Assessing Motivational Biases in Brain and Behavior: Event-Related Potential and Response Time Concomitants of the Approach-Avoidance Task

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Abstract

The Approach-Avoidance Task (AAT) is designed to 1) measure the implicit motivated action biases that are instantiated by emotional stimuli, and 2) assess the changes in such biases that drive psychiatric disorder. To establish AAT sensitivity to emotional action bias at a neural level, some work has measured event-related potential (ERP) correlates — however, a lack of research with unpleasant, pleasant, and neutral stimuli together and also a common focus on psychiatric disorder-matched (rather than generally evocative) content limits foundational conclusions that can be drawn. In current research, then, 38 subjects completed an AAT where normative (rather than idiosyncratic) unpleasant, pleasant, and neutral images were shown with a color border indicating if a joystick should be rapidly pushed or pulled to decrease or increase image size. Using generally arousing stimuli, response times (RTs) were found to be faster on unpleasant push compared to unpleasant pull trials, t(37)=2.4, p=.02, and 32-sensor electroencephalography (EEG) also revealed that amplitude of a stimulus-response conflict-related ERP – the N200 – was reduced on unpleasant compared to neutral push trials and un-pleasant push compared to unpleasant pull trials, t(32)=5.5, p<.001. In addition, preliminary exploration of individual differences suggested that relevant variables of dimensional trait anxiety, depression, and anxiety disorder treatment seeking status did not impact RT- or N200-indicated emotional biases. Together, then, findings are consistent with a neurobehavioral avoidance bias for unpleasant stimuli while also suggesting a need to further test whether selecting images for idiosyncratic relevance is critical to revealing individual variations in emotional bias.
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ABSTRACT

The Approach-Avoidance Task (AAT) is designed to 1) measure the implicit motivated action biases that are instantiated by emotional stimuli, and 2) assess the changes in such biases that drive psychiatric disorder. To establish AAT sensitivity to emotional action bias at a neural level, some work has measured event-related potential (ERP) correlates of the task — however, a lack of research with unpleasant, pleasant, and neutral stimuli together and also a common focus on psychiatric disorder-matched (rather than generally evocative) content limits foundational conclusions that can be drawn. In current research, then, 38 subjects completed an AAT where normative (rather than idiosyncratic) unpleasant, pleasant, and neutral images were shown with a color border indicating if a joystick should be rapidly pushed or pulled to decrease or increase image size. Using generally arousing stimuli, response times (RTs) were found to be faster on unpleasant push compared to unpleasant pull trials, \( t(37)=2.4, p=.02 \), and 32-sensor electroencephalography (EEG) also revealed that amplitude of a stimulus-response conflict-related ERP – the N200 – was reduced on unpleasant compared to neutral push trials and unpleasant push compared to unpleasant pull trials, \( t(32)=5.5, p<.001 \). In addition, preliminary exploration of individual differences suggested that relevant variables of dimensional trait anxiety, depression, and anxiety disorder treatment seeking status did not impact RT- or N200-indicated emotional biases. Together, then, findings are consistent with a neurobehavioral avoidance bias for unpleasant stimuli while also suggesting a need to further test whether selecting images for idiosyncratic relevance is critical to revealing individual variations in emotional bias.

**Keywords:** Approach-Avoidance Task; Emotion; Motivation; Anxiety; ERPs
Emotions have been described as *action dispositions* — neurobiological states that bias a person toward behaviors consistent with the emotion and away from behaviors inconsistent with the emotion (Frijda, 1986). In line with this conceptualization, an Approach – Avoidance Task (AAT; Solarz, 1960; Rinck & Becker, 2007) has been developed with an express purpose to test how innately avoidance-/approach-related actions (moving a joystick away via arm extension or forward via arm flexion; Cacioppo, Priester, Berntson, 1993) are modulated when they are performed in the presence of emotional (unpleasant or pleasant) content. Additionally, the AAT was also designed to assess the impact of psychiatric phenomena (e.g., anxiety/related disorder, substance use disorder) on emotional modulation of avoid/approach actions — given the prominent hypothesis that psychiatric phenomena are often driven by critical changes in the degree to which unpleasant content primes avoidance (e.g., Foa, Huppert, & Cahill, 2006) or pleasant content primes approach (e.g., Volkow, Michaelides, & Baler, 2019). Finally, as an assay of both emotional processing and clinical changes therein, an important feature of the AAT is also meant to be its sensitivity to *implicit* biases that self-report tools may not detect — but which might still emerge in modulated response times (RTs) or potentially even pre-behavioral neural processing (Zech, Gable, van Dijk, & van Dillen, 2022).

Regarding evidence supporting AAT as an assay of implicit emotion action dispositions, then, some studies have indeed found predicted speeding of RTs for avoid-related extension (“push”), compared to approach-related flexion (“pull”), actions when paired with personally salient *unpleasant* stimuli (e.g., feared object images; Rinck & Becker, 2007), and other studies have found the predicted opposite effect (i.e., speeded RTs for pull relative to push) when actions are paired with personally salient *pleasant* images (e.g., erotica; Hofmann, Friese, & Gschwendner, 2009). Conversely and perhaps because many studies use lower-intensity stimuli like facial expressions or words, RT results have also been inconsistent across studies (e.g., Duijndam, Kupper, Denollet, & Karreman, 2020) — an ambiguity that might be reduced by more work with arousing scene stimuli to establish effects when stimulus evocativeness is
heightened (e.g., Wangelin, Bradley, Kastner, & Lang, 2012). In addition, interpretation of AAT findings to date is also muddied by inconsistency in which emotional categories are included across studies – with many using unpleasant and pleasant but no emotionally neutral control images, and others that only include unpleasant or pleasant content. In these cases, the degree to which emotion specifically (rather than other features) drives modulation then cannot be determined due to lack of a comparator that is perceptually analogous but also non-emotional.

