach versus avoidance behaviors toward a neutral stimulus affects the evaluation of this stimulus. Specifically, participants are informed about an allegedly upcoming task in which certain behaviors will have to be performed. Participants are asked to memorize which stimuli require approach behaviors and which stimuli require avoidance behaviors. However, those behaviors are never actually performed. Nevertheless, liking of the to-be-approached stimuli increased, and liking of the to-be-avoided stimuli decreased on direct and indirect evaluative measures. Moreover, such instructed approach–avoidance effects have been demonstrated to be sensitive to relational qualifiers (Van Dessel, De Houwer, & Smith, 2018). That is, evaluative learning effects were stronger when participants were the agents of the behaviors toward the stimuli as compared to a condition in which the stimuli were the agents of approach versus avoidance behaviors toward the participants. These findings suggest that the crucial factor in establishing approach–avoidance effects on evaluations consist in the cognitive representations of the approach versus avoidance action rather than the actual behavior and that the agent of approach and avoidance behavior is crucial in producing effects on evaluations.

Evaluative Learning Toward Stimulus Attributes

Only recently evaluative learning paradigms have been adapted to the study of evaluative learning toward stimulus attributes that are shared by many stimuli. Hütter, Kutzner, and Fiedler (2014) adapted an evaluative conditioning (EC) paradigm for that purpose. An EC procedure consists of the pairing of a conditioned, typically neutral, stimulus (conditioned stimulus (CS)) with an unconditioned stimulus (US) that carries valence. As a consequence of the pairing, the evaluation of the CS (e.g., a particular face) typically changes in the direction of US valence. As an addition to this traditional EC paradigm, Hütter et al.'s (2014) EC procedure contained a contingency between a stimulus attribute (e.g., male and female sex) and the valence of the USs across the individual CS faces. For instance, female faces had a higher probability of being paired negatively than male faces. Hütter et al. (2014) showed that the evaluation of the stimulus attributes reflected the contingency (e.g., female sex was evaluated more negatively than male sex) and that the evaluation of the attribute exerted an effect on the evaluation of the CSs that carried that attribute (e.g., female faces were evaluated more negatively than male faces) over and above the US valence it was paired with. Thus, stimulus attributes acquired evaluative meaning and influenced the evaluation of the stimuli carrying this attribute. In the present research, we investigated whether stimulus attributes can also be isolated from the stimuli used for the approach-avoidance training.

Evaluative Meaning of Colors

Colors are ubiquitous stimulus attributes that constitute an important element of visual appearance. Moreover, color has been assumed to constitute a stimulus attribute that can be charged with meaning. Color has received particular attention in the domain of interpersonal attractiveness, whereby the color red has been assigned a special role. Research has shown that men rate women as more attractive when they wear red or are presented in a red context (Elliot & Niesta, 2008; Lehmann & Calin-Jageman, 2017; Niesta Kayser, Elliot, & Feltman, 2010; see Lehmann, Elliot, & Calin-Jageman, 2018, for a meta-analysis, but see Peperkoorn, Roberts, & Pollet, 2016). The attractiveness of men also seems to be bolstered by the color red (Elliot et al., 2010). Many researchers have suggested that red effects can be explained by the approach versus avoidance connotations that this color carries (Elliot & Maier, 2014; Genschow, Reutner, & Wänke, 2012; Mehta & Zhu, 2009; Reutner, Genschow, & Wänke, 2015). For instance, Rohr, Kamm, Koenigstorfer, Groeppel-Klein, and Wentura (2015) found red to facilitate avoidance responses toward unhealthy foods (but not toward healthy foods). However, to our knowledge there is currently no experimental demonstration that colors acquire approach or avoidance tendencies due to the contingency that individuals experience between colors and approach or avoidance behaviors.

Approach-Avoidance Effects as a Self-Perception Phenomenon

According to self-perception theory, lay individuals interpret their own behaviors to learn about their internal states (Bem, 1967, 1972). For instance, individuals infer their own attitudes from their own overt behavior. That is, they draw inferences from their behaviors toward an object on their attitudes toward that object (Van Dessel, Hughes, & De Houwer, 2019). Indeed, the findings from several applied contexts we summarized above can be rephrased in terms of self-perception theory. For instance, if participants chose one product over the other, they likely infer from this behavior that they liked it more than the other (Ariely & Norton, 2008; Brehm & Cohen, 1962). Moreover, the effort involved in acquiring a certain item can be regarded diagnostic as to how much this person would like to have this item (Kim & Labroo, 2011). Likewise, from expressing gratitude and showing interest in a person one may infer the degree of liking toward that person (Chen et al., 2010; Lambert et al., 2010; Lambert & Fincham, 2011).

Self-perception theory does not only make the prediction that evaluations will change based on approach or avoidance behavior, but it also specifies the conditions under which approach and avoidance behaviors can change the evaluation of stimuli. First, individuals should only use their behavior to infer their attitude when the respective attitudes are weak or ambiguous to start with. This boundary condition fits well with research that demonstrates approach–avoidance effects for unknown social groups, but not groups that individuals know well (Van Dessel et al., 2015). Hence, when individuals have a firm stance toward an attitude object, they do not have to observe their own behavior to infer how they feel about it.

Moreover, who the agent of approach–avoidance behaviors should matter. According to self-perception theory, the positive effects of approach should only be observed when the person evaluating the approached object carried out the approach movement toward that object, but not when the object approached the person. Likewise, the negative effects of avoidance should only become apparent when the person evaluating the avoided object executed the avoidance movement, but not when the object avoided the person. Self-perception theory thus stands in stark contrast to association formation theories that have dominated theorizing on evaluative learning over the last few decades (e.g., Baeyens, Eelen, Crombez, & Van den Bergh, 1992; Eder & Klauer, 2009). According to these theories, learning is not qualified by the relationship between stimuli and behaviors. Hence, approach as a positive behavior should lead to an increase in liking irrespective of the locus of agency.

Testing this inferential phenomenon amounts to manipulating the locus of agency, that is, whether the participant or the target stimulus carries out the movements. According to self-perception theory only the first condition should generate effects on liking and attractiveness. A considerate test of this theory also includes a test of whether merely the perspective of the target stimulus is relevant, that is, whether the target stimulus is approached or avoided (e.g., by another person or deputy agent). If a self-perception mechanism is underlying the evaluative phenomena, a paradigm that manipulates the behaviors only from the perspective of the target stimulus should obtain null effects. Only a paradigm in which participants are the agents of the approach or avoidance behavior toward the stimulus (attribute) should be successful in establishing approach-avoidance effects on evaluation and attractiveness. Finally, a strict test of this theory also regards the impact of a confound in this comparison. That is, when participants are the agent of the behavior, they are active and possibly more involved in the task as compared to a condition in which the target stimulus carries out behaviors. Hence, any difference in effect size may be due to a difference in involvement in the task. Tests of an inference mechanism based on self-perception should thus assess the degree to which task involvement influences the findings.

The Present Research

Most previous research on approach–avoidance effects has assessed the evaluation of the same stimuli used for learning. Research that included untrained stimuli in the test phase demonstrated that approach–avoidance effects generalize to untrained stimuli of the same category. For instance, Wiers, Rinck, Kordts, Houben, and Strack (2010, 2011) demonstrated not only that avoidance training can increase avoidance reactions toward the alcoholic stimuli used during training, but also toward untrained alcoholic stimuli. While such findings demonstrate the power of the approach–avoidance task, it is not clear why these generalization effects occur. There are at least two possibilities (cf. Hütter et al., 2014). First, the evaluative transfer might occur due to the overall similarity of the untrained stimuli to the trained stimuli in multidimensional similarity space. Second, “alcoholic” as an attribute of drinks (or a different attribute that was correlated with alcoholic content) might have acquired new evaluative meaning. Moreover, if the latter is the case, it is unclear whether the evaluation is attached to the category of stimuli circumscribed by the experiment or whether approach–avoidance connotation can be transferred to any novel stimulus displaying this cue. To make a strong claim regarding the approach–avoidance meaning acquired by stimulus attributes, we investigate generalization across stimulus categories and across tasks.

For this purpose, participants exert approach or avoidance behaviors toward one stimulus (i.e., a colored geometric figure) to charge the stimulus attribute (i.e., color) with either an approach or avoidance connotation. Previous research has already shown that participants rate colors they approached more favorably than colors they avoided (Vandenbosch & De Houwer, 2011). Afterward, another stimulus is rated for attractiveness that features the same attribute as the previous stimulus (i.e., a person wearing a t-shirt with the charged color). Because the stimulus attribute was present in a situation in which a person exerted approach or avoidance behaviors, it should serve as a reminder of this behavior in other situations. As a consequence, a person displaying the color that was part of the stimulus that participants approached (or avoided) should be rated more (or less) attractive, even though participants never approached (or avoided) this or any other person during the experiment. Accordingly, we tested the hypothesis that colors will acquire approach or avoidance meaning depending on whether they were displayed by a stimulus that was approached or avoided (Hypothesis 1). This manipulation of approach versus avoidance movements will also become apparent in the attractiveness ratings of persons displaying the colors present at learning (Hypothesis 2).

We also formulate a boundary condition for this effect to occur based on self-perception theory (Bem, 1972). If approach–avoidance effects on attractiveness are a function of self-perception, stimulus attributes should only have an effect when the approach tendencies characterize one’s own behavior. Thus, we should observe no approach–avoidance effects on attractiveness when the stimulus displaying the color executes the approach or avoidance behaviors (Hypothesis 3; Van Dessel et al., 2018).

