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ORIGINAL RESEARCH

Approach-Avoidance Training: Exploring the Role of Action Identification Processes

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Abstract

Approach-Avoidance Training (AAT) aims to modify evaluations and behaviors towards specific stimuli through repetitive engagement in approach and avoidance behaviors. The current research investigates whether training conditions that promote action identification at the level of approach-avoidance movements, rather than at the level of behavioral actions effecting these movements, are more effective in changing evaluative reactions towards fictitious social groups. In two experiments (total $N = 411$), participants directed a computerized manikin, symbolizing the self, towards one group and away from another. Following the training, participants liked the approached group more than the avoided group in both explicit and indirect attitude measures. These changes in liking were not influenced by training conditions that enabled consistent key presses throughout the task (facilitating action identification at the motoric level) and those that necessitated alternating key presses (promoting action identification at the approach-avoidance level). Furthermore, changes in liking were unrelated to changes in AA-related response tendencies as assessed with a separate response task. It is concluded that the manikin task utilized for AAT is robust against task variants that facilitate action identification at the motor level, especially when the training instructions are clear about which stimuli should be approached and avoided. Insights for the practical application of AAT are discussed.

Keywords Approach-avoidance training · Evaluative reactions · Action identification · Approach-avoidance bias · Symbolic manikin task

Human behavior is organized by two primary motivational orientations: the striving for positive outcomes (success, reward, gain, etc.) and the avoidance of negative outcomes (failure, punishment, loss, etc.) (Elliot et al., 2013). In the past decades, a significant amount of attention has been paid to psychological interventions that appear to leverage these orientations to affect subsequent cognitions, evaluations, and behavior, here collectively referred to as *Approach-Avoidance Training* (AAT; e.g., Wiers et al., 2011).

In AAT paradigms, participants engage in repetitive actions of approaching or avoiding a specified stimulus. This can involve behaviors such as pulling or pushing a joystick lever (Wiers et al., 2011), stepping forwards or backwards in a virtual reality environment (e.g., Nuel et al., 2022), or pushing buttons to move a symbolic representation of oneself (e.g., Woud et al., 2013). The action task of approaching or avoiding is conveyed through different means, including explicit approach/avoidance instructions (Van Dessel et al., 2015), visual action effects that zoom stimuli towards and away (e.g., Rougier et al., 2018), or manipulating symbolic displays of the spatial distance between oneself and the stimulus (Woud et al., 2013).

The outcomes of such AAT procedures encompass shifts in evaluative responses (e.g., Van Dessel et al., 2018b), modifications of social behavior (e.g., Kawakami et al., 2007), and changes in the consumption of alcohol and food (e.g., Kakoschke et al., 2017). However, a significant number of studies also failed to obtain AAT effects (e.g., Becker et al., 2015; Krishna & Eder, 2018; Vandenbosch & Houwer, 2011). Consequently, a crucial question in current psychological research revolves around identifying the factors that contribute to the effectiveness of AAT.

Research on this question is informed by current theories that delineate mechanisms underlying AAT effects. Early accounts referred to the contiguity principle underlying

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association formation, proposing that cognitive representations of the training stimuli can become directly associated with representations of approach/avoidance behaviors after repeated pairings (Wiers et al., 2013). However, these associative explanations did not fit empirical findings well (e.g., Eder & Krishna, 2023; Van Dessel et al., 2018b) and have therefore been replaced with new theoretical approaches that emphasize the acquisition of propositional knowledge structures through AAT (Van Dessel et al., 2019; Wiers et al., 2020). Knowledge structures include beliefs about relations between stimuli and actions (the stimulus-action relationship, e.g., "I avoid alcoholic beverages") and how actions are causally related to relevant outcomes (the action-outcome-relationship; "I avoid things that I do not want"). Via inferential reasoning, a new belief is created about how stimuli are related to action motivations ("alcohol is aversive") which affects future behavior (e.g., less consumption of alcohol; see Wiers et al., 2011).

According to recent theorizing about AAT effects, the trained action (or more precisely, its cognitive construal) is the centerpiece in the network of proposition because it serves as the intersecting element in stimulus-action and action-outcome relations. Processes related to the action construal, particularly concerning a framing with respect to approach and avoidance, should therefore have a significant impact on AAT effects. Consistent with this hypothesis, research has demonstrated that outcomes of AAT procedures depend on how the trained behavior was framed in the task instructions: when participants were instructed to move a computerized manikin (representing the self) towards stimulus A and away from stimulus B, stimulus A was liked more than stimulus B. In contrast, when instructions were to move the manikin downwards and upwards on the computer screen, stimulus A was liked less than stimulus B (Van Dessel et al., 2018b). Hence, AAT effects were mediated by how the trained action was construed on the cognitive level.

The insight from the research reviewed above is that, in the context of AAT, one should ensure that the trained action is explicitly construed as being related to approach and avoidance during the task (Eder & Rothermund, 2008). However, even with meticulous attention to task instructions, participants may spontaneously recode the task-defined action when other action features become more salient or instrumental to solving the task. In fact, actions could be identified at different levels of abstraction, ranging from simple behavioral acts, such as the press of a button, to relatively abstract actions, such as the pursuit of approach/avoidance (Vallacher & Wegner, 2012). AAT paradigms likely differ in the extent to which they are amenable to action identification on these levels.

An illustrative example is the symbolic manikin AAT task in which participants are asked to repeatedly direct a small manikin on the computer screen with keypresses either towards or away from specific stimuli presented at the center of the screen. Using this procedure, studies have shown that participants liked the approached stimuli more than the avoided ones after sufficient training (e.g., Huijding et al., 2011; Van Dessel et al., 2018b; Woud et al., 2013). Notably, participants could construe the task-defined actions either at the level of the instructed keypress (e.g., pressing one button in response to stimulus A and the other button in response to stimulus B), or, in line with the task instruction, at the level of the manikin movement towards and away from the stimulus effected by these keypresses (e.g., pressing the button effecting "approach" in response to stimulus A and press the button effecting "avoidance" in response to stimulus B). Clearly, one would expect an AAT effect with action identification at the approach/avoidance level and not at the keypress level.

To promote action identification at the approach/avoidance level, the start location of the manikin therefore is typically varied during the AAT task. In half of the trials, the manikin starts at an upper location, and in the randomly selected other half of the trials, it starts at a lower location on the screen. When the start position is the upper location, key 1 must be pressed to move the manikin towards the stimulus presented at the center, and key 2 to move it away. Conversely, when the manikin starts at the lower location, key 1 must be pressed to move the manikin away, and key 2 to perform a movement towards the stimulus. Depending on the start location of the manikin, the same keypress triggers manikin movements in opposite directions, which should promote action identification at the level of the generated manikin movement towards and away from stimuli. While action construal in the form of pressing the response keys 1 and 2 would still be possible, it would make the task more complex because the participant must employ four instead of only two stimulus–response mapping rules to complete the manikin task.