Since RT could be an inconsistent downstream index of dispositions that are encoded in pre-behavioral neural circuit activity changes, it is also possible that latent biases toward motive actions are more apparent in neural indices than RT. Given this possibility, research has begun examining AAT neural correlates with scalp-based electroencephalographic recording of event-related potentials (ERPs) – an index that is sensitive to millisecond changes in cortical processing of motivationally relevant stimuli (see Kappenman & Luck, 2016). In analyzing AAT-related ERPs, particular focus has been placed on a frontal N200 component that scales with degree of conflict between a stimulus and an instructed response in other task contexts (Donkers & van Boxtel, 2004), and that also reliably arises in an AAT context (Ernst, Weidner, Ehlis, & Fallgatter, 2012; Ernst, Plichta, Lutz, Zesewitz et al., 2013; Di Lemma, Stancak, Soto, Fallon, & Field, 2020; Cofresí, Kohen, Motschman, Wiers, Piasecki, & Bartholow, 2022). Though a clear AAT-based ERP consistently emerges, however, basic ERP modulations, like those for RT, are inconsistent – and so, the two studies with general emotional stimuli found, in one case, a predicted N200 increase on incongruent push pleasant trials but no modulation on unpleasant trials (Ernst et al., 2013), and in the other case, increased ERP amplitudes on both push pleasant and push unpleasant trials even as RT was slowed in the former and speeded in the latter (Ernst et al., 2012). Unfortunately, equivocality of ERP effects, again like RT, is also difficult to interpret due to lack of an emotionally neutral condition in each case; and so, to clarify the AAT literature, one critical aim of current work was to test RT and ERP modulation when comparable neutral comparators are included along with unpleasant and pleasant scenes.
In addition to comparing emotional to neutral scenes, another important step toward understanding AAT effects is testing if modulation also occurs for normatively, rather than idiosyncratically, arousing/ salient stimuli. In the many AAT RT studies that exist, most test effects when content is selected for relevance to the sample – for example, when images of spiders are shown to individuals with spider phobia (Rinck & Becker, 2007), alcohol or drug cues are shown to individuals with use disorder (e.g., Field, Kiernan, Eastwood, & Child, 2008), or erotic images are matched to subjects based on sexual orientation (e.g., Hofmann et al., 2009). In such studies, it is then common to find predicted modulations in clinical groups (e.g., speeded RTs for spider push, compared to pull, trials in spider phobics; Rinck & Becker, 2007) but no effects in any non-clinical comparison group that may also be included – a pattern that supports clinical bias toward disorder-relevant stimuli but not normative action modulation by general emotion stimuli. In ERP work, similarly, predicted modulations have also been stronger when clinical matching or intervention is used — for example, such that individuals at higher risk for alcohol disorder show greater conflict-related ERP enhancement on push alcohol trials than lower risk individuals (Cofresi et al., 2022), and heavy drinkers show increased N200 amplitudes on pull alcohol trials after cue avoidance training (Di Lemma et al., 2020). Together, then, RT and ERP data are increasingly consistent with emotion biasing in highly clinically or personally relevant contexts, but they do not clarify if AAT captures a) general biases that are instantiated by any emotional stimulus and then strengthened by clinical/ personal relevance, or b) biases that are specific to relevant stimuli and not present for arousing stimuli generally. Moreover – although observations of no effect in non-clinical comparison groups could suggest that AAT is indeed insensitive to bias outside of idiosyncratically salient contexts, this also cannot be established since stimuli selected for relevance to certain (especially clinical) groups are often markedly less arousing/ evocative for non-clinical groups (e.g., Hamm, Cuthbert, Globisch, & Vaitl, 1997). Thus, an alternative cannot be ruled out that a lack of effects in non-clinical groups has occurred simply because stimuli have not been emotional enough for those groups.
Lack of clarity as to whether AAT is sensitive to emotional bias generally or idiosyncratic effects specifically could in turn also impact its use as a clinical assessment, since it is also not known if the task can assess the nonspecific bias changes that typify many clinic presentations (e.g., a general bias toward avoiding any unpleasant context that characterizes presentations marked by high anxiousness; Behar, DiMarco, Hekler, Mohlman, & Staples, 2009). To begin addressing this, then, current work also conducted a preliminary exploration of clinic-relevant individual differences across participants varying in trait anxiety, depression, and psychiatric treatment seeking. Informing this effort, participants in this study also completed a task in which escape/avoidance physiology is assessed during simple motor preparation – and in that task, increasing trait anxiety related to increasing fear expression (startle reflex reactivity) during preparation to escape unpleasant images via a simple button press (Sege, Taylor, Lopez, Fleischmann, White, & McTeague, 2023). Given that already published finding, it could be that similar changes also appear for the modulation of more dynamic action, or its neural underpinnings, in the AAT. Alternatively, it is important to note that the escape/avoidance task from our prior article also differs from the AAT in that action in that task is very simple (participants simply press a button on all active trials) and highly prepared (i.e., an informative cue is shown for more than 5 seconds prior to responding) – and as such, across multiple studies with that task anxiety-related differences in reflexive fear expressivity have appeared even as behavior itself remains highly consistent (i.e., all subjects quickly and accurately execute escape action; Sege, Bradley, & Lang, 2018; Sege et al., 2022). Given that AAT assesses more complex action in a more dynamic task context, meanwhile, different patterns of individual difference could arise in that task – an outcome that, in concert with our prior work on simple action preparation, could then inform how complementary assessments might be used to assess different dimensions of emotional action processing.

In sum, current work was primarily designed to test if predicted RT and ERP modulations arise in an AAT with normative (not idiosyncratic) unpleasant, pleasant, and neutral scenes;
and, as a secondary aim, it also began exploring if clinic-relevant differences still arise when AAT stimuli are not matched to a specific syndrome. Regarding the primary aim, the conceptual issue at hand is whether behavioral and/or neural modulations are in line with an emotion-as-action-disposition model when normative scenes are used – such that push responding is enhanced (i.e., RTs speeded and N200s reduced) by unpleasant stimuli, pull responding is enhanced by pleasant stimuli, and neither effect is apparent for neutral stimuli. As an additional test of the primary aim, then, the current study also examined congruence between N200 and RT modulations in unpleasant, pleasant, and neutral contexts – with the rationale that, a) a congruence of reduced N200 amplitudes and faster RTs would be in line with an interpretation that foreground stimuli are altering action biases in the brain and behavior, and b) having such an effect appear more strongly in emotional conditions could provide added evidence for AAT sensitivity to emotion (as opposed other image feature) effects. Regarding individual difference explorations, then, it could be that an AAT with normative stimuli is still sensitive to variations in general emotion-elicited biases – and, if so, unpleasant push facilitation could be exaggerated and/or pleasant pull facilitation blunted (reduced) as trait anxiety and/or depression increases. Alternatively, if no individual differences arise here whereas differences have appeared in prior AAT studies using matched stimuli, this could begin to suggest that it is critical to match stimuli to clinical syndrome in order to reveal relevant individual differences using this particular task. While further work that also includes matched stimuli is needed in either case to further test these possibilities, then, current work began to explore these questions by relating variations in trait anxiety, current depressive symptoms, and treatment seeking to emotional modulations of RT and ERP amplitudes in an exploratory fashion.