We report how we determined our sample sizes, all data exclusions (if any), all manipulations, and all measures in the experiments. The stimulus materials and data sets of all experiments are publicly available at https://dx.doi.org/10.5281/zenodo.3378929.

Experiment Series 1

This first line of studies tested Hypotheses 1 and 2. In Experiment 1a, participants were the agent of approach-avoidance behaviors. That is, participants approached or avoided different colored stimuli. In Experiment 1b, the colored stimuli were the agents of the approach-avoidance behaviors. That is, colored stimuli approached or avoided the participants.

Experiment 1a

Experiment 1a implemented a joystick task modeled after Wiers et al. (2010). In this task, participants push some stimuli away from themselves, while they pull others toward themselves. We implemented color as an irrelevant, but perfectly correlated, stimulus feature. After participants completed the approach-avoidance task, we presented participants with portraits of female and male persons wearing the colors that participants had previously approached and avoided. We expected that colors would acquire approach–avoidance meaning (Hypothesis 1) and that colors associated with approach behavior would lead to higher attractiveness ratings than colors associated with avoidance behavior (Hypothesis 2). We used a funnel debriefing procedure to assess whether potential effects on attractiveness ratings were due to demand artifacts of the experiment. We report these results in the online supplemental materials.

Method

Participants. We used G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) to calculate sample size a priori (F tests; ANOVA, Repeated measures, within factors with 2 groups [approach vs. avoidance] and 6 measurements per group [6 portraits per color]). We based calculation of sample size on a small effect ($f = .1$, $\alpha = .05$; $1 - \beta = .80$, $r = .5$) of movement on attractiveness ratings as we lacked experience with this paradigm. Required sample size was 110 participants. As the experiment was part of multiexperiment sessions that lasted up to one hour, we increased sample size in accordance with other studies that required a larger sample size to account for potential data loss. We collected data of 123 (97 female, 26 male) students of different majors at the University of Tübingen. They were between 18 and 58 years old ($M = 23.46$, $SD = 5.60$).[1] Participants received course credit or 4.00 € and a chocolate bar for participation in this experiment.

Design. The design realized one within-participants factor with two levels (movement: approach vs. avoidance). Selecting from all three pretested colors, assignment of specific colors to movement was counterbalanced across participants. Moreover, we controlled for sex of the target stimuli (male vs. female) in our analyses of the attractiveness ratings.

Materials. Material selection was supported by a small pilot test with $N = 17$ (11 female) students of different majors at the University of Tübingen. Participants were between 20 and 26 years old ($M = 23.12$, $SD = 1.41$). Participants rated 22 Caucasian female and 17 Caucasian male portraits from the Radboud Faces Database (Langner et al., 2010) for attractiveness on two 101-point scales. The first item asked "How attractive is this person?" with the end-points of the scale labeled *not at all attractive* and *very attractive*. The second item read: "If I would meet him/her in person, I would think he/she is attractive." The scale reached from *definitely not* to *definitely yes*. The two scales were combined into one attractiveness rating. From this set, we selected 6 male and 6 female portraits with their means at the neutral midpoint of the scale (male: $M = 49.13$, female: $M = 50.58$). The selected male and female portraits showed the smallest differences in attractiveness, $t(10) = -0.49$, $p = .636$, $d = -0.31$.[2] Participants also rated 12 color patches for their approach versus avoidance connotation on a 101-point scale ranging from *approach* to *avoidance*. The same scale was used for an assessment of valence from *negative* to *positive*. We selected three novel and unfamiliar colors (neon pink, RGB [225, 42, 122]; neon yellow, RGB [223, 201, 19]; neon blue, RGB [31, 86, 202]). Those colors showed the smallest differences in approach connotation, $F(2, 34) = 1.16$, $p = .324$, $\eta_p^2 = .064$, and valence, $F(2, 34) = 0.30$, $p = .744$, $\eta_p^2 = .078$.

Procedure. We implemented an adapted version of the joystick-based approach–avoidance task (Wiers et al., 2010, 2011). Participants were presented with triangles that pointed either upward or downward. We instructed participants to push away (avoidance) the triangles pointing upward and to pull toward them (approach) triangles pointing downward. We implemented a perfect contingency between triangle orientation and triangle color. The assignment of colors to the approach versus avoidance movement was counterbalanced across participants. In line with previous research, the joystick response elicited a virtual movement of the picture to strengthen the approach and avoidance character of the movements (Genschow et al., 2013; Genschow, Florack, & Wänke, 2014; Wiers et al., 2010, 2011). That is, in the approach condition the pulling movement gradually increased the size of the triangles until they filled the whole screen. Likewise, in the avoidance condition, the pushing movement gradually decreased the size of the triangles until they disappeared. Importantly, approach stimuli could only be approached and avoidance stimuli could only be avoided. That is, a movement of the joystick inconsistent with orientation (and color) of the triangle did not have any consequence for its size on the screen. Whether or not participants first initiated an incorrect movement was not registered. A given trial lasted until the correct movement was completed. Speed was not encouraged. The next trial started as soon as participants returned the joystick to its default position, but only after an intertrial interval of 500 ms. Participants were prompted to return the joystick to its default position after 500 ms. Participants performed 220 movements per orientation (color) for a total of 440 trials.

In the subsequent attractiveness ratings, participants rated the six male and six female portraits in random order via a single item asking "How attractive do you find this person?" on a 21-point scale ranging from *not at all attractive* to *very attractive*. Colors were assigned at random to portraits with the exception that each color was worn by three male and three female targets.

Participants then completed the funnel debriefing procedure (see online supplemental materials) and reported the conditional probability of triangles of a given color being presented in a particular orientation on a scale from −50 ("exclusively pointing down") to 50 ("exclusively pointing up"). They also rated the two colors for their approach versus avoidance connotations on a 21-point scale ("Do you associate this color more strongly with approach or avoidance?" with the endpoints "approach" and "avoidance"). All rating scales involved the use of a slider whose initial position was the midpoint of the scale. The final demographic section of the experiment also included an item that asked for participants' sexual orientation (with the four options "heterosexual," "homosexual," "bisexual," and "other") as we considered the possibility that sexual orientation could influence the attractiveness ratings.[3]

Results

Conditional probability judgment. Generally, participants reported the conditional probability accurately, reporting that the approach color was present on approach trials ($M = 43.04$, $SD = 18.66$) while the avoidance color was present on avoidance trials

[1] Most participants reported a heterosexual orientation, one reported a homosexual orientation, and six participants reported a bisexual orientation. Eight participants did not indicate their sexual orientation.

[2] Note that the portraits were rated in a context of more attractive and less attractive portraits and that sample size was small. In the subsequent studies that used only the selected portraits, we consistently found differences between the female and male portraits. The RaFD model numbers were 7, 12, 15, 16, 19, 23, 26, 30, 32, 33, 61, 71.

[3] Participants' sexual orientation did not exert a systematic influence on attractiveness ratings. That is, retaining only heterosexual participants for analysis generally did not alter the effects of movement and locus of agency on attractiveness. This observation is in line with the fact that participant gender and target sex did not interact in predicting attractiveness ratings. These analyses are presented in the online supplemental materials. Overall, we have no indication of an influence of sexual orientation on attractiveness ratings in the present set of experiments.

(M = −42.11, SD = 18.62). This difference was significant, $F(1, 122) = 934.58$, $p < .001$, $\eta_p^2 = .885$.

Color ratings. Participants indicated stronger approach connotations for colors paired with approach behaviors (M = 12.93, SD = 5.27) than for colors paired with avoidance behaviors (M = 10.98, SD = 5.38), $F(1, 122) = 5.72$, $p = .018$, $\eta_p^2 = .045$.

Attractiveness ratings. The attractiveness ratings were submitted to a 2 (movement: approach vs. avoidance) × 2 (target sex: male vs. female) repeated-measures ANOVA. They are presented in the left panel of Figure 1. These ratings demonstrated a main effect of movement, $F(1, 122) = 4.95$, $p = .028$, $\eta_p^2 = .039$, indicating that individuals wearing colors that had been approached were perceived as more attractive (M = 10.62, SD = 2.85) than individuals wearing colors that had been avoided (M = 9.83, SD = 2.43). This effect was not moderated by target sex, $F(1, 122) = 0.05$, $p = .829$, $\eta_p^2 = .000$. The main effect of target sex was significant, $F(1, 122) = 4.34$, $p = .039$, $\eta_p^2 = .034$, indicating that female targets were perceived as more attractive (M = 10.47, SD = 0.20) than male targets (M = 9.98, SD = 0.20). The approach (vs. avoidance) connotation that the colors acquired correlated with the attractiveness ratings in both the approach and the avoidance condition (see Table 1).