Variation of the manikin start position hence could be an important procedural element that facilitates action identification at the approach/avoidance level, or if not properly implemented, at the keypress level. We recently tested this assumption with symbolic manikin tasks in which the start location of the manikin alternated predictably from one task block to the next (requiring a re-mapping of approach/avoidance movement to response keys) or remained constant (requiring no re-mapping). Specifically, participants were trained in AAT task blocks to approach the manikin members of one fictitious social group ("Niffites," names ending with -nif) with a press of one response key and to avoid members of the other group ("Loopites," names ending with -lop) with a press of the other key. In addition to this task, trial blocks of another task (the "test task") were intermixed in which participants responded not to the identity of the group but to the font style (italics, bold) with which a group name was displayed. This test task probed for training-induced changes in response tendencies consistent with the trained keypress action (up or down arrow keypress) or with the trained action goal (approach, avoidance), which could be dissociated when the start location of the manikin was different in the AAT and test tasks. Results demonstrated that the relation between the stimuli and AA movement acquired during the training led to faster responses in the test task when the response was consistent with the trained approach/avoidance goal but inconsistent with the trained keypress action, whereas the relation to the keypress action effecting the AA movement had no influence (Eder & Krishna, 2023).

This research suggests that participants identified the task-defined actions at the level of approach-avoidance movement even when conditions would have permitted action identification at the keypress level. However, this conclusion comes with several qualifications. Firstly, we not only instructed the task-defined actions at the approach/avoidance level but also randomly interspersed so-called "goal-reminder trials" during training and test in which participants were to respond to the words "Approach" and "Avoid" with corresponding actions. These goal-reminder trials could arguably have suppressed a re-coding of the task-defined actions (for evidence see Eder & Rothermund, 2008). Secondly, we exclusively measured training-induced changes in AA response tendencies and did not include other outcome measures of AAT (e.g., training-induced changes in evaluative reactions to the groups after the training). Accordingly, it is not clear whether action identification could affect evaluative and/or motivational training outcomes, and hence the effectiveness of the training procedure. This was examined in the present study.

Experiment 1

For our first experiment, we used the manikin AAT procedure based on Eder and Krishna (2023, Study 3). In brief, participants were trained to approach or avoid members from two fictitious groups, alternating with a test task in which they had to respond to the font of group names. Instructions for both tasks stressed action identification at the approach/avoidance level (e.g., "Approach Niffites and avoid Loopites!" for the AAT task, "Approach the name written in italics and avoid the name presented in bold font!" for the font task); goal-reminder trials were not presented. After training, the liking of the groups was measured using explicit and indirect attitude measures (ratings, IAT).

We compared a condition in which participants performed the same keypress actions to approach or avoid in both the training and test tasks (S-R same group) with one in which the mapping of the keypress action to the manikin's approach/avoidance movement was reversed between the training and test tasks (S-R reversed group). Figure 1 illustrates the basic structure of these conditions. With the varying start location of the manikin (upper vs lower half of the screen), the S-R reversed group must press the opposite response key in both tasks to generate an analogous approach/avoidance effect. We expected that this task requirement would increase the level of action identification at the approach/avoidance level. Thus, we preregistered the hypothesis that AAT effects on evaluations (better liking of the approached group) would be larger in the S-R reversed group than in the S-R same group.

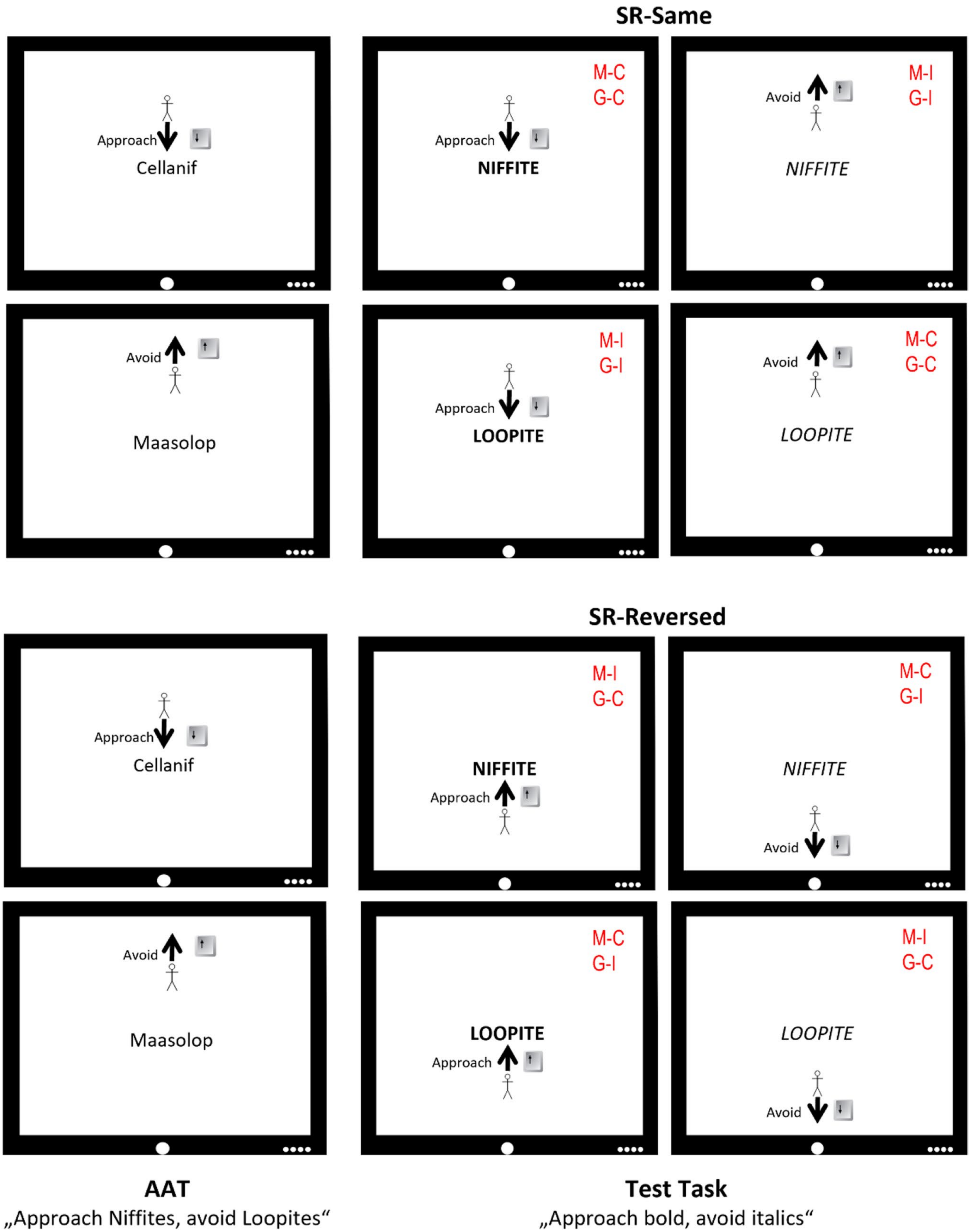
In addition, we also planned analyses with metrics derived from participants' reaction times (RTs) in the test task. As depicted in Fig. 1, responses in the test trial could be consistent with the trained keypress (motor-congruency) and/or consistent with the trained AA movement (goal-congruency). Faster responses in test trials where the response is consistent with the trained AA movement, but inconsistent at the keypress level, should index action identification at the approach/avoidance level (see Eder & Krishna, 2023). Conversely, faster responses when the action is consistent at the keypress level but inconsistent with the AA movement suggest dominance of action identification at the keypress level. Therefore, response tendencies in the S-R reversed group condition might reveal the level at which an individual identified the task-defined response. This index could, in turn, be related to the individual's liking change in line with our research hypothesis (larger AAT effect with identification at the approach/avoidance level).