Method

Participants

Thirty-eight community-dwelling adults ages 18 – 65 completed this study. Participants were recruited via advertisements in the community and in a large Southeastern medical center,
and also via online advertisements. Of study completers, 19 reported that they were receiving or attempting to start anxiety/related disorder treatment, and 19 reported no treatment interest. EEG data were unavailable from 5 participants (3 treatment-seekers, 2 non-treatment-seekers) who opted out of recording. The study was IRB approved and participants gave written consent.

Sample Characterization

Questionnaires were a demographics survey and the: 1) Spielberger State-Trait Anxiety Inventory Trait Form (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983); 2) Beck Depression Inventory – Second Edition (BDI-II; Beck, Steer, & Brown, 1996), and; 3) an Illness Intrusiveness Rating Scale (IIRS; Devins, Binik, Hutchinson, Hollomby, Barre, & Guttman, 1983) survey of mental health-related impairment. Psychiatric diagnosis was also assessed for all subjects via MINI Interview (Sheehan, Lecrubier, Sheehan, Amorim, et al., 1998).

Study Task: The Approach-Avoidance Test

Participants completed an AAT in which a joystick is rapidly pushed away or pulled forward to change the size of foreground scenes. In this version, correct responding was guided not by any image feature, but by the color of a surrounding frame – such that a green frame indicated that the correct response was to pull the joystick forward to increase image size, and a blue frame indicated a correct response was to push the joystick away to decrease image size (Rinck, & Becker, 2007; see Figure 1). Each trial started with a 13.75cm x 18cm image superimposed on a 27cm x 36cm green or blue rectangle, and these stimuli stayed on the screen at that size until the participant initiated a response. Each trial continued until image size increased to the same as the border (pull response) or decreased so the image was no longer visible (push response), after which image and border disappeared. The next trial then began as soon as the joystick returned to center. E-Prime software (Psychology Software Tools, Pittsburgh, PA) was used to present all task stimuli on a computer monitor 90cm from the participant. Responses were made with a desk-mounted ThrustMaster T.16000M© FCS joystick.
AAT images were chosen to depict content that was generally unpleasant, pleasant, or neutral for most participants. Ninety-six pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) or Emotional Picture Set (EmoPicS; Wessa, Kanske, Neumeister, Bode, Heissler, & Schönfelder, 2010) were selected such that 32 depicted violent (e.g., mutilated face) or disgusting (e.g., vomit/ feces) scenes, 32 depicted fun or enjoyable scenes (e.g., adventure sports), and 32 depicted everyday scenes (e.g., people at work) or objects. Each image was presented (in color) twice throughout the task, resulting in 192 trials. Normative ratings for the IAPS (Lang et al., 2008) and EmoPics (Wessa et al., 2010) indicated that: 1) disgusting/ violent images were more unpleasant, $t(85)=13.4$, $p<.001$ and fun/ enjoyable images were more pleasant, $t(85)=12.5$, $p<.001$, than everyday images, and; 2) fun/ enjoyable, $t(85)=12.0$, $p<.001$, and disgusting/ violent, $t(85)=19.3$, $p<.001$, pictures were more emotionally arousing than the everyday set. Arousal was also higher for disgust/ violence, relative to fun/
enjoyable, images, \( t(85)=8.2, p<.001 \). In addition to normative ratings, current study participants also rated disgust/ violent, fun/ enjoyable, and everyday image sets on 1 (very unpleasant) – 9 (very pleasant; 5 = neutral) Likert scales, and they rated the disgust/ violent set as more unpleasant than the everyday set, \( t(37)=9.0, p<.001 \), and the fun/ enjoyable set as more pleasant than the everyday set, \( t(37)=8.6, p<.001 \). Finally, in addition to emotionality, each image set also included a similar number of figure/ ground-type images and complex scenes.

Data Collection

EEG/ERP. Electroencephalography was recorded using a Brain Products© actiCHamp® 32-channel active sensor and amplifier system. ActiCap© cloth caps with 10-20 standard sensor positions held sensors on the head. Online, data were sampled at 500 Hz and referenced to a common mode reference and then to sensor Fz. In addition to EEG data, electrooculogram (EOG) data were collected using 2 Ag/ AgCl sensors placed above and below the right eye (vertical), and 2 placed laterally to each eye (horizontal; data also sampled at 500Hz).

Behavioral Data. Response time (RT) was measured as the time from picture onset until a response was completed (Jacobus, Taylor, Gray, Meredith, et al., 2018).

Procedure

Following questionnaire completion and sensor attachment, participants were told which border color would signal to push or pull the joystick irrespective of content presented during the trial. Participants were told to try to make their response as quickly as they could and to continue their response until the image disappeared. The task typically finished in < 5 minutes. After the task, sensors were removed and participants were debriefed and paid.

Data Processing

EEG/ ERP. Offline processing of EEG data began with re-referencing to the average of all sensors and filtering using Butterworth filters with 1/3 amplitude cut-offs of .01 Hz – 30 Hz. After filtering, EEG was segmented relative to picture onset from 200ms pre-onset – 1000ms post-onset. Next, EOG data were used to correct eye movement artifacts by inputting these to a
Blink detection algorithm (Gratton, Coles, & Donchin, 1983). After correction, remaining artifact was then removed based on criteria of overly large (≥ 200 µV) or small (≤ .50 µV) voltage range in rolling 200-ms windows moving through each segment in 50-ms increments (Keil, Debener, Gratton, Junghöfer, et al., 2014). Finally, data were baseline corrected for each segment and trial-averaged within condition.

ERP quantification for analysis was guided by visual inspection of waveforms and scalp topographies along with reference to literatures for each component. Prior literature indicates AAT images should elicit a multi-component ERP comprising an early negative peak ~150ms post-onset at frontal/central sensors (N100), another negative peak ~250ms post onset at frontal/central sensors (N200), and a subsequent slow-wave positivity that begins 300-400ms post-onset and is maximal over central/parietal sites (P300/LPP). N200 was a component of primary interest, but N100 and P300/LPP components were also analyzed for completeness. Actual observed time/sensor windows for each ERP component are presented in the Results.