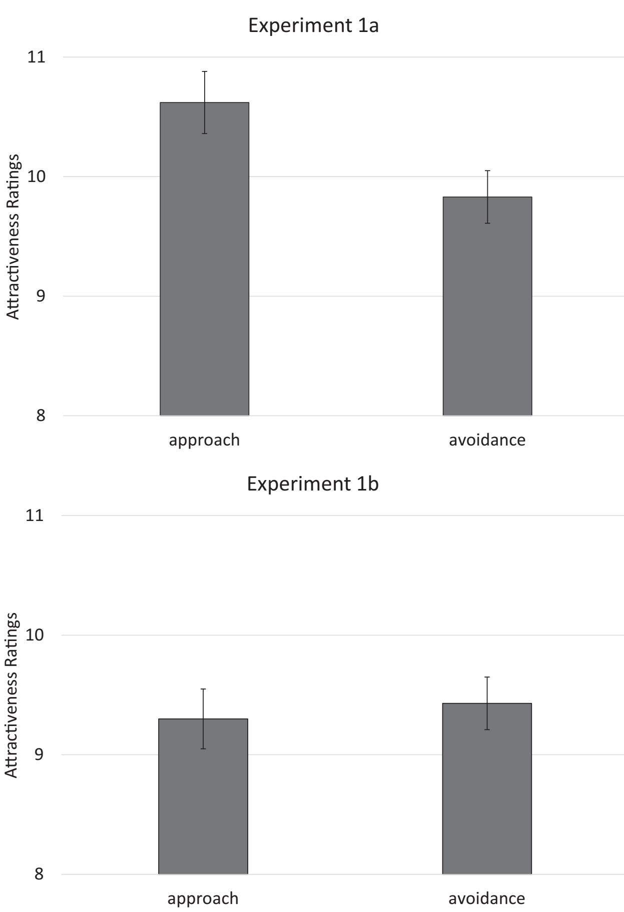

Figure 1. Attractiveness ratings as a function of movement in Experiments 1a and 1b. Error bars represent standard errors.

Discussion

Experiment 1a is the first demonstration that approach and avoidance connotations can be acquired by colors via a simple learning procedure and that these connotations influence attractiveness ratings of individuals wearing these colors. As expected, when the rater approached (or avoided) the color, the wearer of the respective color is rated as more (or less) attractive.

Experiment 1b

Experiment 1b examined whether we would find the same effects as in Experiment 1a if not the participants—but rather the colored stimuli—were the agents of the approach–avoidance behaviors. Self-perception theory (Bem, 1972) states that individuals use their own behavior, but not the behavior of others, as a source for judgments and evaluations. Hence, the effects that we obtained in Experiment 1a should not be obtained in a variant in which the colored stimuli are the agents of approach-avoidance behaviors. On the other hand, it is possible that the perspective of the judge is irrelevant, and any reminder of approach–avoidance behavior would have the same effects. To test these two hypotheses against each other, we conducted Experiment 1b.

Method

Participants. As in the previous experiment, we based calculation of sample size on a small effect ($f = .1$, $\alpha = \beta = .05$) of movement on attractiveness ratings. Required sample size was 110 participants. As the experiment was part of multiexperiment sessions that lasted up to one hour, we increased sample size in accordance with other studies that required a larger sample size to account for potential data loss. We collected data of 119 students (91 female, 19 male) of different majors at the University of Tübingen for this laboratory study. Participants were between 18 and 64 years old (M = 22.90, SD = 6.30).[4]

Design. The design realized one within-participants factor with two levels (movement: approach vs. avoidance). Assignment of specific colors to movement was counterbalanced across participants. We controlled for target sex in the analysis of the attractiveness ratings.

Materials and procedure. Materials and procedure were identical to those of Experiment 1a with three exceptions. First, in this passive version of the approach–avoidance task, participants did not carry out any movements. Instead, the colored stimuli served as the agents of approach-avoidance behaviors. That is, participants watched triangles of different colors increasing versus decreasing in size. Instructions provided a framing for these changes in size. Specifically, participants were told that some triangles would move toward them while others would move away from them. Hence, as in Experiment 1a, the self was employed as a reference point. The number of trials (n = 440) was identical to the approach–avoidance training implemented in Experiment 1a. Second, in this experiment we also assessed an evaluative rating of the colors to investigate whether approach and avoidance manip-

[4] Most participants reported a heterosexual orientation, three reported a homosexual orientation, and five participants reported a bisexual orientation. Eight participants did not indicate their sexual orientation.

Table 1
Correlation Coefficients Reflecting the Degree of Correspondence Between Measures in the Six Experiments

	Correlations of color ratings with attractiveness ratings					
	Evaluation		Approach connotation		Correlations between color ratings	
Condition	Approach	Avoidance	Approach	Avoidance	Approach	Avoidance
Exp. 1a (N = 123)	—	—	.241 (p = .007)	.382 (p = .000)	—	—
Exp. 1b (N = 120)	.197 (p = .031)	.102 (p = .267)	.075 (p = .417)	.098 (p = .285)	.640 (p = .000)	.462 (p = .000)
Exp. 2 (N = 222)	—	—	.052 (p = .441)	.199 (p = .003)	—	—
agent:manikin (N = 112)	—	—	.027 (p = .774)	.231 (p = .014)	—	—
agent:stimulus (N = 110)	—	—	.063 (p = .512)	.165 (p = .086)	—	—
Exp. 3a (N = 401)	.113 (p = .023)	.095 (p = .056)	.125 (p = .012)	.144 (p = .004)	.713 (p = .000)	.693 (p = .000)
agent:manikin (N = 204)	.116 (p = .098)	.124 (p = .077)	.090 (p = .199)	.191 (p = .006)	.721 (p = .000)	.700 (p = .000)
agent:stimulus (N = 197)	.111 (p = .121)	.067 (p = .351)	.160 (p = .025)	.098 (p = .006)	.708 (p = .000)	.686 (p = .000)
Exp. 3b (N = 347)	.054 (p = .314)	.210 (p = .000)	.055 (p = .308)	.212 (p = .000)	.624 (p = .000)	.672 (p = .000)
agent:manikin (N = 174)	.070 (p = .362)	.303 (p = .000)	.066 (p = .388)	.308 (p = .000)	.570 (p = .000)	.660 (p = .000)
agent:stimulus (N = 173)	.043 (p = .578)	.120 (p = .117)	.046 (p = .550)	.116 (p = .129)	.672 (p = .000)	.684 (p = .000)
Exp. 4 (N = 397)	.304 (p = .000)	.355 (p = .000)	.162 (p = .001)	.354 (p = .000)	.429 (p = .000)	.551 (p = .000)
agent:participant (N = 201)	.339 (p = .000)	.403 (p = .000)	.176 (p = .012)	.415 (p = .000)	.435 (p = .000)	.558 (p = .000)
agent:stimulus (N = 196)	.265 (p = .000)	.300 (p = .000)	.134 (p = .061)	.283 (p = .000)	.434 (p = .000)	.537 (p = .000)

ulations would be reflected in participants' evaluations of these colors. Those ratings were assessed on a 21-point scale with the endpoints *very unpleasant* (0) and *very pleasant* (21). Third, we adapted the measure of subjective conditional probability to assess the relation between color and movement more directly. We now asked participants whether they could predict the movement of a triangle from its color. Ratings were given on a 101-point scale with the endpoints *always moved away from me* (−50) and *always moved towards me* (50). Participants used a slider to give a response. The slider initially marked the midpoint of the scale. Participants were instructed to leave the slider in the middle of the scale if the triangle of the respective color moved toward them and away from them equally often.

Results

Subjective conditional probabilities. Subjective conditional probability judgments demonstrated a large effect of movement, $F(1, 118) = 391.56$, $p < .001$, $\eta^2_p = .768$, with approach colors showing a stronger relation to approach movements ($M = 18.89$, $SD = 4.33$) than avoidance colors ($M = 3.28$, $SD = 4.56$).

Color ratings. The approach connotation assigned to colors differed significantly between the colors paired with approach behaviors ($M = 12.35$, $SD = 5.69$) and those paired with avoidance behaviors ($M = 10.42$, $SD = 5.77$), $F(1, 118) = 4.20$, $p = .043$, $\eta^2_p = .034$. On the evaluative rating scale, participants did not evaluate colors that were associated with approach ($M = 12.07$, $SD = 5.16$) more positively than colors associated with avoidance ($M = 12.40$, $SD = 5.33$), $F(1, 118) = 0.10$, $p = .757$, $\eta^2_p = .001$. Nevertheless, ratings of valence and approach connotation were strongly correlated (see Table 1).

Attractiveness ratings. The attractiveness ratings that are displayed in Figure 1 were submitted to a 2 (movement: approach vs. avoidance) × 2 (target sex: male vs. female) repeated-measures ANOVA. We did not obtain a main effect of movement, $F(1, 118) = 0.27$, $p = .605$, $\eta^2_p = .002$. There was a main effect of target sex indicating that female targets ($M = 9.72$, $SD = 0.23$) were perceived as more attractive than male targets ($M = 9.00$, $SD = 0.25$), $F(1, 118) = 7.81$, $p = .006$, $\eta^2_p = .062$. However, target sex did not moderate the effect of movement, $F(1, 118) = 2.17$, $p = .143$, $\eta^2_p = .018$. The approach (vs. avoidance) connotation that the colors acquired generally were not related to the attractiveness ratings (see Table 1).

Discussion

Experiment 1b indicates that when color stimuli are the agents and, thus, approach or avoid the participant, participants do not use color connotations when evaluating the attractiveness of face stimuli. This result suggests that the approach–avoidance effects documented in Experiment 1a constitute a self-perception phenomenon and thereby provides initial support for Hypothesis 3.

