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Internet-delivered approach-avoidance conflict task shows temporal stability and relation to trait anxiety

Johanna M. Hoppe [a,*], Johan Vegelius [a,b], Malin Gingnell [a], Johannes Björkstrand [c,1], Andreas Frick [a,1]

[a] Department of Medical Sciences, Psychiatry, Uppsala University, Uppsala, Sweden
[b] Department of Statistics, Uppsala University, Uppsala, Sweden
[c] Department of Psychology, Lund University, Sweden

A R T I C L E I N F O

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A B S T R A C T

Excessive avoidance causes functional impairment and maintains anxiety disorders. In the laboratory, approach-avoidance conflict tasks (AACT) can be used to study approach-avoidance behavior in mixed outcome situations (i.e., the same behavior entails both aversive and rewarding consequences). We tested the feasibility of a novel, internet-delivered AACT (iAACT) by conceptually replicating results from laboratory AACTs, including the temporal stability of results and the relation between trait anxiety and approach-avoidance behavior. Individuals from the general population (n = 186) completed a measure of trait anxiety and the iAACT, which entailed choosing either to approach aversive stimuli (image-sound) and receive a reward (points), or to avoid them and not receive a reward (i.e., costly avoidance). The temporal stability of approach-avoidance behavior was assessed by inviting participants to repeat the iAACT six weeks later (n = 91). Consistent with previous findings in laboratory AACTs, results showed that approach behavior to aversive stimuli increased with higher reward levels. These findings were replicated in the follow-up session. Also consistent with previous studies, higher trait anxiety was associated with elevated costly avoidance. In conclusion, the consistency of our results with laboratory studies indicates that the iAACT is feasible and may provide a cost-effective and scalable method to study anxiety-related approach-avoidance behavior remotely.

1. Introduction

Avoidance behavior is a core feature of anxiety disorders. In essence, avoidance is an adaptive defensive response to protect us from (real) threats and harm. However, systematic avoidance of anxiety-provoking (safe) situations critically contributes to maintaining psychopathological symptoms by preventing the individual from learning that the aversive outcome may not occur (anymore) or is manageable (Craske et al., 2017), a process referred to as *protection from extinction* (Lovibond et al., 2009). Another less acknowledged but nonetheless critical consequence of avoidance is the loss of positive outcomes associated with approaching, instead of avoiding, the anxiety-provoking situation. For example, avoiding dating because of social anxiety will reduce the risk of rejection and discomfort but will prevent the individual from disconfirming the belief that they will be humiliated or not be able to handle rejection *and* prevent the

* Correspondence to: Department of Medical Sciences, Uppsala University Hospital, 751 85 Uppsala, Sweden.
E-mail address: johanna.motilla_hoppe@neuro.uu.se (J.M. Hoppe).
[1] These authors contributed equally

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person from fulfilling the wish of finding a partner. As a result, social anxiety and loneliness will persist. In other words, anxiety-provoking situations often include approach-avoidance conflicts, i.e., mixed-outcome situations in which avoidance of an aversive outcome is conflicted with the loss of competing rewards and vice versa (Pittig et al., 2020). In line with this notion, exposure therapy, the gold-standard psychological treatment for anxiety disorders, includes an approach-avoidance conflict in which the patient must confront the anxiety-provoking situation to improve well-being and function (Craske, 2015). Despite the vital role of avoidance in anxiety disorders and its detrimental effects on well-being and function, knowledge about the psychological mechanisms underlying why individuals differ in their tendency to avoid rather than approach when facing an approach-avoidance conflict is incomplete (Pittig et al., 2020). A better understanding of the mechanisms underlying approach-avoidance behavior could help us develop and refine interventions to treat and prevent psychopathological conditions (Holmes et al., 2018); Pittig et al., 2016).