Behavior. Analysis of response times excluded trials in which response completion took > 2000ms (Hahn, Simons, Simons, Wiers, & Welker, 2019) or where an incorrect response was completed. RTs > 2000ms were rare (25 neutral, 19 pleasant, 24 unpleasant), as were errant responses (43 neutral, 48 pleasant, 55 unpleasant; Total trials = 2,400 for each valence; long responses ≤ 1% for each valence, errant responses < 2.5% for each valence). Median RT was analyzed since it better estimates central tendency than does the mean (Jacobus et al, 2018).

Data Analysis

Prior to main analyses, sample characterization was conducted and included testing differences across treatment-seekers and non-treatment-seekers in biological sex or race/ethnicity (using χ² tests) and age, anxiety, depression, and functional impairment (using independent-samples t-tests). For the primary aim of the study, Analyses of Variance (ANOVAs) were then conducted with task variables as repeated measures (Jennings, 1987). Primary analyses centered around separate 3 (Valence: Unpleasant, Pleasant, Neutral) x 2 (Response
Type: Push, Pull) ANOVAs for RT and each ERP component. In addition, an analysis of the congruence between RT and ERP effects was also conducted with the rationale that, if RTs do reflect an emotional bias toward or away from motive actions and N200 modulations also reflect conflict between image content and behavior, then it should be that N200 amplitudes are increased for slower trials and this might be particularly true for emotional, as opposed to neutral, trials. To test this hypothesis, trials were categorized into fast vs. slow trials as determined by median split of RTs (separately within each condition), and N200 amplitude was then used as a DV in an ANOVA with response speed (Fast, Slow), response type (Push, Pull), valence (Unpleasant, Pleasant, Neutral), and their interaction as within-subjects factors.

For the secondary exploration of clinic-relevant individual differences, RT and ERP variables from each condition and also condition difference (i.e., modulation) scores (push – pull unpleasant, push unpleasant – push neutral, etc.) were each correlated with trait anxiety (STAI), depression (BDI), and functional impairment (IIRS) scores. In addition, main task ANOVAs were repeated with treatment seeking status (2; Treatment Seeker, Not Treatment Seeking) added as a between-subjects factor. For these exploratory group analyses, independent-samples t-test comparisons were also conducted and depicted for all conditions and modulation scores so that effect sizes could be assessed independently of inferential significance.

Results

Sample Characteristics. Table 1 presents sample demographics, survey scores, and psychiatric diagnoses in the sample. The sample as a whole predominantly identified as female (65.5%), predominantly identified as white (87%), and was ~32 years old on average. In comparing treatment seeking individuals to those not seeking treatment, no differences arose in percent who identified as female, \( \chi^2(1,37)=0.1, p=.73 \), percent who identified as a racial/ethnic minority, \( \chi^2(1,37)=2.1, p=.15 \), or age, \( t(36)=0.3, p=.97, d=.01 \). Meanwhile and as expected, treatment seekers did report higher anxiety, \( t(36)=7.8, p<.001, d=2.5 \), depression, \( t(36)=5.8, p<.001, d=1.9 \), and functional impact of symptoms, \( t(43)= 8.4, p<.001, d=2.7 \).
**Table 1. Sample Characteristics.**

<table>
<thead>
<tr>
<th></th>
<th>Treatment Seekers (n=19)</th>
<th>Controls (n=19)</th>
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</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
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<tr>
<td>Mean(SD) Age</td>
<td>31.7 (9.4)</td>
<td>31.8 (9.5)</td>
</tr>
<tr>
<td>N(%) Female</td>
<td>13 (68)</td>
<td>12 (63)</td>
</tr>
<tr>
<td>N(%) Minority*</td>
<td>1 (5)</td>
<td>4 (21)</td>
</tr>
<tr>
<td><strong>Mean(SD) Symptom Scores</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STAI-T (Scale Range: 20 – 80)</td>
<td>52.3 (7.3)</td>
<td>33.3 (7.8)</td>
</tr>
<tr>
<td>BDI-II (Scale Range: 0 – 63)</td>
<td>18.7 (9.8)</td>
<td>4.4 (3.8)</td>
</tr>
<tr>
<td>IIRS (Scale Range: 15 – 105)</td>
<td>56.5 (15.7)</td>
<td>20.9 (9.5)</td>
</tr>
<tr>
<td><strong>Primary Diagnosis N(%)</strong>**</td>
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<tr>
<td>Posttraumatic Stress Disorder</td>
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<tr>
<td>Generalized Anxiety Disorder</td>
<td>5(26)</td>
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</tr>
<tr>
<td>Mood Dis. w/ Anxiety***</td>
<td>4(21)</td>
<td></td>
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<tr>
<td>Obsessive-Compulsive Disorder</td>
<td>2(10.5)</td>
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<tr>
<td>Adjustment Disorder w/ Anxiety</td>
<td>2(10.5)</td>
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</tr>
</tbody>
</table>

*Note: STAI-T = State-Trait Anxiety Inventory – Trait Form; BDI-II = Beck Depression Inventory – II Edition; IIRS = Illness Intrusiveness Rating Scale
**No control participant met criteria for any assessed psychiatric diagnosis
***Secondary anxiety disorders for subjects with primary mood disorder: 2 generalized anxiety, 1 social anxiety, 1 anxiety not otherwise specified

**Task Effects: Behavior.** Figure 2 depicts mean AAT response times (RTs) across each task condition. Analysis indicated that non-significant effects of response type, $F(1,36)=0.8$, $p=.37$, $\eta_p^2=.02$, and valence, $F(2,35)=0.8$, $p=.45$, $\eta_p^2=.02$, were qualified by a Response Type X Valence interaction, $F(2,35)=4.8$, $p=.02$, $\eta_p^2=.12$. Follow-up decomposition of the interaction specified that RTs were slower for pull-unpleasant trials than for pull-pleasant trials, $t(37)=2.6$, $p=.01$, $d=.42$, pull-neutral trials, $t(37)=2.3$, $p=.03$, $d=.37$, and push-unpleasant trials, $t(37)=2.4$, $p=.02$, $d=.39$. No other comparisons were significant, with the next smallest $p$ (.12) and largest $d$ (.26) for push-unpleasant compared to push-neutral trials.
**Task Effects: Cortical Processing.**