Method

Sample

We planned sample size to detect small-to-medium interaction effect sizes ($d \geq 0.4$) with 80% power. Our initial sample included 219 participants. Four were excluded due to incomplete data, and 15 were excluded for having error rates exceeding 25% in either the training or test tasks. No participants were excluded for exceeding a 50-min completion time. The criteria for these data exclusions were preregistered. Deviating from our pre-registration, we excluded three additional participants who recorded at least 15% of their responses below 400 ms in any critical IAT block.[1] Consequently, our final sample comprised 197 participants (gender: 91 females, 104 males, 2 other; age: $M = 28.1$ years; $SD = 8.1$). Informed consent was obtained from all participants, and the study procedures were approved by

[1] Note that this exclusion criterion did not substantively change the results of any preregistered analysis.


SR-Same
Approach
Cellanif
M-C
G-C
Approach
NIFFITE
M-I
G-I
Avoid
NIFFITE
Avoid
Maasolop
M-I
G-I
Approach
LOOPITE
M-C
G-C
Avoid
LOOPITE
SR-Reversed
Approach
Cellanif
M-I
G-C
NIFFITE
Approach
M-C
G-I
NIFFITE
Avoid
Avoid
Maasolop
M-C
G-I
LOOPITE
Approach
M-I
G-C
LOOPITE
Avoid
AAT
„Approach Niffites, avoid Loopites“
Test Task
„Approach bold, avoid italics“

◂**Fig. 1** Graphical illustration of the tasks and conditions. *Note.* The leftmost row shows the AAT; the other rows illustrate the test task. From these, the upper four panels show the test task as implemented in the S-R same condition of Study 1, whereas the four panels below show the test task as implemented in the S-R reversed condition of Study 1 and in Study 2. The positioning of the manikin in the AAT and the assignment of the AA responses to the fonts were counterbalanced across participants. Only the target word at the center and the manikin were visible to the participant. MC, motor-congruent; M-I, motor-incongruent; GC, goal-congruent; GI, goal-incongruent

the Institutional Review Board (see our Ethics Approval Statement).

Design

The experiment utilized a 2 *x* 2 mixed design, with one between-subject factor (S-R same vs. S-R reversed) and one within-subject factor (approached group vs. avoided group). The following factors were counterbalanced across participants: (1) assignment of the two groups (Niffites, Loopites) to the response keys (AAT); (2) assignment of the fonts to the responses (test task); (3) start position of the manikin (top vs bottom) (AAT); (4) order of the rating and IAT tasks; (5) assignment of the positive and negative categories to the response keys (IAT); (6) initial mapping of the target categories (Niffites, Loopites) to the response keys (IAT).

Procedure

Figure 1 shows the basic design of the tasks in the S-R same and S-R reversed conditions. Participants began with training (AAT), and then alternated between AAT and test task blocks. Thereafter, they completed the rating and IAT tasks in counterbalanced order. General task instructions for the AAT and test tasks were:

> "In the following screens, a small manikin will appear on your screen. This manikin represents you. YOUR TASK as the manikin will be to APPROACH or AVOID a word or name that appears on screen as fast as possible using the arrow keys. Tapping the key is enough. The rule for when to approach or avoid a word or name depends on what kind of word or name appears." (emphasis in the original)

AAT Task Instructions for this task were to approach and avoid two fictitious social groups (Niffites, Loopites) by pressing the up or down arrow keys. The targets were four names of either Niffites (names ending on –nif: "Cellanif," "Eskannif," "Lebbunif," "Zallunif") or Loopites (names ending on –lop: "Maasolop," "Neenolop," "Omeelop," "Wenaalop"). Each of the target exemplars was presented once per block (eight trials). Participants were instructed to approach one fictitious group and avoid the other (counterbalanced assignment).

In each trial, the manikin always appeared on a specific half of the screen (top or bottom, counterbalanced across participants). After 750 ms, the target word appeared in the center of the screen and participants responded as quickly as possible by tapping an arrow key. The manikin then moved in the direction of the response key for 300 ms. If the participant responded incorrectly or did not respond within 2000 ms, an error message appeared for 2000 ms. After 50 ms, the next trial began.

Test Task The test task mirrored the training task with the following exceptions: (i) the target stimuli were the group names "NIFFITE" and "LOOPITE," presented in capital letters, instead of individual group member names; (ii) participants were instructed to move the manikin toward or away from the target depending on the word's font; (iii) for each target word, half of the trials were presented in bold font and the other half in italics; (iv) in the S-R same group, the manikin's starting position on the screen was the same as in the training task, whereas in the S-R reversed group, the manikin appeared on the opposite half of the screen. Each block consisted of eight trials, with two trials for each group name in each font style.

Task Sequence Participants completed seven AAT blocks and six test blocks, with the sequence alternating between AAT and test tasks, initiating and concluding with an AAT block. At the outset, they were briefed that achieving a rate of 70% correct responses in any block, whether training or test, would qualify them for an additional monetary incentive of £0.02 per block, on top of a base compensation of £1.50 for participation. Following each block, feedback was provided, detailing their performance and indicating whether they met the reward criterion for that specific block.