Experiment 2

Experiment 2 addresses a confound between the paradigms used in Experiments 1a and 1b that is natural to the agency factor. That is, when participants execute movements toward or away from a colored stimulus (Experiment 1a), they are active. In contrast, when the colored stimulus is the agent of approach and avoidance behaviors (Experiment 1a), participants are passive. Hence, the approach–avoidance effects we observed in Experiment 1a, but not in Experiment 1b, may be due to participants' involvement with the task, rather than the locus of agency. To deal with this shortcoming in Experiment 2, we used a joystick version of the manikin task developed by De Houwer, Crombez, Baeyens, and Hermans (2001). In all conditions, participants were responsible for executing movements. Thus, participants had an active role irrespective of the locus of agency. In the conditions in which the manikin was the agent, they moved a manikin toward colored stimuli (approach) or away from colored stimuli (avoidance). In the condition in which the color stimuli were the agents, participants moved the colored stimuli toward (approach) or away (avoidance) from the manikin, depending on the assigned movement. If taking an active role per se is a crucial factor explaining the differences between Experiments 1a and 1b, and if approach–avoidance effects on stimulus attributes can be explained via associative learning, both the manikin and the color conditions should produce effects on the attractiveness ratings as in Experiment 1a.

Method

Participants. Sample size was based on the calculation for Experiment 1a. We doubled sample size as we included a between-participants factor. As participants served 222 (177 female, 46 male) students of different majors at the University of Tübingen. This sample size allows detecting small effects (i.e., f = .09 with a power of 80% and f = .12 with a power of 95%) regarding the between-within interaction of agent × movement. Participants' age varied between 18 and 54 years (M = 20.82, SD = 3.85).[5] Participants received course credit or 4.00 € and a chocolate bar for participating in this experiment.

Design. The experiment employed a 2 (agent: manikin vs. triangle) × 2 (movement: approach vs. avoid) × 2 (sex of target: female vs. male) mixed design with repeated measures on the last two factors. Selecting from all three pretested colors, assignment of specific colors to movement was counterbalanced across participants. We also counterbalanced the orientation of the triangle that required an approach (vs. avoidance) movement (i.e., upright or reversed) across participants. We controlled for target sex in the analysis of the attractiveness ratings.

Procedure and materials. We modeled the joystick task after the manikin task developed by De Houwer et al. (2001). Specifically, a manikin and a triangle were presented above each other on the screen with relative position counterbalanced across participants. Participants were asked to imagine that the manikin represented themselves. Depending on agent condition, participants were instructed to move the triangle or the manikin. Triangles had two possible orientations, pointing either up or down. As in Experiment 1a, this orientation determined the movement participants had to perform. The mapping of orientation to movement was counterbalanced across participants (i.e., for some participants the triangle pointing down required an approach behavior, for others it required an avoidance behavior). We implemented a perfect contingency between triangle orientation and triangle color. In the avoidance condition, the agent of the behavior (i.e., the manikin or the triangle depending on agent condition) moved out of the screen. In the approach condition, the movement was completed when the agent covered the target of the behavior. Importantly, as in Experiment 1a, participants could only perform the correct movements. Moving the joystick in a direction incompatible with the movement assigned to the triangle did not have any effect. A given trial lasted until the correct movement was completed. Speed was not encouraged. The next trial started as soon as participants brought the joystick back to its default position, but only after an intertrial interval of 500 ms. An error message occurred if the joystick was not in the default position after 500 ms. Participants performed 220 movements per orientation (color) for a total of 440 trials. We implemented the same measures as in Experiment 1a. Evaluative ratings for the colors were not collected in this experiment.

Results

Subjective conditional probabilities. There were no significant differences in conditional probability judgments across approach and avoidance conditions, $F(1, 220) = 0.15$, $p = .703$, $\eta_p^2 = .001$. Thus, participants were unable to report the implemented contingency between color and the orientation of the triangle that determined the required response. The Movement × Agent interaction was not significant, $F(1, 220) = 0.70$, $p = .402$, $\eta_p^2 = .003$ (approach/manikin: $M = -0.01$, $SD = 35.23$; approach/triangle: $M = -3.45$, $SD = 32.10$; avoidance/manikin: $M = -1.98$, $SD = 34.71$; avoidance/triangle: $M = 1.82$, $SD = 29.21$). Locus of agency also did not affect the results, $F(1, 220) = 0.04$, $p = .850$, $\eta_p^2 = .000$.

Color ratings. Colors paired with approach behavior (M = 13.24, SD = 5.38) were rated higher in approach connotation than colors paired with avoidance behavior (M = 9.75, SD = 5.39), $F(1, 122) = 31.04$, $p < .0001$, $\eta_p^2 = .124$. This effect was not moderated by locus of agency, $F(1, 122) = 2.75$, $p = .100$, $\eta_p^2 = .012$.

Attractiveness ratings. Attractiveness ratings were submitted to a 2 (movement: approach vs. avoidance) × 2 (agent: manikin vs. triangle) × 2 (target sex: male vs. female) mixed-model ANOVA with repeated measures on the first and third factors. A marginally significant main effect of movement was obtained, $F(1, 220) = 3.73$, $p = .055$, $\eta_p^2 = .017$, indicating that targets were rated more attractive when they wore an approach (M = 28.52, SD = 8.36) rather than an avoidance color (M = 27.51, SD = 7.38). The interaction of movement and locus of agency did not reach significance, $F(1, 220) = 1.83$, $p = .177$, $\eta_p^2 = .008$. However, the significance of the simple effects differed between conditions in the expected direction. Specifically, the main effect of movement was significant in the agent:manikin condition, $F(1, 111) = 5.51$, $p = .021$, $\eta_p^2 = .047$, but not in the agent:stimulus condition, $F(1, 109) = 0.16$, $p = .688$, $\eta_p^2 = .001$. Except for a main effect of target sex that indicated that female targets (M = 9.53, SD = 0.18) received higher attractiveness ratings than male targets (M = 9.15, SD = 0.18), $F(1, 220) = 4.11$, $p = .044$, $\eta_p^2 = .018$, no other effects were significant, F's ≤ 1.53, p's ≥ .218. The attractiveness ratings per condition are given in Figure 2. We obtained only small, mostly nonsignificant correlations between the ratings of the colors and the attractiveness ratings (see Table 1).

Discussion

Experiment 2 used a joystick version of the manikin task in which participants executed all movements. The experiment demonstrates that task involvement alone is not sufficient for producing approach–avoidance effects on attractiveness.

Experiment Series 3

The experiments in this series were designed to resolve another important confound complicating the interpretation of the differences in results between Experiments 1a and 1b. Specifically, there is ambiguity as to whether the role of the colored stimulus or the role of the rater is crucial in producing these effects, or whether both need to act in concert (i.e., the rater needs to be active in executing approach vs. avoidance movements toward the colored stimuli). Experiments

[5] Reported sexual orientation was "heterosexual" for 191 participants. Six participants reported to be homosexual, seven to be bisexual. Eighteen participants did not provide information on their sexual orientation.

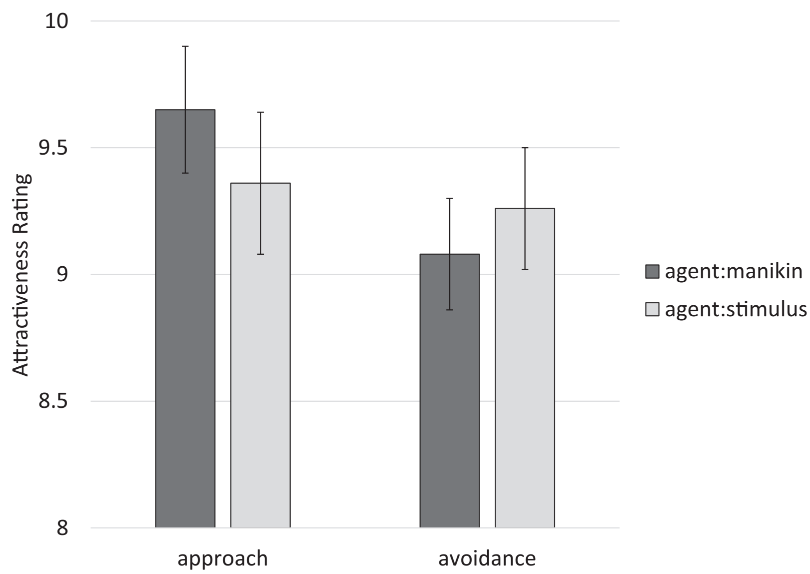

Figure 2. Attractiveness ratings as a function of movement and locus of agency in Experiment 2. Error bars represent standard errors.

3a and 3b thus implemented a task that exclusively manipulated the role of the color. Participants always took on a passive observer role in this setting and did not execute any movements. If the perspective of the color is crucial, then the passive paradigm should also produce effects of approach and avoidance on attractiveness. If the role of the judge in executing these movements is important, these experiments should not show any effects on evaluation of the colors and the attractiveness of the targets wearing these colors.

To design a task that allows manipulating the role of the color independent of the role of the participant, we adapted the manikin task (De Houwer et al., 2001). In the version of the task in which the color is the recipient of an action, the manikin moved either toward the color stimulus or away from it. In the version in which the color is the agent of an action, the color stimulus moved either toward the manikin or away from it. Importantly, participants merely watched these movements.

General Method

As we predicted a null effect on the attractiveness ratings, we ran the experiment in two versions, Experiment 3a and Experiment 3b.

Design. Both experiments realized a 2 (movement: approach vs. avoidance) $\times$ 2 (agent: manikin vs. color stimulus) mixed design with repeated measures on the first factor. Assignment of specific colors to movement was counterbalanced across participants. Our analysis of the attractiveness ratings controlled for target sex.