Figures 3 and 4 show an image-locked ERP that arose in all conditions and comprised prototypical N100, N200, and P300/ LPP components. For the N100, signal was maximal from 110 – 160ms post onset and across a frontocentral sensor cluster (Fz, FC1, FC2, Cz). Analysis of the averaged signal within this time and sensor window indicated that response type, $F(1,31)=11.3$, $p=.002$, $\eta^2_p=.27$, and valence, $F(2,30)=1.1$, $p=.33$, $\eta^2_p=.04$, effects were accompanied by a Valence X Response Type effect that approached significance, $F(2,30)=2.9$, $p=.06$, $\eta^2_p=.09$. Follow-up indicated an increase in N100 negativity for neutral push compared to pull trials, $t(32)=4.4$, $p<.001$, $d=0.8$, but no difference for unpleasant push vs. pull, $t(32)=1.1$, $p=.29$, $d=0.2$, or pleasant push vs. pull, $t(32)=0.5$, $p=.64$, $d=.08$, trials.

For the critical N200, signal was maximal from 220 – 320ms post-onset and across frontocentral sensors (Fz, FC1, FC2, Cz). To remove N100 differences and isolate N200 effects for analysis, N200 signal was averaged within the indicated time/ sensor window and then deviated from the N100 average via subtraction.\(^2\) Analysis of this score indicated a Response Type X Valence interaction, $F(2,30)=25.7$, $p<.001$, $\eta^2_p=.45$, that qualified response type, $F(1,31)=1.6$, $p=.22$, $\eta^2_p=.05$, and valence, $F(2,30)=25.1$, $p<.001$, $\eta^2_p=.45$, effects. Follow-up indicated reduced N200 negativity for unpleasant push vs. pull trials, $t(32)=5.5$, $p<.001$, $d=1.0$, increased N200 negativity for neutral push vs. pull trials, $t(32)=3.9$, $p<.001$, $d=0.7$, and no difference for pleasant push vs. pull trials, $t(32)=0.6$, $p=.54$, $d=0.1$. Within response types, no difference arose

\(^2\) Results did not change if raw N200 amplitude scores, rather than scores deviated from the N100, were used.
in a pull context but in the push condition N200s were less negative for unpleasant vs. pleasant, $t(32)=8.0, p<.001, d=1.4$, unpleasant vs. neutral, $t(32)=8.6, p<.001, d=1.5$, and pleasant vs. neutral, $t(32)=3.4$, $p=.002, d=0.6$, trials.

Finally, for a P300/ LPP component (Figure 4), signal was maximal from 500 – 900ms post-onset and across a centroparietal sensor cluster (CP1, CP2, Pz, P3, P4). Analysis of signal averaged within this time/ sensor window and deviated from the N200 (to remove differences in that window and isolate P300/ LPP\(^3\)) indicated significant effects of response type, $F(1,31)=4.5, p=.04, \eta_p^2=.13$, and valence, $F(2,30)=7.0, p=.004, \eta_p^2=.18$, accompanied by a non-significant Response Type X Valence interaction, $F(2,30)=1.7, p=.19, \eta_p^2=.05$. Follow-up of the valence main effect indicated increased LPP positivity for unpleasant relative to neutral trials, $t(32)=3.6, p=.001, d=0.6$, pleasant relative to neutral trials, $t(32)=1.8, p=.09, d=0.3$, and unpleasant relative to pleasant trials, $t(32)=2.1, p=.05, d=0.4$. Follow-up of the response type effect then indicated that LPP was also increased for push compared to pull trials, $t(32)=2.2, p=.04, d=0.4$.

Confluence of RT and Conflict-Related N200 ERP Component

In a first analysis of how N200 was modulated for fast vs. slow trials, effects of speed, $F(1,31)=7.4, p=.01, \eta_p^2=.19$, and a Valence X Speed interaction, $F(2,30)=3.1, p=.05, \eta_p^2=.09$, arose. Since effects of response type, $F(1,31)=0.1, p=.76, \eta_p^2<.01$, Response Type X Speed, $F(1,31)<.01, p=.92, \eta_p^2<.01$, and the three-way interaction, $F(2,30)=0.3, p=.77, \eta_p^2=.01$, were

\(^3\) Again, results were the same if the raw LPP amplitude score was used instead of the deviated score.
not significant, a follow-up was then conducted with trials collapsed across push/ pull conditions – and in this ANOVA, effects of speed, $F(1,31)=7.4$, $p=.01$, $\eta_p^2=.19$, and valence, $F(2,30)=12.3$, $p<.001$, $\eta_p^2=.29$, were qualified by a marginal interaction, $F(2,30)=3.0$, $p=.06$, $\eta_p^2=.09$. Further follow-up within each valence then found speed effects for unpleasant, $F(1,31)=8.6$, $p=.006$, $\eta_p^2=.22$, and pleasant, $F(1,31)=6.2$, $p=.02$, $\eta_p^2=.17$, but not neutral, $F(1,31)=0.3$, $p=.88$, $\eta_p^2<.01$, trials; and in paired comparisons, N200s were more negative for slow (relative to fast) unpleasant, $t(32)=3.0$, $p=.005$, $d=.52$, and pleasant, $t(32)=2.5$, $p=.02$, $d=.43$, trials whereas no slow vs. fast difference arose for the neutral condition, $t(32)=0.2$, $p=.86$, $d=.03$.

**Exploration of Clinic-Relevant Individual Differences**

Table 2 depicts exploratory correlations between dimensional symptoms (STAI, BDI, IIRS) and task indices (raw scores and modulation difference scores). For RT, no significant differences or suggestive effect sizes arose for raw scores but, for modulation scores, anxiety, depression, and functional impairment were related significantly and/ or with small-to-moderate effect size ($r$) to increasingly speeded (i.e., negative) push pleasant – neutral and push
unpleasant – neutral RT differences. For N200, then, no relationships arose for modulation scores but, for raw scores, STAI, BDI, and IIRS correlations with pull neutral and push neutral N200 amplitudes approached significance as did a BDI correlation with push pleasant N200 amplitudes (increasing symptom scores related to decreasing N200 negativities in each case).