Recent years have seen increasing interest in studying approach-avoidance behavior experimentally in humans (e.g., Aupperle et al., 2011; Björkstrand et al., 2016; Björkstrand et al., 2017; Heuer et al., 2007; Lemmens et al., 2021; Pittig & Dehler, 2019; Rinck et al., 2013; Rinck & Becker, 2007; Smith et al., 2021; Smith et al., 2021). Previously, experimental studies focused on low-cost avoidance, that is, when avoidance is not associated with loss of positive outcomes (e.g., the individual can opt to escape an electric shock by pressing a button without any cost/aversive consequence (e.g., Lovibond et al., 2009). However, as low-cost avoidance could be regarded as adaptive, and navigating threats in everyday life often requires decision-making based on cost-benefit consideration (i.e., approach-avoidance conflict), the external validity and relevance for psychopathology of low-cost avoidance experimental tasks have been debated (Krypotos et al., 2018). It has been argued that approach-avoidance conflict tasks (AACT) offer a more valid model for studying approach-avoidance behavior experimentally (Krypotos et al., 2018; Pittig et al., 2020). In principle, an AACT entails being confronted with an approach-avoidance conflict, including the option to either (1) approach an aversive stimulus (e.g., be exposed to aversive images or electric shocks) and attain a reward (e.g., money, points) or (2) avoid the aversive stimulus (neutral image, no electric shock) at the cost of not receiving/losing a reward (for reviews, see Krypotos et al., 2018; Pittig et al., 2020). In line with the inherent adaptive function of threat avoidance, findings show that when given the option, individuals generally choose to avoid situations that entail an aversive outcome when avoidance is not associated with a cost (i.e., "low-cost avoidance"; e.g., Lovibond et al., 2009; Pittig et al., 2021; Pittig & Scherbaum, 2020). However, when introducing a competing reward (e.g., money or points) for approaching the same situation, avoidance decreases (e.g., Aupperle et al., 2011; Björkstrand et al., 2016; Pittig et al., 2018; Sierra-Mercado et al., 2015). Indeed, approach behavior has been shown to increase despite unchanged subjective and physiological fear responses toward the aversive outcome (Pittig et al., 2021; Pittig & Dehler, 2019). Specifically, approach behavior has been observed to increase in proportion to the size and likelihood of receiving the reward and the intensity and probability of the occurrence of the aversive consequence (for review, see Pittig et al., 2020). Thus, evidence from AACTs indicates that individuals are more prone to approach a potentially threatening situation in the presence of competing rewards.

The term "costly avoidance" has been used to describe when avoidance is associated with a cost. Consistent with the proposed link between psychopathology and avoidance behavior, preliminary findings from a pioneering AACT study by Pittig and colleagues (Pittig et al., 2021) showed that individuals with anxiety disorders continue to avoid in the presence of competing rewards to a greater extent than non-clinical individuals. Notably, in this study, individuals with anxiety disorders and non-clinical individuals did not differ in (conditioned) fear of the aversive stimulus, suggesting that elevated costly avoidance in anxiety disorders may be influenced by other factors than fear responses (Pittig et al., 2021). Further suggesting a link between psychopathology and approach-avoidance conflicts, other experimental studies have observed a relationship between costly avoidance and levels of trait anxiety in non-clinical individuals (Pittig et al., 2014; Pittig & Scherbaum, 2020), in which high-anxious individuals show higher levels of costly avoidance compared to low-anxious individuals.

Previous studies have thus provided new insights into motivational factors and individual differences driving approach-avoidance in individuals with psychopathological conditions (e.g., Björkstrand et al., 2016; Heuer et al., 2007; Pittig et al., 2021; Smith et al., 2021) and non-clinical individuals (e.g., Aupperle et al., 2011; Pittig & Dehler, 2019; Pittig and Scherbaum, 2020) However, the number of studies exploring approach-avoidance behavior is limited and there are inconsistencies in results that call for further research. For instance, one study found that costly avoidance in individuals with psychopathological conditions (depression and/or anxiety disorders, or substance use disorder) was associated with decision uncertainty rather than emotional conflict (the latter defined as sensitivity to negative outcomes versus rewards; Smith et al., 2021; Smith et al., 2021). Also, another study did not find an association between trait anxiety and costly avoidance, although using a limited sample size (Aupperle et al., 2011). Furthermore, the relationship between costly avoidance, psychopathology, and trait anxiety appears to be non-linear as a bimodal distribution has been observed in which some patients (Pittig et al., 2021; Smith et al., 2021) and highly anxious individuals (Pittig & Scherbaum, 2020) show persistent avoidance while others show little or no avoidance. Also, the relationship between psychopathological symptoms and costly avoidance at a dimensional level is not fully understood. For instance, in one study, elevated costly avoidance was observed in anxiety disorders compared to healthy individuals, but symptom severity was not significantly associated with costly avoidance within the patient group (Pittig et al., 2021). Moreover, only one study has explored the temporal stability of approach-avoidance behavior in AACTs (Smith et al., 2021), suggesting that approach-avoidance behavior is stable over time. In sum, the mechanisms underlying approach-avoidance behavior and its link to psychopathology need to be investigated further in well-powered studies. This enterprise could be facilitated by cost-effective and scalable methods for data collection, such as internet-delivered behavioral tasks.