Materials and procedure. The procedure of Experiment 3a was identical to the previous experiments with small adaptions. The main adaptation concerned the learning phase. On each trial, the manikin and a colored triangle were presented above each other on the screen. Whether the manikin was displayed below or above the colored triangle was counterbalanced across trials. When the manikin (triangle) was the agent of an approach movement, it continuously moved toward the triangle (manikin) until it covered the stimulus. When the manikin (triangle) was the agent of an avoidance movement, it continuously moved away from the triangle (manikin) until it left the screen. The approach and avoidance movements covered the same distance and had the same duration of 1000 ms. The intertrial interval was 250 ms. The learning phase included 160 trials per movement. In total, the learning phase lasted about six and a half minutes. Participants merely watched these movements for the whole period. The measure of subjective conditional probability was adapted and asked participants to indicate the percentage of trials on which each of four events occurred: (a) triangles of this color moved toward the manikin, (b) triangles of this color moved away from this manikin, (c) the manikin moved toward triangles of this color, or (d) the manikin moved away from triangles of this color. The four percentages had to sum up to 100%.

Experiment 3b was identical to Experiment 3a with the following adaptations introduced to the learning phase. First, the number of trials was reduced from 160 to 50 trials per movement. Second, the duration of each trial was increased from 1000 ms to 1400 ms. The learning phase thus amounted to 2.75 min. Third, the experiment was conducted in the laboratory rather than online.

Experiment 3a

Participants. We recruited participants for this online experiment via the official student mailing list of the University of Tübingen. We decided to conclude data collection as soon as the daily return rate would drop below 10 participants. This was the case on the fifth day of data collection. During these five days, 401 participants (287 female, 109 male, 5 “other”) took part in this experiment in exchange for a lottery ticket toward winning one of 10 gift coupons for a major online retail store worth 20 euros each. Participants were between 18 and 50 years old (M = 22.63, SD =

3.75).[6] The sample size achieved allows detecting effects as small as $f = .07$ with a power of $1 - \beta = .80$ and $f = .09$ with a power of $1 - \beta = .95$.

Conditional probability judgments. We analyzed participants' percentage estimates of the correct categories. The correct judgment would have been 100%. Participants reported the contingencies implemented in the learning phase in both the approach ($M = 70.16$; $SD = 31.49$) and avoidance conditions ($M = 67.60$; $SD = 32.81$). In both the approach, $t(400) = 12.82$, $p < .001$ and avoidance conditions, $t(400) = 10.74$, $p < .001$, the estimated conditional probability was larger than 50%.

Submitting participants' estimates to a 2 (movement) $\times$ 2 (agent) ANOVA demonstrates that participants perceived the contingency more accurately in the approach condition than in the avoidance condition, $F(1, 399) = 11.57$, $p < .001$, $\eta_p^2 = .028$. Whether the manikin or the color stimulus was the agent of the movement did not moderate this effect, $F(1, 399) = 0.00$, $p = .995$, $\eta_p^2 = .000$. There was a main effect of agent condition, $F(1, 399) = 15.79$, $p < .001$, $\eta_p^2 = .038$, indicating that participants tended to perceive the contingency more strongly in the condition in which the manikin was the agent rather than the colored stimulus.

Color ratings. The approach connotation assigned to colors differed significantly between the colors paired with approach behaviors ($M = 11.81$, $SD = 5.52$) and those paired with avoidance behaviors ($M = 10.36$, $SD = 5.38$) in the expected direction, $F(1, 399) = 9.92$, $p = .002$, $\eta_p^2 = .024$. Agent condition did not moderate this effect, $F(1, 399) = 0.03$, $p = .867$, $\eta_p^2 = .000$. The main effect of agent condition was also not significant, $F(1, 399) = 2.00$, $p = .158$, $\eta_p^2 = .005$. Participants did not evaluate colors that were associated with approach ($M = 11.67$, $SD = 5.32$) more positively than colors associated with avoidance ($M = 11.04$, $SD = 5.19$), $F(1, 399) = 2.40$, $p = .122$, $\eta_p^2 = .006$, irrespective of agent condition, $F(1, 399) = 0.44$, $p = .506$, $\eta_p^2 = .001$. The correlation between approach ratings and evaluative ratings was significant (see Table 1).

Attractiveness ratings. There was no main effect of movement on the rated attractiveness of the target persons, $F(1, 399) = 0.00$, $p = .966$, $\eta_p^2 = .000$. Agent condition did not influence this result, $F(1, 399) = 0.72$, $p = .397$, $\eta_p^2 = .002$. Again, we obtained an effect of target sex, $F(1, 399) = 44.37$, $p < .001$, $\eta_p^2 = .100$, indicating that female targets ($M = 9.57$, $SD = 0.15$) received higher attractiveness ratings than male targets ($M = 8.56$, $SD = 0.16$). All other effects were nonsignificant, largest $F = 0.80$, smallest $p = .371$. Attractiveness ratings per condition are displayed in Figure 3. As in Experiment 2, we obtained only small correlations between the ratings of the colors and the attractiveness ratings (see Table 1).

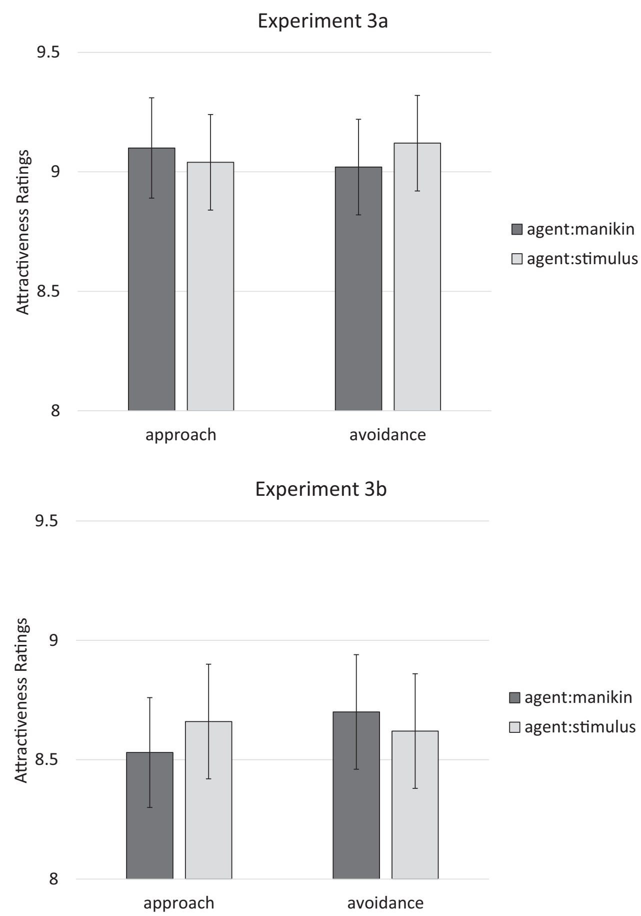

Figure 3. Attractiveness ratings as a function of movement and locus of agency in Experiments 3a and 3b. Error bars represent standard errors.

Experiment 3b

Participants. Participants were recruited on the campuses of the Universities of Tübingen and Cologne. While we targeted the sample size of the previous experiment, we specified fixed periods of several weeks for data collection in labs on campus in Tübingen and Cologne. In total, 347 students (246 female, 99 male, 2 "other") of different majors took part in this experiment. Participants were between 15 and 65 years old ($M = 22.93$, $SD = 5.46$).[7] This sample size allows detecting effects as small as $f = .08$ with a power of $1 - \beta = .80$ and $f = .10$ with a power of $1 - \beta = .95$.

Conditional probability judgments. Participants' judgments reflected the contingencies implemented in the learning phase in both the approach ($M = 65.45$; $SD = 31.28$) and avoidance conditions ($M = 65.17$; $SD = 31.88$). Thus, in both the approach, $t(346) = 9.20$, $p < .001$ and avoidance conditions, $t(346) = 8.86$, $p < .001$, participants estimated the conditional probability to be larger than 50%.

A 2 (movement) $\times$ 2 (agent) ANOVA indicated that neither movement, $F(1, 345) = 0.07$, $p = .793$, $\eta_p^2 = .000$, nor agent condition influenced accuracy, $F(1, 345) = 1.63$, $p = .202$, $\eta_p^2 = .005$. There also was no interaction effect, $F(1, 345) = 0.02$, $p = .903$, $\eta_p^2 = .000$.

Color ratings. The approach connotation assigned to colors differed significantly between the colors paired with approach

[6] Most participants reported a heterosexual orientation, 13 reported a homosexual orientation, and 36 participants reported a bisexual orientation. Twelve participants did not indicate their sexual orientation.

[7] Twelve of the participants reported a homosexual orientation. Twenty-three reported to be bisexual. Five participants did not report their sexual orientation. All others were heterosexual.

behaviors ($M = 11.87$, $SD = 5.64$) and those paired with avoidance behaviors ($M = 10.57$, $SD = 5.75$), $F(1, 345) = 6.17$, $p = .013$, $\eta_p^2 = .018$. Agent condition did not moderate this effect, $F(1, 345) = 0.19$, $p = .661$, $\eta_p^2 = .001$. The main effect of agent condition was also not significant, $F(1, 345) = 0.11$, $p = .741$, $\eta_p^2 = .000$. Participants did not evaluate colors that were associated with approach ($M = 11.21$, $SD = 4.94$) more positively than colors associated with avoidance ($M = 11.42$, $SD = 5.26$), $F(1, 345) = 0.23$, $p = .635$, $\eta_p^2 = .001$, irrespective of agent condition, $F(1, 345) = 0.03$, $p = .856$, $\eta_p^2 = .000$. The correlation between approach ratings and evaluative ratings was significant (see Table 1).