As for a grouping variable of treatment seeking status, adding this factor to the ANOVA for RT indicated no moderating effect on response type, $F(1,36)=0.1, p=.76, \eta^2_p<.01$, or the Response Type X Valence interaction, $F(2,35)=0.7, p=.51, \eta^2_p=.02$, while an effect on valence approached significance, $F(2,35)=2.8, p=.07, \eta^2_p=.07$. Though exploratory group comparisons for each valence/ response type raw score indicated no group differences and consistently small effect sizes, then, comparison of modulation scores across groups revealed a significantly larger push pleasant vs. push neutral difference for treatment-seekers than for non-treatment-seekers, and a medium effect size (and $p=.14$) effect in the same direction for the push unpleasant vs. push neutral difference. To allow exploratory examination of effect sizes, table 3 shows $t$-test comparisons across groups for all RT raw scores and condition difference scores.

For the critical ERP variable (N200), then, no moderating effect of treatment seeking status on response type, $F(1,31)=1.2, p=.28, \eta^2_p=.04$, valence, $F(2,30)=0.5, p=.62, \eta^2_p=.02$, or the Response Type X Valence interaction, $F(2,30)=0.5, p=.59, \eta^2_p=.02$, arose. In exploratory pairwise comparisons to test for suggestive trends (see table 3 for all comparisons), meanwhile, a marginal difference between groups arose for N200 amplitude in the push-neutral condition, and small-to-medium effect sizes also arose for pull neutral, pull unpleasant, push-pleasant, and push-unpleasant comparisons. Exploratory comparisons of modulation scores, meanwhile, indicated no significant or suggestive trends and also generally small effect sizes, with the largest effect for a push – pull neutral difference score.  

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4 For the N100 group did not moderate response type, $F(2,30)=1.1, p=.30, \eta^2_p=.04$, valence, $F(2,30)=1.8, p=.18, \eta^2_p=.05$, or interaction, $F(2,30)=0.6, p=.54, \eta^2_p=.02$, effects. For LPP, group also did not moderate response type, $F(1,31)=0.9, p=.35, \eta^2_p=.03$, valence, $F(2,30)=0.1, p=.88, \eta^2_p<.01$, or the interaction, $F(2,30)=2.5, p=.11, \eta^2_p=.07$.  

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Table 2. RT and N200 amplitude correlations with self-report mental health measures.

<table>
<thead>
<tr>
<th></th>
<th>Raw Scores</th>
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<th>Modulation Difference Scores</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>STAI-T</td>
<td>BDI-II</td>
<td>IIRS</td>
</tr>
<tr>
<td></td>
<td>r (p)</td>
<td>r (p)</td>
<td>r (p)</td>
<td></td>
</tr>
<tr>
<td>Pull Pleas.</td>
<td>.06 (.72)</td>
<td>.01 (.94)</td>
<td>-.00 (.99)</td>
<td>Pull Pleas.</td>
</tr>
<tr>
<td>Pull Neut.</td>
<td>.13 (.43)</td>
<td>.04 (.82)</td>
<td>.03 (.86)</td>
<td>Pull Neut.</td>
</tr>
<tr>
<td>Pull Unpl.</td>
<td>.11 (.50)</td>
<td>.02 (.92)</td>
<td>.04 (.79)</td>
<td>Pull Unpl.</td>
</tr>
<tr>
<td>Push Pleas.</td>
<td>.04 (.79)</td>
<td>.00 (.99)</td>
<td>-.02 (.92)</td>
<td>Push Pleas.</td>
</tr>
<tr>
<td>Push Neut.</td>
<td>.22 (.18)</td>
<td>.12 (.47)</td>
<td>.09 (.61)</td>
<td>Push Neut.</td>
</tr>
<tr>
<td>Push Unpl.</td>
<td>.04 (.81)</td>
<td>-.03 (.87)</td>
<td>-.06 (.72)</td>
<td>Push Unpl.</td>
</tr>
</tbody>
</table>

Note: ^p < .10; *p < .05.
Table 3. Comparisons of RTs and N200 amplitudes across treatment-seeking (TS) and non-treatment-seeking (NTS) groups.

<table>
<thead>
<tr>
<th></th>
<th>RT</th>
<th>N200</th>
<th></th>
<th>N200</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>TS M (SD)</td>
<td>NTS M (SD)</td>
<td>T-test (d) (df = 37)</td>
<td>TS M (SD)</td>
<td>NTS M (SD)</td>
</tr>
<tr>
<td>Pull Pleas.</td>
<td>587.1 (69.6)</td>
<td>600.6 (69.7)</td>
<td>0.6 (.19)</td>
<td>Pull Pleas.</td>
<td>-1.5 (1.7)</td>
</tr>
<tr>
<td>Pull Neut.</td>
<td>592.8 (76.3)</td>
<td>598.8 (78.4)</td>
<td>0.2 (.08)</td>
<td>Pull Neut.</td>
<td>-1.1 (1.7)</td>
</tr>
<tr>
<td>Pull Unpl.</td>
<td>597.9 (78.8)</td>
<td>613.3 (77.3)</td>
<td>0.6 (.20)</td>
<td>Pull Unpl.</td>
<td>-1.0 (1.7)</td>
</tr>
<tr>
<td>Push Pleas.</td>
<td>584.6 (74.6)</td>
<td>603.1 (73.9)</td>
<td>0.8 (.25)</td>
<td>Push Pleas.</td>
<td>-1.1 (1.8)</td>
</tr>
<tr>
<td>Push Neut.</td>
<td>600.9 (71.5)</td>
<td>596.8 (72.7)</td>
<td>0.2 (.06)</td>
<td>Push Neut.</td>
<td>-1.6 (1.5)</td>
</tr>
<tr>
<td>Push Unpl.</td>
<td>584.1 (76.6)</td>
<td>596.1 (72.6)</td>
<td>0.5 (.16)</td>
<td>Push Unpl.</td>
<td>-0.1 (1.6)</td>
</tr>
</tbody>
</table>