The replication crisis, partly driven by underpowered studies, warrants the development of low-cost and scalable experimental methods to enable well-powered studies (Allison et al., 1997; Holmes et al., 2018; Munafò et al., 2017). Conducting empirical research in a laboratory setting can be time-consuming and costly. Furthermore, the fact that participants need to travel to the laboratory, sometimes several times (e.g., longitudinal studies), limits the geographical area from which participants can be recruited and may increase drop-out rates. Remotely-delivered experiments have the potential to facilitate large-scale data collection and minimize cost (e.g., Aubé et al., 2019; Björkstrand et al., 2022; Cameron et al., 2022; Purves et al., 2019). Furthermore, internet-delivered experiments could also promote the inclusion of a broader range of participants, allowing for more heterogenous, ecologically valid samples, thus countering the threats to the validity of results when experiments are conducted on homogenous samples (e.g., only including student populations; Hanel & Vione, 2016). Potentially, anyone with access to a smartphone and internet connection could participate in internet-delivered experiments. However, more research is needed regarding the feasibility of using different devices (computer/smartphone/tablet) to deliver psychological experiments. In line with the potential advantages of remotely-delivered experiments, recent years have seen increasing interest in the development of internet-delivered experiments (Aubé et al., 2019; Zech et al., 2020) and interventions (e.g., Macy et al., 2015; Van Dessel et al., 2018; Weil et al., 2017; Wittekind et al., 2015; Wittekind et al., 2019) based on approach-avoidance behavior. These have primarily used approach-avoidance tasks in which participants are instructed to pull a stimulus towards themselves (approach) or push it away (avoided), i.e., zooming into or out from the stimulus on a screen (Rinck & Becker, 2007). Suggesting the feasibility of internet-based experiments, an online version of the Visual Approach/-Avoidance by the Self Task (iVAAST), which measures spontaneous approach and avoidance tendencies to positive and negative stimuli, showed effects of similar magnitude to those observed in the laboratory version of the VAAST (e.g., faster response time to approach positive stimuli and avoid negative stimuli and vice versa; Aubé et al., 2019). These findings indicate that also approach-avoidance conflict tasks focusing on fear and anxiety-related approach-avoidance behavior could be successfully delivered online.

1.1. Aims of the study

The current study aimed to explore the feasibility of using remote data collection to assess approach-avoidance behavior with a novel iAACT in a community sample. The feasibility of the iAACT was evaluated by conceptually replicating findings on costly avoidance from laboratory-based studies and assessing participant feedback. Specifically, in line with previous findings, we hypothesized that approach behavior in the iAACT would increase with higher reward levels and that trait anxiety would be associated with elevated costly avoidance. We also sought to conceptually replicate preliminary findings indicating temporal stability of costly avoidance (Smith et al., 2021), and extend these findings by exploring if the relationship between trait anxiety and approach-avoidance behavior is stable over time. To this end, participants were invited to complete the task on two occasions, six weeks apart. A secondary aim was to explore the relationship between approach-avoidance behavior and self-reported current psychopathological symptoms (e.g., depressive and anxiety symptoms during the past two weeks) at a dimensional level. The iAACT entailed choosing between two options, either viewing and hearing an aversive image and sound, which was rewarded with a varying number of points (0, 1, 5, 10, 20, 50 points), or viewing and hearing a neutral ("safe") image and sound, which was never rewarded. In order to explore the feasibility of the iAACT on devices other than a computer, a sub-sample was given a choice to conduct the task on either a computer, smartphone, or tablet.

2. Methods

2.1. Participants

Adult participants were recruited from the general population in two cohorts using advertisements in social media. For eligibility, participants were required to be 18 years or older and have normal or corrected vision and hearing. Eligibility criteria were assessed through self-report. All participants provided informed consent. The study was approved by the Swedish Ethical Review Authority (2020–05777) and conducted in accordance with the Helsinki Declaration. Participants received a gift card worth 200 SEK (approximately 20 USD) for completion of each data collection session.