Attractiveness ratings. The attractiveness ratings per condition are displayed in the lower panel of Figure 3. There was no main effect of movement on the rated attractiveness of the target persons, $F(1, 345) = 0.25$, $p = .621$, $\eta_p^2 = .001$. Agent condition did not influence this result, $F(1, 345) = 0.68$, $p = .409$, $\eta_p^2 = .002$. Again, we obtained an effect of target sex, $F(1, 345) = 53.91$, $p < .001$, $\eta_p^2 = .135$, which indicates that female targets ($M = 9.19$, $SD = 0.18$) received higher attractiveness ratings than male targets ($M = 8.07$, $SD = 0.18$). All other effects were nonsignificant, largest $F = 1.21$, smallest $p = .271$. As in Experiment 3a, we obtained only small correlations between the ratings of the colors and the attractiveness ratings (see Table 1).

Discussion

Even in this passive paradigm, the colors acquired approach and avoidance connotations. However, in two high-powered experiments, we did not find any evidence of these connotations influencing the perceived attractiveness of the persons wearing those colors. These experiments are thus the first to indicate that the perspective of the color alone (i.e., whether it is being approached or avoided) is insufficient for generating the effects observed in Experiment 1a. Thus, in these two experiments, we did not obtain any evidence for the effectiveness of vicarious approach and avoidance behaviors. This finding is thus in line with our reasoning that approach–avoidance effects on stimulus attributes constitute a self-perception phenomenon.

Experiment 4

Experiment 4 was designed as a conceptual replication of Experiments 1a and 1b within a single experiment to test Hypothesis 3 more directly. We used an instructed approach–avoidance task that we adapted from Van Dessel et al. (2018). We chose this paradigm as it has been shown to produce large learning effects (Van Dessel et al., 2015), and it keeps the task involvement of participants equal across all conditions.

Method

The experiment was preregistered. The preregistration is available under https://aspredicted.org/h6z3h.pdf.

Participants. We used G*Power (Faul et al., 2007) to determine sample size a priori (F tests; ANOVA: repeated measures, within-between interaction). With the default settings ($r = .5$) and the assumption of a small effect of $f = .1$, $\alpha = .05$, $1 - \beta = .95$; 2 groups (to account for the between-participants agent factor), and 2 measurements (to account for the within-participants factor movement), the required sample size was $N = 328$. To account for 30% data loss due to participants failing the instructional manipulation check, we requested 469 participants on Amazon Mechanical Turk.[8] After completion of the study, however, full data sets of 471 participants had been recorded. In line with our preregistered protocol, we excluded 74 participants that failed the instructional manipulation check. This left us with 397 participants for analysis (151 female, 245 male, 1 "other").[9] Participants were between 19 and 75 years old ($M = 35.24$, $SD = 11.05$).[10]

Design. The experiment employed a 2 (agent: participant vs. color stimuli) × 2 (movement: approach vs. avoid) × 2 (sex of target: female vs. male) mixed design with repeated measures on the last two factors. Assignment of specific colors to movement (2 out of 3) was counterbalanced across participants. We controlled for target sex in the analysis of the attractiveness ratings.

Materials and procedure. The approach-avoidance task consisted of the following instructions (adapted from Van Dessel et al., 2018) for the condition in which participants were assigned agency over the approach and avoidance movements, with the modifications for the condition in which the color stimuli were the agents in square brackets:

> It is very important that you read the following information attentively. You will need this information to complete the upcoming task successfully.
>
> You will perform a task in which you will move toward (name of color) triangles [(name of color) triangles will move toward you] and you will move away from (name of color) triangles [(name of color) triangles will move away from you].
>
> It is very important to remember which action belongs to which type of triangle. Later on, we will explain to you exactly how you will be able to perform this task.
>
> For now, it is crucial that you remember that you will move toward (name of color) triangles [(name of color) triangles will move toward you] and move away from (name of color) triangles [(name of color) triangles will move away from you].
>
> Before we will start this particular task, you will complete a short attractiveness rating task. This task will last about 2 min. Make sure that during that task you do not forget the instructions for the next task.
>
> Please press 'Next' once you have memorized which action belongs to which type of triangle and are ready to begin the attractiveness rating task.

At the first mention of the colors of the triangles, a triangle of the respective color was presented below the relevant line.

[8] We requested participants within the US with a HIT approval rate of at least 80%. There were no other preconditions for taking part in this study.

[9] Of the 397 participants, 13 reported a homosexual orientation, 55 reported a bisexual orientation, 3 indicated "other," and one participant did not answer this item. All others indicated being heterosexual.

[10] Five participants gave implausible responses on the age measure. Those participants were retained, but their responses were not used to describe the distribution of age in this sample.

The experiment continued with the attractiveness judgments, the funnel debriefing, and the ratings of the colors on valence and approach–avoidance connotation.

We asked participants to report which instructions they received regarding the two colored triangles. The response options depended on the agent condition. In the condition in which participants were the agent, they were given the options “I would move towards this triangle” and “I would move away from this triangle.” In the condition in which the colored triangles were the agents, participants chose between “This triangle would move towards me” and “This triangle would move away from me.” In all conditions, participants were given a third response option (“I don’t remember”).

We included an instructional manipulation check before the assessment of demographic variables. The instructional manipulation check served to increase the quality of the data by retaining only participants that responded to the item correctly and thus read the instructions properly (Oppenheimer, Meyvis, & Davidenko, 2009). We gave participants a somewhat lengthy text to read that contained response instructions:

> Most modern theories of judgment and decision making recognize the fact that judgments do not take place in a vacuum. Individual preferences and knowledge, along with situational variables can greatly impact the judgment process. In order to facilitate our research on judgment and decision making we are interested in knowing certain factors about you, the decision maker. Specifically, we are interested in whether you actually take the time to read the directions; if not, then some of our instructions will be ineffective. So, in order to demonstrate that you have read the instructions, please ignore the question below and simply type in “no answer” in the text box. Thank you very much!
>
> When was the last time you evaluated (privately or publicly) the attractiveness of another person?

Results

Memory for instructions. Of the 397 participants, 304 recalled both movements correctly. Memory for the approach movement (83.88%) was better than the avoidance movement (79.60%; McNemar test statistic $= 6.24$, $p = .012$). The probability of remembering the instructions correctly did not depend on locus of agency, $\chi^2(1) = 0.48$, $p = .490$.

Color ratings. We obtained a significant main effect of movement on the approach–avoidance connotation of the colors, $F(1, 395) = 279.73$, $p < .001$, $\eta_p^2 = .415$ indicating that participants associated approach-related colors more with approach ($M = 15.87$, $SD = 4.89$) than avoidance-related colors ($M = 7.26$, $SD = 6.59$). This effect was moderated by agent condition, $F(1, 395) = 5.63$, $p = .018$, $\eta_p^2 = .014$, indicating that the effect was larger when participants were the agent, $F(1, 200) = 193.50$, $p < .001$, $\eta_p^2 = .492$, as compared to the color stimulus, $F(1, 195) = 97.18$, $p < .001$, $\eta_p^2 = .333$. There was no main effect of agent condition, $F(1, 395) = 0.54$, $p = .464$, $\eta_p^2 = .001$. The correlation between approach ratings and evaluative ratings was strong (see Table 1).

We also obtained an effect of movement on evaluation, $F(1, 395) = 52.09$, $p < .001$, $\eta_p^2 = .117$, indicating that colors in the approach condition were evaluated more positively ($M = 14.10$, $SD = 4.90$) than colors in the avoidance condition ($M = 10.90$, $SD = 6.03$). This main effect was not moderated by agent condition, $F(1, 395) = 1.50$, $p = .222$, $\eta_p^2 = .004$. There was no main effect of agent condition, $F(1, 395) = 0.99$, $p = .320$, $\eta_p^2 = .003$.

Attractiveness ratings. Attractiveness ratings that are displayed in Figure 4 were submitted to a 2 (movement: approach vs. avoidance) × 2 (agent: self vs. stimulus) × 2 (target sex: male vs. female) ANOVA. We obtained a main effect of movement, $F(1, 395) = 12.77$, $p < .001$, $\eta_p^2 = .031$ indicating that targets wearing approach-connotated colors were perceived as more attractive ($M = 11.57$, $SD = 0.20$) than targets wearing avoidance-connotated colors ($M = 10.81$, $SD = 0.20$). The interaction between movement and agent condition was significant as well, $F(1, 395) = 6.57$, $p = .011$, $\eta_p^2 = .016$. Separate analyses per agent condition demonstrate a significant effect of movement when participants were the agents of the movements, $F(1, 200) = 13.13$, $p < .001$, $\eta_p^2 = .062$, but not when color stimuli were the agents, $F(1, 195) = 0.94$, $p = .334$, $\eta_p^2 = .005$. Attractiveness ratings also demonstrated an effect of target sex, $F(1, 395) = 18.12$, $p < .001$, $\eta_p^2 = .044$, indicating that female targets ($M = 11.62$, $SD = 0.18$) were perceived as more attractive than male targets ($M = 10.76$, $SD = 0.21$). However, target sex did not moderate any of the effects, F’s ≤ 3.13, p’s $\geq .077$.[11] Attractiveness ratings were strongly correlated with both the approach and evaluative ratings of the colors (see Table 1).