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<tr>
<td></td>
<td>RT</td>
<td>N200</td>
<td></td>
<td>N200</td>
</tr>
<tr>
<td></td>
<td>TS M (SD)</td>
<td>NTS M (SD)</td>
<td>T-test (d) (df = 37)</td>
<td>TS M (SD)</td>
</tr>
<tr>
<td>Pull Pls. – Ntr.</td>
<td>-5.8 (26.8)</td>
<td>1.8 (25.0)</td>
<td>0.9 (.29)</td>
<td>Pull Pls. – Ntr.</td>
</tr>
<tr>
<td>Unp. – Ntr.</td>
<td>5.1 (21.5)</td>
<td>14.5 (30.6)</td>
<td>1.1 (.36)</td>
<td>Unp. – Ntr.</td>
</tr>
<tr>
<td>Unp. – Pls.</td>
<td>10.8 (27.7)</td>
<td>12.7 (29.3)</td>
<td>0.2 (.07)</td>
<td>Unp. – Pls.</td>
</tr>
<tr>
<td>Push Pls. – Ntr.</td>
<td>-16.3 (32.1)</td>
<td>6.3 (24.3)</td>
<td>2.4 (.79)^</td>
<td>Push Pls. – Ntr.</td>
</tr>
<tr>
<td>Unp. – Ntr.</td>
<td>-16.8 (34.9)</td>
<td>-0.8 (31.3)</td>
<td>1.5 (.48)</td>
<td>Unp. – Ntr.</td>
</tr>
<tr>
<td>Unp. – Pls.</td>
<td>-0.6 (28.9)</td>
<td>-7.1 (33.1)</td>
<td>0.6 (.21)</td>
<td>Unp. – Pls.</td>
</tr>
<tr>
<td>Push – Pull Pleas.</td>
<td>-2.4 (36.8)</td>
<td>2.5 (34.8)</td>
<td>0.4 (.14)</td>
<td>Push – Pull Pleas.</td>
</tr>
<tr>
<td>Neut.</td>
<td>8.1 (35.8)</td>
<td>-2.0 (28.8)</td>
<td>1.0 (.31)</td>
<td>Neut.</td>
</tr>
<tr>
<td>Unpl.</td>
<td>-13.8 (43.1)</td>
<td>-17.3 (37.4)</td>
<td>0.3 (.09)</td>
<td>Unpl.</td>
</tr>
</tbody>
</table>

Note: ^p < .10; *p < .05.
Finally, if treatment seeking group was entered into the analysis of N200 moderation by response speed, effects of group and its interaction with any task factor were all not significant in the initial full-factorial ANOVA (all ps>.39). In the follow-up ANOVA with collapsing across push and pull trials, group also did not interact with valence, $F(2,30)=0.03$, $p=.97$, $\eta_p^2<.01$, RT, $F(1,31)<.01$, $p=.99$, $\eta_p^2<.01$, or the interaction, $F(2,30)=0.6$, $p=.88$, $\eta_p^2=.02$. Similarly, in follow-up ANOVAs within each valence, group did not interact with RT for neutral, $F(1,31)=0.2$, $p=.99$, $\eta_p^2<.01$, pleasant, $F(1,31)=0.6$, $p=.99$, $\eta_p^2=.02$, or unpleasant, $F(1,31)=0.1$, $p=.71$, $\eta_p^2<.01$, trials.

Discussion

This study tested if RT and ERP modulations in a common AAT task are consistent with predictions when generally unpleasant, pleasant, and neutral scenes are used, and it began to explore if clinic-relevant differences arise when stimuli are not matched to disorder. Regarding task effects of main interest – normative high-arousing unpleasant scenes did produce predicted effects such that RT was speeded for unpleasant push (“avoid”) compared to pull (“approach”) trials, and amplitude of a stimulus-response conflict-related N200 (Donkers & van Boxtel 2004) was also reduced for unpleasant push compared to pull trials. In addition, tests of concordance between behavioral (RT) and neural (N200) modulations revealed predictable effects (increased N200, i.e., neural conflict, on slower trials) for unpleasant and pleasant, but not neutral, images – a result that could further support an interpretation that emotion enhances behavioral manifestation of neural conflict. Regarding simple RT and N200 modulations for pleasant and neutral trials, meanwhile, effects were not as predicted – such that: 1) no RT or ERP modulation arose for pleasant trials, and 2) N200s were increased for push compared to pull neutral trials in contrast with predictions that bias processing would not be modulated by minimally emotional content. As a whole, task effects then give some support for the AAT as an assay of emotional (especially unpleasant) action dispositions while also raising caveats with respect to additional factors, beyond emotional content, that might influence AAT modulations.
One factor indicated by current data as critical to consider is emotional arousal level – inasmuch as a lack of RT/ERP modulation for pleasant trials could be due to selected images being less salient/arousing than unpleasant images (even as they were still more arousing than neutral images). Despite the high pleasant valence of images in this study, then, current data suggest that neurobehavioral modulations in the AAT may not be reliable if intensity or arousal level of stimuli is not also optimized along with valence. At the same time, observed confluence between N200 and RT under pleasant (as for unpleasant) conditions still suggest some emotion-related increase in impact of neural bias processing on downstream behavior – i.e., such that reduced neural conflict leads to more efficient action resolution under unpleasant and pleasant, but not neutral, conditions. Given this, current data could then suggest that even lower-intensity emotional stimuli might elicit some general facilitation of motivated action, but higher intensity levels are needed to bring about specific priming of emotion-congruent actions – i.e., avoid (push) actions for unpleasant stimuli and approach (pull) actions for pleasant stimuli. In addition, current findings could also suggest that selecting images for idiosyncratic relevance may indeed be more critical for pleasant than unpleasant action disposition assessment since identifying static images that are generally high in pleasant valence and also intensity is a known challenge (cf. Bradley, Codispoti, Cuthbert, & Lang, 2001).

Neutral image findings, meanwhile, may suggest an additional factor of visual complexity – which influences the degree to which images are interesting to explore even if emotionality is held constant – as critical to consider in designing an AAT study. Reduced N200 for neutral pull relative to push trials that, in AAT parlance, could suggest an approach bias for neutral images has not been reported in prior studies – but, importantly, prior studies with neutral images have routinely selected sets that entirely comprise simple object pictures (e.g., Najmi, Kuckertz, & Amir, 2010; Hofmann et al., 2009). Given that neutral images in current work included many complex scenes, meanwhile, current findings could reflect a bias toward increasing the size of those scenes that, despite (or because of) their emotional neutrality, perhaps invited exploration
and disambiguation (cf. Wei, Roodenrys, Miller, & Barkus, 2020). Taken as a whole, current results could then suggest that AAT neurobehavior modulations can be influenced by other features (e.g., interest value) when emotional intensity is minimal, whereas they are increasingly influenced by general facilitation of approach/avoid action as emotional intensity increases and then are more strongly biased toward specific emotion-congruent (avoidance or approach) action when emotional intensity is maximized. Relatedly, current data then also point to a need for continued systematic manipulation of stimulus complexity, emotional arousal level, and other features in continued research to further establish how emotion effects of primary interest can be isolated and maximized across AAT administrations.