2.2. Stimuli and materials

The iAACT was delivered remotely over the internet using the PsyToolkit platform (Stoet, 2010; Stoet, 2017). Cohort 1 was required to perform the iAACT using a computer with a keyboard. In order to explore the feasibility of the iAACT on devices other than a computer, participants in cohort 2 were given a choice to use any device type (e.g., computer, smartphone, tablet). Consent and questionnaire data were collected online using REDCap (Research Electronic Data Capture), a secure, web-based software platform designed to support data capture for research studies (Research Electronic Data Caputure; Harris et al., 2009; Harris et al., 2019), hosted by Uppsala University.

Aversive and neutral images included in the experimental paradigm were obtained from the affective image libraries International Affective Picture System (IAPS; Lang and Bradley, 2007), DIsgust-RelaTed-Images (DIRTI; Haberkamp et al., 2017), Nencki Affective Picture System (NAPS; Marchewka et al., 2014), and Open Affective Standardized Image Set (OASIS; Kurdi et al., 2017). Aversive images displayed injuries, surgery, and excrements. Neutral images represented uninjured body parts (e.g., hands, feet), people in relaxing environments/nature, and clean bathrooms (see Supplementary materials Table S1 for a list of specific stimuli). A total of 18 aversive and 18 neutral images were used at each time point (i.e., sessions 1 and 2). Sounds were obtained from the International Affective Digitized Sounds library (IADS: Bradley & Lang, 2007). The aversive sounds consisted of a woman screaming in despair (session 1: IADS sound 277; session 2: IADS sound 276), and the neutral consisted of the sound of rippling water for session 1 (IADS sound 172) and paper folding for session 2 (IADS sound 728).

Trait anxiety was measured using the Spielberger State-Trait Anxiety Inventory - Trait version (STAI-T; Spielberger et al., 1970), yielding a score between 20 and 80, with higher scores representing higher anxiety levels. The extended version of the Inventory of Depression and Anxiety Symptoms (IDAS-II; Watson et al., 2012) was used to assess current psychopathological symptoms. The IDAS-II is a self-reported 19-scale measure assessing specific symptoms of internalizing disorders, including depression, anxiety disorders, OCD, bipolar disorder, and PTSD, present during the past two weeks.

2.3. Procedure

2.3.1. Session 1

Participants meeting eligibility criteria received an email containing a link to the webpage in which the experiment was delivered and a link to the questionnaires, including STAI-T and IDAS-II. For cohort 1, the experiment had to be conducted using a computer with a keyboard. For cohort 2, the experiment could be conducted using any device with a web browser (computer, smartphone, or tablet). Participants were instructed to conduct the experiment in a quiet place to avoid disruptions and use headphones. A two-step procedure was used to calibrate the computer volume to be unpleasantly loud (but not damage their hearing). First, participants listened to a recording of the reading of a neutral text and set their sound level to their preferred listening volume. Subsequently, they listened to an alarm sound to set the volume to be markedly unpleasant but bearable. The iAACT was framed as a game in which participants were instructed to win as many points as possible. After completing the iAACT, participants reported compliance with instructions, if experiencing any technical problems or disruptions, and information about the device used to perform the experiment.

2.3.2. Session 2

Six weeks after session 1, participants were contacted via email with an invitation to complete the experiment and answer the STAI-T again. During session 2, participants repeated the same experimental procedure and iAACT as session 1, but with different aversive and neutral images and sounds.

2.3.3. Approach-avoidance task

The iAACT consisted of trials where participants chose between one of two symbols displayed on the screen together with the number of points rewarded if choosing the symbol (1) a skull or (2) a smiley (see Fig. 1). Participants were instructed that choosing the skull would always be followed by an aversive image and sound, while choosing the smiley would be followed by a neutral image and sound. The skull was associated with varying amounts of points (0, 1, 5, 10, 20 or 50) and the smiley was never rewarded with points (0 points). For cohort 1, choices were made using the keyboard (‘A’ and ‘L’ keys), and for cohort 2, participants used their mouse or touch screen to click on the chosen symbol. Participants had 7 s to choose between the symbols. If no active choice was made within 7 s, a neutral image-sound was displayed, and the trial was discarded from analyses. Participants had to make an active choice in more than 90% of the trials to be included in analyses. After choosing one of the symbols, the image was displayed for 4 s together with the accompanying sound, followed by a text for 3 s displaying the number of points won for the individual trial and the total number of points obtained in the game. After the presentation of each image-sound pair, a fixation cross was displayed on the screen for 3–4 s (randomly chosen in steps of 100 ms). The experimental paradigm included 30 trials, with the order of images randomized across