Liking Measures After finishing the task sequence, participants completed an explicit and an indirect attitude measure (counterbalanced order). The explicit measure consisted of a 7-point Likert scale, asking participants to express their relative preference for Niffites or Loopites (side of presentation randomized) from – 3 (strong preference for left group) to 3 (strong preference for right group). The indirect measure was the Implicit Association Test (IAT; Nosek et al., 2007), assessing participants' relative preferences for Niffites or Loopites. The IAT was structured into seven blocks. In the first block (20 trials), participants categorized adjectives, such as "marvelous" or "tragic" as positive or negative using the "E" and "I" keys (see Table S1 in the supplement for the list). In the second block (20 trials), participants categorized group member names (from the AAT) as either Niffites or Loopites, using the same keys. In the third block (20 trials)

Table 1 Descriptive statistics by S-R condition (Experiment 1)

Variable	S-R same $n=95$ *M (SD)*	S-R reversed $n=102$ *M (SD)*
AAT		
Error rate	4.1% (3.3)	5.2% (4.6)
Test task		
Error rate	5.3% (4.5)	6.0% (4.6)
Reaction time	467 ms (63)	460 ms (55)
Congruency score	2.3 ms (30)	3.7 ms (33)
Liking		
Preference rating	0.85 (1.38)	0.87 (1.49)
IAT D2 score	0.36 (0.47)	0.35 (0.42)

Note: Preference and D2 scores are coded such that higher values indicate more preference for the approached group in the AAT

and the fourth block (40 trials), participants alternately categorized valenced words and group members using the same response keys. In the fifth block (40 trials), the task was to categorize targets as Niffites or Loopites using the same keys but with reversed mapping from the previous blocks. In the sixth block (20 trials) and seventh block (40 trials), participants again alternately categorized valenced words and group members, but this time with the new, reversed target categorization mapping. Throughout the IAT, valenced words were displayed in orange and target words in blue to clearly differentiate the categorization tasks. Participants were instructed to respond both as quickly and as accurately. If they made an incorrect response, a red X appeared in the top half of the screen and remained until the correct response was given. The next trial began after 150 ms.

Results

Data preparation was as preregistered unless otherwise noted. The first block of the test task, as well as the first, second, and fifth blocks of the IAT, was excluded. Test task trials with RTs exceeding 1.5 interquartiles above the participant's third quartile were removed (4.7% of the trials). IAT D2 scores were calculated following recommendations by Richetin et al. (2015). Specifically, IAT trials with RTs exceeding 10,000 ms ($<0.1\%$ of trials) or below 400 ms (1.0% of trials) were removed; trials with RTs greater than 3000 ms were winsorized to 3000 ms; and the practice and test blocks were pooled together for the computation of the D2 scores. Preference scores and IAT D2 scores were coded such that higher values reflect greater preference for the approached group. Table 1 summarizes relevant descriptive statistics for each condition. Additional analyses including counterbalanced factors are reported in the supplement to this article.

Liking Measures We hypothesized more liking of the approached group following training. This was confirmed by a one-sided t-test against zero (supplemented by a Bayesian test using a Cauchy prior with a scale value of 1), which showed a significant preference for the approached group in both the explicit measure, $t(196)=8.44$, $p<0.001$, $d_z=0.602$, BF10 = 7.79e + 11, and the IAT D2 score, $t(196)=11.13$, $p<0.001$, $d_z=0.793$, BF10 = 3.19e + 19. We also expected a larger liking change in the S-R reversed condition. However, independent samples one-sided t-tests revealed no significant differences between the S-R same and S-R reversed groups for either the explicit measure, $t(195)=0.10$, $p=0.461$, $d_s=0.014$, BF01 = 8.92, or the IAT D2 score, $t(195)=-0.07$, $p>0.943$, $d_s=-0.010$, BF01 = 8.94 (see the violin plots in Fig. 2).

Congruency Scores For additional analyses, we computed a congruency score based on participants' reaction times in the test task. This score reflects whether the required response in a test trial was aligned with the trained keypress (motor-congruency) and/or with the trained AA movement (goal-congruency). In the S-R reversed group, motor-congruent test trials were always goal-incongruent and motor-incongruent trials were always goal-congruent (see Fig. 1). By subtracting the mean RT in goal-congruent trials from that in goal-incongruent trials, we derived a congruency score for the S-R reversed condition. This score signifies whether an individual's reaction time was more significantly influenced by the congruency relation with the trained AA movement goal (indicated by a positive value) or with the trained keypress action (indicated by a negative value). For the S-R same group, a similar training-induced congruency effect was computed (see Table 1). However, in this condition, the score could not distinguish between motor and goal congruency relations because they were confounded (see Fig. 1).

In our previous study using the same procedure, but with the inclusion of "goal-reminder" trials, we observed small-sized congruency effects in both the S-R-same and the S-R-reversed conditions (Eder & Krishna, 2023, Study 3). To determine if these findings could be replicated in the current setup without "goal-reminder" trials, we conducted an analysis of variance (ANOVA) on the congruency scores with the factor S-R Condition (same vs. reversed). The ANOVA indicated no significant intercept, $F(1,195)=1.74$, $p=0.189$, $\eta_p^2=0.009$, and no significant main effect of *Condition*, $F(1,195)=0.09$, $p=0.766$, $\eta_p^2<0.001$. Thus, response tendencies did not change in either condition after training.

Regression Analysis A further analysis examined whether individual variation of the congruency scores, reflecting the relative dominance of associations with AA movements versus keypress actions (see the section above), is related to