Discussion

Experiment 4 demonstrated that stimulus attributes such as color acquire approach–avoidance connotations in an instructed approach–avoidance procedure. These connotations then have the power to influence attractiveness ratings. However, the obtained effect on attractiveness ratings strongly depended on the locus of agency. That is, although the colors acquired approach and avoidance meaning in all conditions, they influenced attractiveness ratings only when participants imagined executing approach or avoidance movements toward that color in a previous phase. This experiment thus provides support for Hypothesis 3.

The effects of the instructed movements on evaluation expands the findings obtained by Van Dessel and colleagues (2015) in two ways. First, we demonstrate that approach–avoidance effects can also be observed in stimuli that carry an attribute (i.e., color) that was present in the original stimulus used for learning. Second, by assessing attractiveness we show that this finding extends to ratings other than liking or warmth.

Bayesian Analyses

Throughout the report of our experiments, we presented effect sizes and frequentist analyses to evaluate our hypotheses in light of the collected data. The p value reflects the probability of obtaining a result equal to or more extreme than what was observed in the experiment given that the null hypothesis is true, p(data|H0). In this section, we implement a Bayesian analysis approach to aid the

[11] Repeating the analyses only with participants that indicated the assignment of colors to roles correctly at the end of the experiment ($N = 304$) resulted in comparable but somewhat stronger effects with a main effect of movement, $F(1, 302) = 25.84$, $p < .001$, $\eta_p^2 = .079$, and its moderation by agent condition, $F(1, 302) = 9.97$, $p = .002$, $\eta_p^2 = .032$.

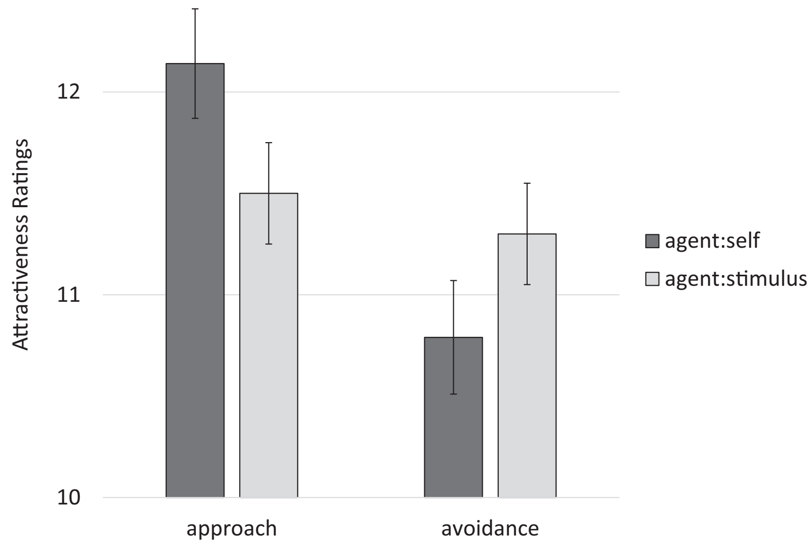

Figure 4. Attractiveness ratings as a function of movement and locus of agency in Experiment 4. Error bars represent standard errors.

interpretation of our findings. Specifically, we estimated Bayes factors that represent the relative amount of evidence in favor of the null hypothesis, p(H0|data), and the alternative hypothesis, p(H1|data), respectively. We relied on the JASP software (JASP Team, 2018; see also Rouder, Morey, Verhagen, Swagman, & Wagenmakers, 2017) to conduct the analyses that were based on a model comparison procedure and a prior of $h = .5$ for the possible range of effect size for all measures (cf. Rouder et al., 2017).

Tables 2 and 3 report Bayes factors that quantify the relative evidence in favor of the alternative hypothesis, BF_{10}. A value of 1 indicates that there is evidence neither in favor of the null hypothesis, nor in favor of the alternative hypothesis. Values larger than 1 indicate that the alternative hypothesis is better supported by the data than the null hypothesis. Values smaller than 1 indicate relatively stronger support for the null hypothesis. In our interpretation of the Bayes factors, we follow Jeffreys (1961) as well as Lee and Wagenmakers (2013).

Table 2 reports the Bayes factors (BF_{10}) for the main effects of movement in the separate conditions of the experiments as well as across the conditions of an experiment. The Bayes factors indicate that the colors acquired approach versus avoidance meaning as reported in the color ratings. However, evidence ranges from "anecdotal" ($BF_{10} < 3$) to "extreme" ($BF_{10} < 100$) across the experiments, with the weakest effects in the passive manikin procedure implemented in Experiments 3a and 3b and the strongest effects in the instructed approach-avoidance procedure of Experiment 4. Bayesian analysis of the Movement × Agent interaction summarized in Table 3 indicates that while effects were "extreme" in both agent conditions of Experiment 4, they were stronger in the condition in which participants were the agents of the movements. There was "strong" evidence for a difference between the two conditions.

The Bayesian approach also supports our interpretation of the effects of approach–avoidance procedures on color evaluations. Of note, the instructed procedure in Experiment 4 provided "extreme" support for an effect on the evaluation of the colors in both agent conditions, while all other experiments offered "anecdotal" ($0.33 \le BF_{10} \le 1$) to "moderate" ($BF_{10} \le 0.33$) to "strong"

Table 2
Bayes Factors BF_{10} for the Main Effect of Movement on the Different Dependent Measures

Experiment	Color approach connotations	Attractiveness ratings	Color evaluations
Exp. 1a	8.05	6.22	—
Exp. 1b	3.63	.11	.15
Exp. 2	4.74 * 10^8	.55	—
agent:manikin	2.12 * 10^7	2.33	—
agent:stimulus	29.29	.11	—
Exp. 3a	96.97	.06	.37
agent:manikin	6.27	.09	.14
agent:stimulus	2.22	.09	.50
Exp. 3b	7.89	.07	.10
agent:manikin	2.62	.12	.12
agent:stimulus	.53	.09	.13
Exp. 4	1.21 * 10^75	441.21	1.94 * 10^13
agent:participant	5.84 * 10^47	9254.01	5.23 * 10^8
agent:stimulus	3.48 * 10^27	.12	10958.14

Note. In the experiments involving a between-participants factor, we report the results across and within the between-participants conditions.

Table 3
Bayes Factors BF_{10} for the Movement × Agent Interaction on the Different Dependent Measures

Experiment	Color approach connotations	Attractiveness ratings	Color evaluations
Exp. 2	.69	.29	—
Exp. 3a	.12	.09	.14
Exp. 3b	.14	.11	.11
Exp. 4	11.13	7.49	.29

($BF_{10} \leq 0.10$) support for the null hypothesis. Thus, approach–avoidance movements exerted a direct effect on color evaluations only under very specific conditions.

Regarding the attractiveness ratings that are most central to our argument, the Bayesian analysis indicates that there is "moderate" evidence in favor of our hypothesis in Experiment 1a and "extreme" evidence in Experiment 4. These experimental procedures fulfill the boundary conditions predicted by self-perception theory (Bem, 1972). That is, participants were the agents of approach–avoidance actions toward the target colors. All other conditions yielded "moderate" to "strong" evidence in favor of the null hypothesis. Importantly, while the main effect of movement was significant in the agent:manikin condition of Experiment 2, Bayesian analysis indicates that evidence in favor of this effect is "anecdotal" (Lee & Wagenmakers, 2013) or "barely worth mentioning" (Jeffreys, 1961). Thus, we will not interpret this effect in the discussion of our findings.

The analysis of the Movement × Agent interaction reported in Table 3 further supports our interpretation of the significant effect obtained in Experiment 4. In Bayesian terms, Experiment 4 offers "moderate" evidence in favor of the moderating role of the locus of agency on effects of stimulus attributes on ratings of attractiveness.

General Discussion

The present research aims to link three important disciplines of psychology: the basic study of the origins of attitudes, the study of attractiveness, and the applied field of color psychology. In line with previous research demonstrating a bidirectional link between approach movements and evaluations, the present research demonstrates that relative to avoidance movements, approach movements lead to higher attractiveness ratings of a stimulus. We extend this research in several important ways. First, we show that approach–avoidance meaning can be attached to stimulus attributes such as color. Second, these attributes bias the evaluation of other stimuli that carry this attribute even though they were never approached or avoided. Third, this evaluation can be carried on to other classes of stimuli (i.e., from geometric shapes to faces) and another class of rating (from approach-avoidance to attractiveness). The present research thereby significantly extends the scope and relevance of approach-avoidance tasks.

Fourth, we demonstrate extensively that these effects are based on self-perception (Bem, 1972) as we show that they occur only when participants executed these movements or imagined executing them. Participants found those targets that displayed a color they approached (or avoided) more (or less) attractive. The present research thus demonstrates that one's own approach and avoidance behaviors are charged with evaluative meaning, much more so than approach–avoidance behaviors observed in others (see also Van Dessel et al., 2018). As a consequence, the present findings cannot be explained by reference to associative learning models (e.g., Baeyens et al., 1992; Eder & Klauer, 2009). By contrast, our results can be explained by an inferential learning account that is based on propositions that store information on the concrete relationship between behaviors and stimuli (Van Dessel et al., 2019).