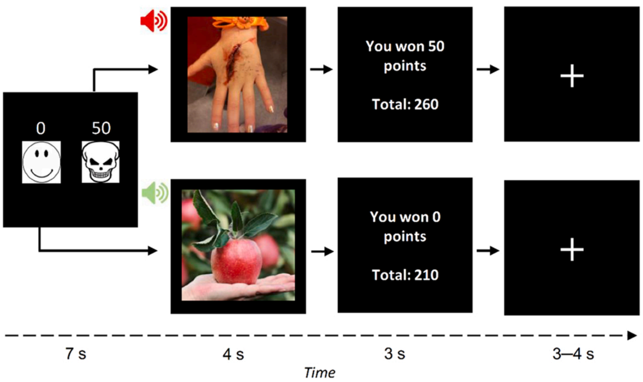

Fig. 1. Approach-Avoidance Task. The approach-avoidance task consisted of a game in which participants were instructed to win as many points as possible. Participants had to decide between two options, either viewing and hearing an aversive image and sound, which was rewarded with a varying number of points (0, 1, 5, 10, 20, 50 points), or viewing and hearing a neutral (“safe”) image and sound, which was never rewarded. Participants were instructed that choosing the “skull symbol” would always be followed by an aversive image and sound, while choosing the “smiley” would be followed by a neutral image and sound. Points rewarded for selecting each option were displayed above the symbols. In the example above, choosing the “skull symbol” would be rewarded with 50 points and entail the presentation of an aversive image and sound, while choosing the “smiley” would yield 0 points and the presentation of a neutral image and sound. Participants had 7 s to choose between the aversive vs neutral image-sound. Images were displayed for 4 s with an accompanying sound (aversive: woman screaming; neutral: rippling water [session 1] or paper folding [session 2]), respectively. After each image-sound pair, the number of points won was presented for 3 s. A fixation cross was then displayed on the screen for 3–4 s (randomly chosen in steps of 100 ms) before the start of the next trial (30 trials in total). Images shown in the figure are not the same as the ones used in the experiment.

participants (the same aversive/neutral image stimulus could only be displayed twice). Each reward level (i.e., 0, 1, 5, 10, 20, or 50) was presented 5 times, in randomized order, and the location (left vs. right) of each symbol (skull vs. smiley) was counterbalanced across trials. Points were not associated with any monetary or other "real" reward. Notably, several previous studies have demonstrated that hypothetical rewards, such as points, effectively modulate approach/avoidance behavior (Aupperle et al., 2011; Pittig, 2019; Pittig et al., 2018; Pittig & Dehler, 2019). After completing the iAACT, participants were asked to rate for each neutral and aversive image (36 in total) how much they agreed from 1 (not at all) to 7 (totally) with feeling fear, disgust, and discomfort while viewing each image. Mean scores for all ratings of aversive and neutral images were calculated for each participant.

2.4. Data analysis

Participants who approached the aversive image more than 1 time on 0-point trials were excluded because they were deemed less likely to experience the incentive conflict between rewarding points and aversive images, of interest here. Likewise, participants who responded to less than 90% of the trials in each session were excluded.

We calculated the proportion of incentive conflict trials (i.e., trials with >0 reward for approaching the aversive stimuli) that each participant chose to approach the aversive stimuli, both across all reward levels, and for each reward level separately.

For each session, choice (approach to or avoidance of the aversive stimulus) was modeled for each trial by fitting a mixed effects logistic regression model using generalized linear mixed models with a binomial family and logistic link function in R 4.1.1 (R Core Team, 2021) and the package lme4 version 1.1–27.1 (Bates et al., 2015). We only included trials with non-zero rewards in the analyses because these were designed to induce the incentive conflict of interest. Models were fitted by maximum likelihood using the adaptive Gauss-Hermite approximation with 20 points per axis (nAGQ=20). Subject was modeled as a random factor (intercept) in all models and other predictors as fixed variables. For each session, an initial model was constructed including the following predictors: reward level (linearized by recoding to 1, 2, 3, 4, 5), trial number (1−30), and each individual's mean aversiveness rating of the aversive images. To test the relationship between trait anxiety and approach behavior, a second model including only subject (random intercept) and STAI-T scores as fixed effect was then fitted. To further assess the relationship between trait anxiety and approach behavior, a third model was fitted with the addition of STAI-T to the first model including reward level, trial number and aversiveness rating. Analysis of variance (ANOVA) was used to assess the addition of STAI-T to the model (i.e., comparing models one and three). Thus, a total of three models per session were fitted for these analyses. For the secondary aim to test the relationship between approach behavior and psychopathological symptoms, we fitted separate models for each IDAS-II subscale including subject (random intercept) and the score on the subscale as predictors (i.e., similar to the simple STAI-T model described above).