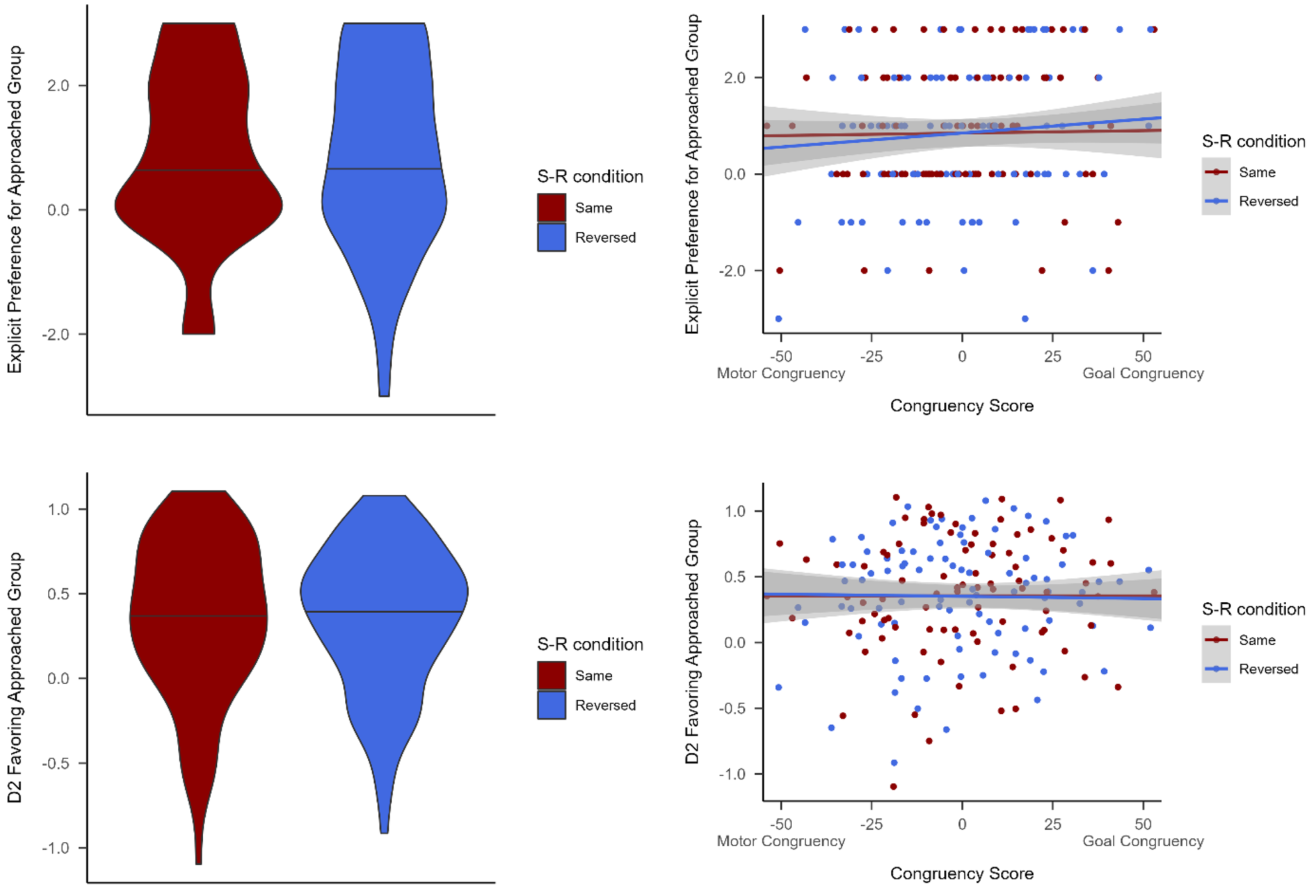


Fig. 2 Violin and scatter plots for explicit preference and IAT D2 measures as a function of condition and congruency scores (Experiment 1)

liking changes after the training. Mean-centered congruency scores, S-R condition as a contrast-coded variable (same: -0.5; reversed: 0.5), and their interaction term were entered in separate linear multiple regression models predicting the explicit liking measure and the IAT D2 score.[2] The results are shown in Table 2.

Average congruency scores did not significantly predict explicit and IAT liking changes. The interaction terms also failed to achieve significance, indicating that training in the S-R same and S-R reversed conditions did not make a difference. In short, there was no indication that training-induced changes in response tendencies were predictive of explicit or IAT liking changes.

Exploratory linear regression analyses for mean-centered congruency scores predicting both liking measures were calculated separately for the S-R same and reversed conditions for descriptive purposes. The main effect of congruency did not achieve significance for either the S-R same, explicit: $B=0.001$, $SE=0.005$, $p=0.831$; D2: $B=0.000$, $SE=0.002$, $p=0.994$, or S-R reversed condition,

Table 2 Regression of liking changes on congruency score and S-R condition

Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Explicit liking					
Adjusted $R^2=-0.006$					
Intercept	0.861	0.103	0.659	1.063	<0.001
S-R condition	0.015	0.205	−0.389	0.420	0.940
Congruency score	0.003	0.003	−0.003	0.010	0.302
Interaction	0.005	0.007	−0.008	0.018	0.472
D2					
Adjusted $R^2=-0.015$					
Intercept	0.353	0.032	0.290	0.416	<0.001
S-R condition	−0.004	0.064	−0.130	0.122	0.946
Congruency score	−0.000	0.001	−0.002	0.002	0.865
Interaction	−0.000	0.002	−0.004	0.004	0.875

[2] Note that we preregistered an analogously structured ANCOVA analysis for both experiments. The regression models are essentially identical barring slight deviations in the main effects due to unbalanced samples. The results do not substantively differ in either experiment (see the supplement for a report of the preregistered ANCOVA analyses).

explicit: $B = 0.006$, $SE = 0.004$, $p = 0.193$; D2: $B = -0.000$, $SE = 0.001$, $p = 0.792$.

Discussion

Experiment 1 tested the hypothesis that AAT effects on evaluation would be more pronounced when the task encourages action identification at the AA goal level rather than at the motor level (keypress). We posited that the S-R same condition, by allowing participants to perform the same motor response across both tasks, enables action identification at the keypress level (i.e., pressing the arrow keys), in contrast to the S-R reversed condition, in which opposite keys had to be pressed in both tasks. Therefore, we anticipated that the S-R-reversed group would exhibit a larger training-induced liking change in comparison to the S-R-same group (Eder & Rothermund, 2008; Van Dessel et al., 2018b). However, although the training procedures generated evaluative AAT effects on both explicit and indirect measures, the magnitude of the effects did not vary between training conditions. Moreover, we found no evidence that changes in response tendencies, as gauged by performance in the test task (congruency scores), were predictive of training-induced liking changes. This is consistent with prior research that analogously found no relation between training outcomes and changes in AA tendencies (e.g., Dickson et al., 2016; Machulska et al., 2016; Wiers et al., 2011).

A straightforward explanation for the null effect could be that the training procedure in the S-R-same condition failed to adequately emphasize action identification at the keypress level. Indeed, task instructions for the S-R-same condition made explicit reference to AA movements of the manikin, which could have discouraged action identification as key pressing. Furthermore, response tendencies in the test task were unaffected by the training procedures in both conditions (see the congruency scores Table 1). This contrasts with our prior study (Eder & Krishna, 2023, Study 3), where we noted a change in the response bias following the intermixing of goal-reminder trials, which presumably strengthened action identification at the AA level. Consequently, for a subsequent study, we decided to incorporate similar goal-reminder trials to foster action identification at the keypress level and AA levels.

Experiment 2

In Experiment 2, we exclusively implemented the S-R reversed condition, this time introducing a between-subject variation in the emphasis on action identification at the keypress and AA levels. Specifically, we intermixed additional "goal-reminder trials" during each task that should remind participants of the respective action frame. In the keypress-reminder condition, participants responded to the prompts "UP-KEY" and "DOWN-KEY" with a press the corresponding arrow key. In the AA-reminder condition, they responded to the prompts "APPROACH" and "AVOID." By intermixing these trials during the AAT and test task, we aimed to foster action identification processes at the respective levels (for evidence see Eder & Rothermund, 2008; Van Dessel et al., 2018b). It is important to highlight that participants in the keypress-reminder condition were given AA instructions for the remaining trials (AAT, font task). Therefore, while the keypress-reminder condition was designed to promote action identification at the keypress level, it did not force participants to adhere strictly to this frame throughout the training. This is a notable difference to a previous study of Van Dessel et al. (2018). In this study, the AAT effect, obtained with standard AAT instructions, was inverted when participants received instructions to move the manikin upwards and downwards during the training.