Turning to a preliminary exploration of individual difference effects – current data are not strongly consistent with clinic-relevant changes in emotional bias with an AAT that uses general, as opposed to disorder-specific, stimuli; but rather, they indicate that continued work must also keep examining how stimulus features beyond emotionality might influence individual difference, in addition to task, effects. RT effects included some suggestive results in line with increasing avoidance bias as symptom burden increases – namely such that a push unpleasant-neutral modulation score related to symptom burden and was associated with a medium effect size in comparison of treatment-seeking to non-treatment-seeking groups. Importantly contextualizing these findings, however, the same patterns in the same direction were also observed for a push pleasant-neutral modulation score (with conventional significance for the group comparison); and in addition, push unpleasant-pleasant, push-pull unpleasant, and push-pull pleasant modulation scores did not approach significance or meaningful effect sizes while the largest (though still small) effect sizes were observed for a push-pull neutral score. Similarly for N200, then, the largest effect sizes for both correlational and group comparison analyses were also associated with neutral contexts, while overall direction of trends was toward smaller N200s with increasing symptom burden for all conditions. Taken as a whole, current data might, if anything, then point to potential variation in how ambiguous neutral contents are processed as a function...
of anxiety and related symptoms, while providing minimal evidence of specifically and strongly exaggerated avoidance bias in the presence of generally arousing unpleasant images for even very anxious individuals. Given the speculative nature of any interpretations at this point, meanwhile, current data more than anything again indicate a need for further systematic manipulation of various image properties (complexity, emotional arousal and valence, personal relevance) to determine how such properties can be tuned to optimize sensitivity to clinic-relevant differences.

A lack of strong individual difference effects for highly arousing unpleasant conditions in this study contrasts with other studies that have found individual differences in similar sample sizes and, perhaps critically, also used matching of AAT stimuli to syndromes of interest (e.g., Rinck & Becker, 2007). Moreover, current minimal effects also contrast with a reliable increase in startle reactivity during escape preparation with increasing anxiety that was found in another task with this study sample (a finding that also replicated prior results; Sege et al., 2018; Sege et al., 2023). With this added context, an alternative interpretation of current data could be that general anxiety (as opposed to specific fear; McTeague & Lang, 2012) does not impact an overt behavioral priming dimension of emotional action dispositions (as assessed in the AAT) but it does impact a sub-overt fear activation dimension of such dispositions (as assessed in our prior published task). Relatedly, current data could also initially suggest that the AAT is better suited to assessing clinical bias toward specifically feared or craved content than it is to assessing change in general emotional action tendencies. Indeed, even if future work finds anxiety effects with larger samples, this interpretation could still hold true inasmuch as such effects might not be strong enough to detect at an individual level as is the ultimate goal of clinical assessment.

Importantly, replicating current results in future work would not obviate the AAT’s utility as a tool to assess bias processing or clinical changes in bias toward personally salient stimuli. Rather, if current results are replicated, this could suggest boundary conditions that are relevant to understanding what exact processing phenomena the AAT models and when clinical changes can be expected therein. Importantly for ongoing work, this elucidation is particularly relevant to
a burgeoning “bias modification” literature that uses the AAT (and related tasks) to treat emotion processing/behavioral disruptions by systematically altering stimulus-response contingencies (see Jones & Sharpe, 2017). By understanding what exact process is modelled in the AAT and related tasks, bias modification research might enhance outcomes by increasing the precision with which tasks are systematically tuned to target the intended phenomena. In addition, concomitant changes in real-world, functionally relevant behavior following bias modification might also become more detectable with a better understanding of which real-world behaviors might be impacted by modification training and, importantly, which might not.

As for immediate next steps to build on current work and further define the conceptual implications and boundary conditions of AAT modulations, a number of limitations of this study can be addressed. Regarding basic emotional effects, perhaps the primary need is to manipulate emotional valence, emotional arousal, general evocativeness vs. idiosyncratic relevance, and image complexity even more closely within the same AAT stimulus set, so that specific effects of each factor can be systematically disentangled. In addition, there is a need to employ higher-arousal pleasant stimuli – and though prior work found RT modulations consistent with AAT conceptualization using high-arousing erotic stimuli in an all-male sample (Hofmann et al., 2009), the difficult issue of ensuring that such effects are apparent beyond a specific matched situation is also requisite. As to clinical questions, then, the primary need beyond manipulating study stimuli is to recruit larger samples to support more formal individual difference analyses, such that samples are transdiagnostic but also comprise specific diagnostic groups (including a principally depressed group) of sufficient size to also test for potential diagnostic-specific effects. And finally, there is a need for work that includes both disorder-matched and generally emotional stimulus categories, which would further clarify AAT’s sensitivity to focal versus generalized clinical emotion processing changes.

As for current study implications, principal contributions of these data are to further support AAT as an assay of emotional action dispositions in high-arousal unpleasant contexts,
and to inform further research on how other factors can be manipulated to optimize effects. Regarding clinical questions, current data also serve as an impetus for continued research that more formally compares matched vs. unmatched images and systematically manipulates image characteristics to determine what drives the elicitation of clinic-relevant variations. While a burgeoning clinical literature has developed in which the AAT is used to systematically modify response biases for disorder-relevant stimuli, then (see Jones & Sharpe, 2017), current research points to a critical need to further explicate boundary conditions of AAT effects so future instantiations of the task can better account for non-emotional confounds and, in turn, enhance the basic science and clinical effects that arise with this task.
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References Cited


Cuthbert BN, Insel TR. Toward precision medicine in psychiatry: The NIMH research domain criteria project. In DS Charney, JD Buxbaum, P Sklar, EJ Nestler (eds.), Neurobiology of mental illness (pp. 1076-1088). 2013; Oxford University Press.


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Jacobus, Taylor, Gray, Meredith, et al. A multi-site proof-of-concept investigation of computerized approach-avoidance training in adolescent cannabis users. 2018


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