Color and Attractiveness

Attractiveness is shaped by many influence factors. For instance, psychological theories lend themselves to the prototypes of beauty and body ideals individuals are compared to (Cunningham, 1986; Langlois & Roggman, 1990; Singh, 1993) and to the similarity of individuals to the self (Byrne, 1971; Newcomb, 1961). However, psychological theories have also taken into account factors that arise from the social situation. For instance, the mere exposure effect is regarded an important factor contributing to interpersonal attraction (e.g., Moreland & Beach, 1992). Furthermore, the level of arousal when meeting a potential partner has been shown to influence attraction even when it is entirely unrelated to the potential partner (Dutton & Aron, 1974). The latter two phenomena involve attribution processes, such that unrelated cues such as fluency or arousal are attributed to the attractiveness of the target.

Our findings support an assumption of color-in-context theory, namely that many color connotations are acquired (Elliot & Maier, 2012). The learning perspective has been understudied in psychological research on the meaning and effects of colors. The present research investigates for the first time whether approach and avoidance connotations instigated by colors can be acquired via simple, established learning paradigms. The present research demonstrates that this is indeed the case. Manipulations of approach and avoidance connotations in colors have clear implications for attractiveness ratings.

The role of social learning demonstrated in the present experiments may also explain discrepancies observed in the size of red-attraction and other color effects (Genschow, Noll, Wänke, & Gersbach, 2015). In some studies, this effect is quite large (e.g., Elliot & Niesta, 2008). In others, it is very small to nonexistent (e.g., Peperkoorn et al., 2016). The meta-analysis conducted by Lehmann and colleagues (2018) documents substantial heterogeneity of the red effect across studies. Our learning perspective suggests that the size of the effects may depend on participants' personal experiences of approach and avoidance behavior toward certain colors.

Importantly, we do not mean to provide a comprehensive account for the manifold influences of colors on psychological functioning that have been documented by previous research. On the one hand, there may be other connotations of colors that influence judgments, motivation, and behavior. For instance, the color red has been argued to activate associations to sex, romance, or health (e.g., Stephen, Law Smith, Stirrat, & Perrett, 2009). The present research should not be interpreted as opposing such possibilities, but rather as an invitation to study the influence and the origins of a multitude of influence factors experimentally. On the other hand, the present research does not challenge explanations of effects of color on psychological function by reference to evolutionary theory (e.g., Elliot & Maier, 2012). At the same time, however, the present results suggest that some effects can be explained by an individual's ontogenetic development and do not require recourse to phylogenetic heritage. Ontogenetic explanations have the important epistemological advantage that they lend themselves to experimental investigation.

The Role of Awareness and Demand Artifacts

Our research raises the question of whether the present effects are based on awareness or whether demand artifacts may have driven our results. The question of awareness is relevant to at least three stages of the experimental procedure. First, one may ask whether the acquisition of approach and avoidance connotations depends on awareness of the contingency between color and approach–avoidance behaviors. In the experiments, in which conditional probability judgments were assessed, participants tended to report these conditional probabilities accurately (with the exception of Experiment 2), even though judgments were regressive. At the same time, however, awareness of the contingencies implemented in the approach–avoidance tasks alone was insufficient for generating approach–avoidance effects on attractiveness judgments as shown in Experiments 3a and 3b, which speaks against demand artifacts underlying our results.

The second stage concerns participants' awareness for the meaning they associate with a specific color. In all experiments, we asked participants to indicate the approach (vs. avoidance) connotation of the colors. In all experiments, the colors acquired approach–avoidance meaning as reflected by self-report measures, suggesting that participants were generally aware of the meaning that the colors acquired. The fact that these findings are more consistent across experiments than the results on the evaluation and attractiveness measures also speaks against the operation of demand artifacts.

Third, awareness may concern the question of whether the utilization of approach and avoidance connotations in the attractiveness judgments occurs in a conscious manner. We used a funnel debriefing procedure to assess more explicitly the degree to which findings in our experiments were due to demand artifacts (see the online supplemental materials). In this procedure, only very few participants mentioned the role of the colors during the approach–avoidance task. Removing these participants from analysis did not influence any of our results. In the rating stage of the funnel debriefing procedure, participants generally assigned least importance to the connotations of the colors. Moreover, this estimated influence was highly stable across all experiments, although the experiments differed strongly in the strength of the effects of the colors on attractiveness ratings. In sum, we conclude from the results of the funnel debriefing procedure that the effects that we obtained on the attractiveness ratings were not due to demand artifacts.

Nevertheless, given the present experimental designs, we refrain from making claims on automaticity. Closure on this question may only be achieved via experimental approaches that manipulate awareness (e.g., Pleyers, Corneille, Yzerbyt, & Luminet, 2009; Stahl, Haaf, & Corneille, 2016) and by the utilization of more sensitive measures of awareness and contingency memory at judgment (e.g., Hütter, Sweldens, Stahl, Unkelbach, & Klauer, 2012; Mierop, Hütter, & Corneille, 2017; Sweldens, Tuk, & Hütter, 2017). Another possibility of experimentally addressing the question of whether participants were aware of the influence the colors had on attractiveness ratings is to give participants a chance to withhold their rating whenever they think that they are influenced by the procedure under investigation (Koriat & Goldsmith, 1996; Payne et al., 2013). For instance, in the present paradigm, participants may be given the option to skip their rating of the attractiveness of a person whenever they realize that the color has an influence on their judgment. If the attractiveness ratings demonstrate an influence of the color connotation despite the skip option, this would be first evidence in favor of an unaware influence of color on attractiveness judgments.

Limitations and Future Avenues of Research

The present research raises the question to which degree the present findings generalize to other domains. We assume that these effects hold across a large range of stimuli and judgments. Previous research has shown that colors such as red influence psychological functioning across mating, performance, and consumption contexts. Moreover, colors were demonstrated to extend from judgments to behavior such as task performance (Elliot, Maier, Moller, Friedman, & Meinhardt, 2007; Hill & Barton, 2005; Mehta & Zhu, 2009) and consumption behaviors (Bruno, Martani, Corsini, & Oleari, 2013; Genschow et al., 2012; for a review, see Elliot & Maier, 2014). Future research should thus study whether similar and similarly broad effects can be created in other domains by loading stimulus attributes such as color with approach–avoidance connotations.

Within the present line of research, experiments differed in whether color was implemented as a relevant or irrelevant stimulus attribute in the approach–avoidance task. Specifically, we used color as an irrelevant attribute in the experiential paradigms, while we implemented it as a relevant attribute in the instructed paradigm. For instance, in Experiment 1a, participants were asked to execute approach (or avoidance) movements when the triangle pointed downward (or upward). Color was, however, perfectly correlated with the relevant feature. In the instructed approach–avoidance task in Experiment 4, we told participants that they would later approach triangles of a certain color, while they would avoid triangles of another color. Our research thus mirrors the state of the literature: While some researchers documented approach–avoidance effects on task-relevant stimuli (e.g., Kawakami et al., 2007; Van Dessel et al., 2015), others documented approach–avoidance effects on task-irrelevant stimuli (e.g., Wiers et al., 2011). As task-relevance was not manipulated within one experiment, comparisons between our experiments are speculative. Nevertheless, it stands out that the effect of movement on color evaluations in the instructed paradigm is 10 times as large as the effect in the experiential paradigm. At the same time, however, the size of the effects observed on the attractiveness ratings is almost identical across these paradigms. Moreover, we observed the strongest correlations between color ratings and attractiveness ratings in Experiment 4 (see Table 1). This observation leads us to suggest that future research into the role of attention may help elucidate the mechanisms underlying evaluation of the stimuli used for learning and generalization to novel stimuli.

For the present research, we pretested the male and female portraits to score moderately on an attractiveness scale. Thus, our target stimuli were neither particularly unattractive nor particularly attractive. This selection procedure was employed to give subtle cues a chance to influence attractiveness ratings. Consequently, the effects obtained here may be moderated by the attractiveness of the target individuals (see also Young, 2015). Self-perception theory posits that the observation of the own behavior is most effective when other cues are ambiguous or neutral (Bem, 1972). Thus, highly attractive or highly unattractive targets may not profit from color connotations as these stimuli contain many cues toward attractiveness. This reasoning might also explain why the red effect has not been found for menopausal women as compared to young women (Schwarz & Singer, 2013). Age is a cue related to many attractiveness criteria. Thus, the absence of the red effect might be due to the multitude or extremity of attractiveness cues, rather than declining fertility, the explanation advanced by Schwarz and Singer (2013). In support of this interpretation, the sexual attractiveness of the young target was around the mean of the attractiveness scale, while the rating of the old target fell well below the mean. As this interpretation is post hoc, however, research is required that is designed to address this question experimentally. Furthermore, similar arguments can be made and tested for the moderating role of preexisting connotations of colors.

The Broader Context of This Research

The present research constitutes an integration of two research lines central to the work of both authors. While Mandy Hütter has been studying evaluative learning (e.g., Hütter et al., 2012; Hütter & Sweldens, 2018) and generalization (Hütter et al., 2014), Oliver Genschow has been investigating the predictive validity of approach–avoidance measures (Genschow et al., 2013, 2014, 2017) and the influences of color cues on psychological functioning (Genschow et al., 2012, 2015; Reutner et al., 2015). The present research complements our previous research by demonstrating (a) that stimulus attributes can acquire evaluative meaning (Hütter et al., 2014) in approach–avoidance paradigms and (b) that colors can acquire their meaning via social learning. We plan to continue working on the principles underlying evaluative learning and generalization and enrich this research line with measures that relate to applied fields of psychology.

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