We once again hypothesized that AAT would be more effective with an AA action framing than with a keypress frame. Consequently, we expected larger liking changes following the training in the AA-reminder condition. Furthermore, we expected participants in the AA condition to react faster in goal-consistent than in goal-inconsistent test trials, while participants adopting the keypress frame were expected to respond more swiftly in motor-consistent than in motor-inconsistent trials (for an explanation of the trial types, see Fig. 1). Additional analyses were planned to examine relations between changes in the response bias, as assessed by the test task, and training-induced liking changes (ratings, IAT scores).

Method

Sample

Our initial sample consisted of 253 participants. Two were excluded due to incomplete data, and 37 were excluded for having error rates exceeding 25% in any of the training, test, or reminder trials. Additionally, three participants were removed from the IAT analyses because they had at least 15% of responses faster than 400 ms in any critical IAT block. Consequently, the final sample comprised 214 participants (gender: 89 females, 124 males, 1 non-response; age: $M = 26.8$ years; $SD = 7.0$, 1 non-response). Of these, 104 participants were assigned to the AA-goal condition and 110 to the keypress-goal condition. The sample was determined to be sufficiently powered, with a 20% probability of type II error, to detect a small-to-medium effect size ($d \geq 0.4$) in a two-sided t-test. Informed consent was obtained from all participants, and the study procedures were approved by the Institutional Review Board (see our Ethics Approval Statement).

Design

The experiment utilized a 2 *x* 2 mixed design, with the between-subject factor being the condition (AA vs. keypress) and the within-subject factor being the group (Niffites, Loopites) that was approached versus avoided. Counterbalanced factors were the same as for Experiment 1.

Procedure

Participants began the experiment with a practice task designed to reinforce action identification at either the keypress or AA level. Subsequently, they completed a series of alternating blocks of the AAT (seven blocks) and the test task (six blocks), starting and ending with the AAT. Thereafter, they completed the explicit and IAT measures in counterbalanced order.

Action Framing Task In the AA condition, the target stimuli were the words "APPROACH" and "AVOID," whereas in the keypress condition, the stimuli were "UP-KEY" and "DOWN-KEY" (written in upper case). Task instructions were to respond both quickly and accurately by executing the instructed action (i.e., moving the manikin towards or away from the target, or pressing the up or down arrow key). Participants completed 16 trials of this task. Each word was presented eight times in a random sequence, with the manikin's start position being at the top in half of the trials and at the bottom for the other half of the trials.

AAT Task The training task was identical to that in Experiment 1, except for the random intermixing of four additional trials with the stimuli of the action framing task. Thus, participants performed a total of twelve trials per training block (four Niffites, four Loopites, four action frame stimuli). Note that the instructions for trials involving group member names remained consistent across both conditions. Thus, participants in the keypress condition were instructed to approach/avoid Niffites and Loopites; however, they were asked to press the up and down arrow keys if the word UP-KEY or DOWN-KEY was shown in the trial.

Test Task The test task was identical to that S-R reversed condition of our first experiment (including the use of AA instructions), except for the random intermixing of four additional trials with the stimuli of the action framing task. These words were presented in a standard typeface, without any use of bold or italicized formatting.

Task sequence and liking measures were the same as in Experiment 1.

Table 3 Descriptive statistics for Experiment 2

Variable	Keypress-reminder condition $n = 110$ *M (SD)*	AA-reminder condition $n = 104$ *M (SD)*
AAT		
Error rate (training task)	5.9% (4.6)	5.6% (5.1)
Reaction time (training task)	619 ms (73)	597 ms (79)
Error rate (action frames)	3.1% (3.9)	4.1% (4.7)
Reaction time (action frames)	612 ms (71)	631 ms (71)
Test task		
Error rate (font task)	8.6% (6.0)	8.5% (5.7)
Reaction time (font task)	564 ms (64)	550 ms (67)
Error rate (action frames)	5.7% (5.8)	9.0% (7.1)
Reaction time (action frames)	597 ms (65)	626 ms (72)
Congruency score	−2 (43) ms	9 (39) ms
Liking		
Preference rating	1.25 (1.38)	1.12 (1.49)
IAT D2 score	0.37 (0.44)	0.34 (0.46)

Note: Preference and D2 scores are coded such that higher values mean more preference for the approached group

Results

For the analysis, we excluded the initial block of the test task, along with the first, second, and fifth blocks of the IAT. We also eliminated test task trials with RTs exceeding 1.5 times the interquartile range above each participant's third quartile, resulting in the removal of 2.7% of the test task trials. In the IAT, less than 0.1% of trials were removed due to RTs slower than 10,000 ms, and 2.7% of trials were excluded for RTs faster than 400 ms.

Table 3 shows descriptive statistics for each task and condition. Congruency scores and IAT D2 scores were calculated as in Experiment 1. Additional analyses including counterbalanced factors are reported in the supplement to this article.

Liking Measures A one-sided *t*-test against zero (supplemented by Bayesian tests using a Cauchy prior with a scale value of 1) confirmed more liking of the approached group on both the explicit measure, $t(213) = 12.10$, $p < 0.001$, $d_z = 0.829$, BF10 = 8.15e + 22, and the IAT D2 score, $t(210) = 11.6$, $p < 0.001$, $d_z = 0.798$, BF10 = 1.53e + 21. However, independent samples one-sided *t*-tests showed no

Table 4 Regression of liking changes on congruency score and S-R condition

Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Explicit liking					
Adjusted $R^2 = 0.001$					
Intercept	1.178	0.099	0.983	1.372	< 0.001
S-R condition	−0.082	0.197	−0.471	0.308	0.680
Congruency score	−0.004	0.002	−0.008	0.001	0.139
Interaction	0.003	0.005	−0.006	0.012	0.534
D2					
Adjusted $R^2 = -0.011$					
Intercept	0.353	0.031	0.291	0.415	< 0.001
S-R condition	−0.020	0.062	−0.144	0.103	0.744
Congruency score	−0.000	0.001	−0.002	0.001	0.823
Interaction	0.001	0.002	−0.002	0.004	0.483

significant differences between the keypress and AA conditions for either the explicit measure, $t(208) = 0.61$, $p > 0.999$, d_z = -0.084, BF01 = 7.77, or the IAT D2 score, $t(207) = 0.36$, $p > 0.999$, $d_s = 0.050$, BF01 = 8.29. Thus, although the modified AAT procedure was effective in changing evaluations, we did not find evidence indicating its effectiveness was diminished in conditions where the action framing was ambiguous.

Congruency Score The *t*-test comparing the congruency score in the AA condition against zero was significant, $t(103) = 2.34$, $p = 0.021$, $d_z = 0.229$. An analogous *t*-test conducted on the congruency score in the keypress condition did not yield a significant result, $t(109) = 0.50$, $p = 0.617$, $d_z = -0.048$. The comparison of the congruency scores with an independent samples one-sided *t*-test showed that the congruency score in the AA condition was significantly larger, $t(211) = 1.95$, $p = 0.026$, $d_z = 0.267$.

Regression Analysis Similarly to Experiment 1, mean-centered congruency scores, condition as a contrast-coded variable (keypress condition: −0.5; AA condition: 0.5), and their interaction term were entered in separate linear multiple regression models predicting the explicit liking measure and the IAT D2 score. The results are shown in Table 4. There was no indication that faster responses in line with congruent responding increased AAT effects differently for differing action frames (Fig. 3).

Exploratory linear regression analyses for mean-centered congruency scores predicting both liking measures were calculated separately for the keypress and AA conditions for descriptive purposes. The main effect of congruency did not achieve significance for either the keypress, explicit: $B = -0.0051$, $SE = 0.0030$, $p = 0.096$; D2: $B = -0.0007$, $SE = 0.0010$, $p = 0.475$, or AA condition, explicit: $B = -0.0021$, $SE = 0.0038$, $p = 0.586$; D2: $B = 0.0004$, $SE = 0.0012$, $p = 0.755$.

Discussion

Both AAT procedures succeeded in generating a training-consistent liking change of the groups. While the effect in the AA condition was as expected, we did not expect that the keypress condition with its ambiguous reference frame for the actions would perform on par with the AA condition. With intermixed reminders of AA movements, we also obtained a significant congruency score in the AA condition, which closely replicates the finding of our previous study (Eder & Krishna, 2023, Study 3). Hence, it appears that the inclusion of AA reminders is necessary for a cross-task congruency effect on the AA level (for related evidence, see Liefooghe et al., 2013; Theeuwes et al., 2015). Conversely, the absence of a congruency effect in the keypress condition could indicate that relations to AA movements were less activated in this condition, at least during the test task. This assumption is also corroborated by the significantly larger congruency effect in the AA condition. However, congruency effects did not correlate with liking changes in either condition. This reinforces the conclusion that the evaluative changes induced by the training were not dependent on a modification of response tendencies.

General Discussion

Two experiments investigated action identification processes during AAT procedures, and how they are related to the effectiveness to produce a training-consistent outcome. Our general hypothesis was that task procedures facilitating action identification at the AA level would yield larger training effects on evaluative measures (ratings, IAT) compared to action identification at the keypress level. In Experiment 1, action identification was manipulated through task conditions that either allowed participants to press the same response keys consistently throughout the task (S-R same condition) or required them to press opposite keys (S-R reversed condition). We hypothesized that participants in the S-R same condition would be more likely to identify the task-defined response at the keypress level, which should result in a reduced training effect in this condition. In Experiment 2, we implemented only the S-R reversed condition, but this time with intermixed additional trials that reminded participants to use the arrow keys (keypress condition) or to direct the symbolic manikin towards and away from targets (AA condition). In addition to these experimental manipulations, we probed for training-induced changes in automatic

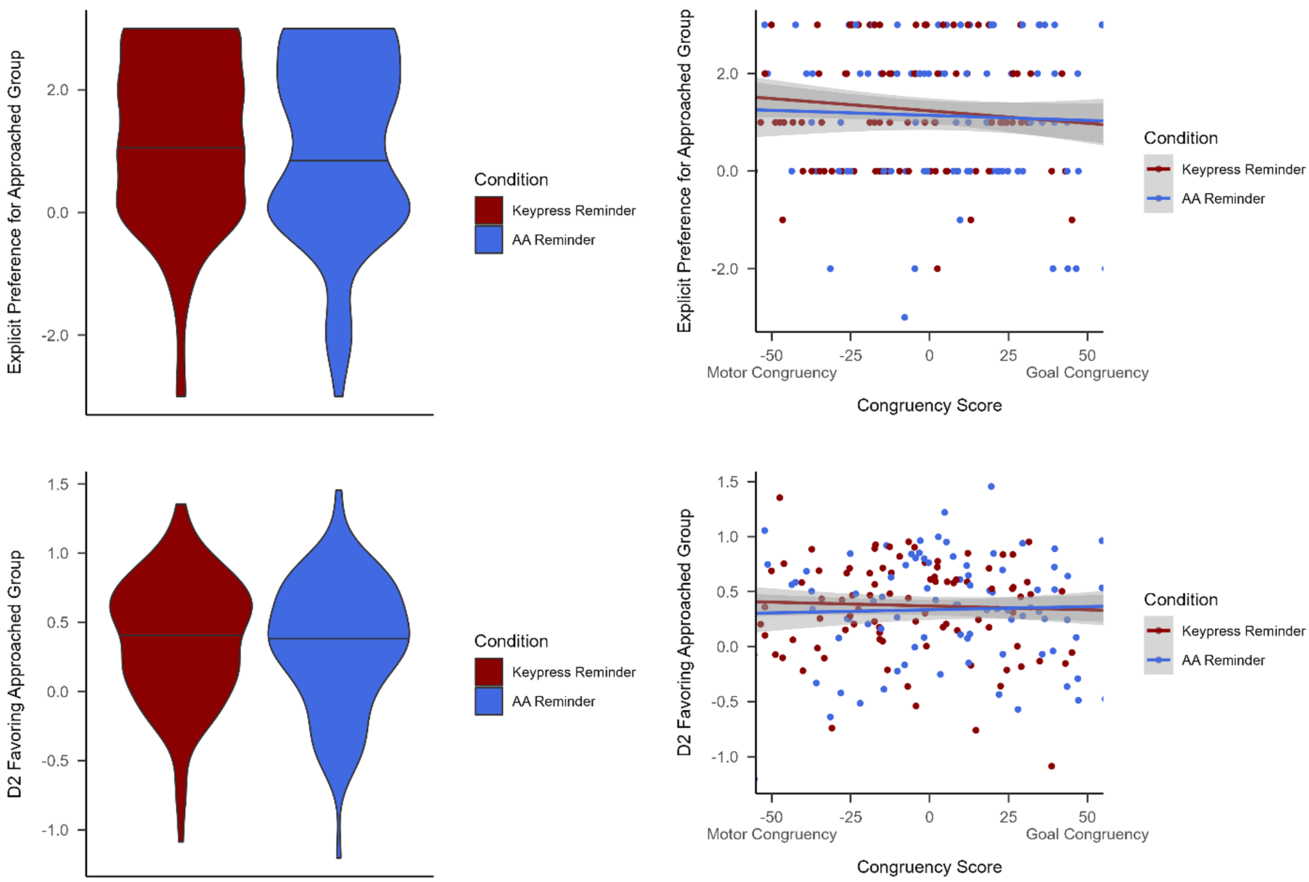


Fig. 3 Violin and scatter plots for explicit preference and IAT D2 measures as a function of condition and congruency scores (Experiment 2)

response tendencies in a flanker-like test task. These changes served as indicators of action identification either at the AA movement or at the keypress level (see the congruency relations in Fig. 1).

The findings from both experiments were consistent. Firstly, both experiments demonstrated training-induced changes in evaluative outcomes. The group that participants were trained to approach was favored over the group they were trained to avoid, as indicated by the explicit measure (preference rating) and the indirect measure (IAT). These AAT effects demonstrate that the present training procedure, consisting of alternating training and test blocks, effectively influenced participants' attitudes.

Secondly, both experiments yielded no evidence for moderation by action identification processes. AAT effects were similar in the S-R same and S-R reversed conditions of Experiment 2, and in the keypress and AA conditions of Experiment 2. A straightforward explanation could be that the experimental manipulations of action identification processes were not sufficient. In fact, congruency scores in the conditions fostering action framing on the keypress level (the S-R same condition in Experiment 1 and the keypress condition in Experiment 2) did not indicate significant facilitation of the trained keypress to a group relative to the opposite key after training. Consequently, it is possible that participants in these conditions also identified the trained responses on the AA level, in line with the general task instructions for the AAT and font (test) tasks. For this discussion, however, it is important to note that a previous study using a similar manikin task for AAT already demonstrated the mediating effect action frames on AAT outcomes (Van Dessel et al., 2018b). In this study, participants were explicitly instructed to move the manikin upwards and downwards in response to group member names. With these task instructions, the group paired with the upward response during training was liked more after training compared to the group assigned to the downward response. Notably, this liking change occurred although the trained upward response involved moving the manikin away from the target (avoidance) and the trained downward response a manikin movement towards the target (approach). Therefore, it is clear that explicitly instructed action frames have a significant impact on training outcomes. The unresolved question was whether a similar effect is observed with subtler variations of AAT procedures. The conclusive finding from the current study is that it does not.

Thirdly, the present study found no evidence for moderation of AAT outcomes by changes in AA-related response tendencies as gauged by the test task. This aligns with other research that analogously found no link between training-induced changes in approach biases and training outcomes (e.g., Dickson et al., 2016; Machulska et al., 2016; Wiers et al., 2011; but see also Sharbanee et al., 2014, for a notable exception). Moreover, it corroborates our previous study finding that training-induced changes in response tendencies are usually minimal and challenging to obtain, even with extensive response training (Eder & Krishna, 2023).

With respect to theoretical explanations, the present findings align well with the propositional account of AAT effects (Van Dessel et al., 2019; Wiers et al., 2020). According to this account, participants inferred better liking of the approached group (the stimulus-evaluation relation) from the relational information that they have approached this group during the training (the stimulus-action relation) and that they typically favor objects they consistently approach (action-outcome relation). The account can explain the present findings if it is assumed that the instructed task goal to approach and avoid the groups was weighted more than the use of keypressing as a simplifying response strategy. This assumption would be in line with numerous demonstrations of instruction-based AAT effects (e.g., Van Dessel et al., 2018a; Van Dessel et al., 2015). Due to the high task relevance of the AA instruction, participants could have not detected the stimulus-keypress relation, or they could have deliberately ignored this relation when drawing an inference about the liking of the groups. Considering that keypressing was necessary for initiating the AA movement, the latter explanation seems more plausible, though more research is needed on this question.

The present research also has limitations. An important limitation is the use of fictitious social groups as training stimuli that had little or no personal relevance for our study participants. We intentionally used neutral stimuli to rigorously control for pre-existing biases induced by the training stimuli (Krishna & Eder, 2019). However, this approach deviates from other AAT studies where the stimuli were clearly important to the participants (e.g., food, alcohol, tobacco), due to their motivational or clinical relevance (see e.g., Becker et al., 2015; Wiers et al., 2011).

Another significant limitation is the use of a symbolic manikin task for AAT. We opted for this task because of its widespread use in AAT research (e.g., Woud et al., 2013), its adaptability for online administration, and its superior performance compared to other AA measurement tasks (Krieglmeyer & Deutsch, 2010). However, the generalizability of the findings to AAT procedures that involve other, potentially more ecological AA behaviors remains uncertain (Eder et al., 2021). Research by Nuel et al. (2019, 2022) did not find an AAT effect on evaluations after training involving whole-body AA behaviors (upper body incline, walking steps), even when the training took place in a highly immersive virtual reality setting. This research raises questions whether training procedures that are more immersive than the manikin task, or that involve behaviors other than keypressing, would make a qualitative difference.

The current studies focused on training-dependent liking changes, and therefore, our conclusions are specifically limited to this training outcome. Previous research employing the manikin task for AAT has also demonstrated training-induced changes in health-related and emotional behaviors (e.g., Cheval et al., 2016; Huijding et al., 2011). Further investigation is needed to determine whether action identification processes influence these outcomes differently.

What can be gleaned from the current and related research for the practical use of AAT procedures? Firstly, instructions for the training should be clear about which stimuli should be approached and which should be avoided. Although previous studies found AAT effects in conditions in which the contingency between stimuli and trained action was irrelevant for the task at hand (e.g., Wiers et al., 2010), it is advisable making this relation obvious to the trainees. Secondly, we obtained large AAT effects on both evaluative measures with the manikin task, and can recommend its use for training. For the trainees, the manikin task is easy to understand, its administration does not require special computer equipment, and it could be administered online. In addition, the task also has potential for behavior modification other than evaluative responses. Thirdly, the sheer volume of training trials, or simply repeating a response to stimuli, appears to be unrelated to the success of the training. Although we did not manipulate the number of training trials systematically, we found no indication that a laborious modification of response biases, requiring a significant number of training trials, was systematically related to the outcome of the training. Although this null finding must be interpreted with caution, our studies were sufficiently powered to detect effect sizes at least in the medium range. Hence, a low number of training trials could be sufficient for many applications.

To summarize, the current research indicates that AAT procedures using the manikin task are relatively unaffected by task procedures that promote action identification at the motor level. Changes in AA-related response tendencies were not related to changes in liking as the training outcome, suggesting that these two aspects are independent.

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Author Contribution AE developed the study concept. Both authors contributed to the study design. AK programmed the experiments, organized the data collection, and analyzed the data. AE drafted the manuscript. AE and AK provided critical revisions.

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Data Availability Preregistration documents, materials, and raw data can be accessed at https://osf.io/85gp6/. Experiment 1 was preregistered at https://osf.io/y82kw, Experiment 2 at https://osf.io/7nyu9.

Declarations

Ethics Approval The study was performed with human subjects in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments and the study procedures were approved by the Institutional Review Board of the University of Würzburg (JMU), Department of Psychology (reference no. GZ 2018–22).

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