3. Results

3.1. Participant characteristics

Two hundred eleven participants (women n = 177, men n = 26, other/do not want to specify n = 8) completed session 1. Of these, 107 participants also completed session 2 (women n = 84, men n = 18, other/do not want to specify n = 5), i.e., 50.7 % completed both sessions (49.3 % dropout after session 1). See Table 1 for further details on participant characteristics.

Participants were excluded from the analyses if they approached more than 1 aversive image on the 0 points level (session 1: n = 23, session 2: n = 9) or responded to less than 90 % of the trials (session 1: n = 2, session 2: n = 1). This left 186 participants (women n = 156, men: n = 22, other/do not want to specify n = 8) in analyses of session 1. Of these, 92 participants (women n = 75, men n = 15, other/do not want to specify n = 5) remained for analyses of session 2. The second session was completed Mdn = 46 (interquartile range [IQR]:13.5, range: 20–190) days after session 1. Two participants did not complete the aversiveness rating procedure and were thus not included in any of the analyses including these variables.

Participants were recruited in two cohorts, cohort 1: n = 95 at session 1 and n = 48 at session 2, and cohort 2: n = 91 at session 1 and n = 44 at session 2. No difference between cohorts in age, sex distribution, STAI-T scores, rating of aversive stimuli, or proportion approach trials on the iAACT could be detected (P's > 0.14). The cohorts were therefore merged and treated as one group in subsequent analyses.

Participants who completed both sessions (n = 92) did not differ from participants who only completed the first session (n = 94) on sex distribution (both sessions: 75 women, 12 men, 5 other/do not want to specify; only session 1: 81 women, 10 men, 3 other/do not want to specify; $\chi^2(2) = 0.89$, $p = 0.640$), age (both sessions: 34.9 (11.6); only session 1: 34.4 (12.4); $t(184) = 0.28$, $p = 0.778$), STAI-

Table 1
Participant characteristics.

	Session 1 (n = 186)			Session 2 (n = 92)		
	Mean	*SD*	range	*Mean*	*SD*	range
Age	34.7	12.1	18–71	34.9	11.6	18–63
STAI-T	50.6	11.0	26–77	50.3	12.0	22–75
Aversiveness ratings[a]	4.5	1.3	1.3–7.0	4.0	1.4	1.6–7.0

Note. [a] Aversiveness ratings refer to participants' ratings of images and sounds presented in the iAACT. STAI-T: Spielberger State-Trait Anxiety Inventory.

T scores (both sessions: 51.0 (11.2); only session 1: 50.2 (11.0); $t(184) = 0.45$, $p = 0.652$), proportion of session 1 conflict trials they approached the aversive stimuli (both sessions: 0.71 (0.33); only session 1: 0.67 (0.32); $t(184) = 0.87$, $p = 0.383$), or ratings of the aversive images (both sessions: 4.6 (1.35); only session 1: 4.5 (1.24); $t(182) = 0.48$, $p = 0.636$).

3.2. Devices used, participant feedback and compliance

Cohort 1 was required to perform the iAACT using a computer with a keyboard and cohort 2 had the choice to use any device type (e.g., computer, smartphone, tablet). Sixty-eight participants (75 %) in cohort 2 provided information on the device used at session 1. Of these, 54 (79 %) used a computer, 7 (10 %) a tablet, and 7 (10 %) a smartphone. For session 2, only 12 participants (27 %) provided information on the device used, of which 11 (92 %) used a computer and 1 (8 %) a smartphone. We could not detect any difference between device types in ratings of aversive stimuli ($F(2, 158) = 1.05$, $p = 0.354$) or proportion of approach trials on the iAACT ($F(2,160) = 0.53$, $p = 0.592$) at session 1, and all participants, regardless of device type, were therefore treated as one group in subsequent analyses. Analyses comparing devices were not performed on session 2 data, because only 1 participant reported using a device other than a computer.

Participant feedback indicated that data collection using the iAACT was both feasible and tolerable. All but two participants reported that they complied with the instructions during session 1; one participant turned off the sound when rating aversive stimuli after completing the iAACT, and one had the sound turned off during 4 stimuli. Four participants reported being disturbed by external factors during session 1. In session 2, one participant reported being disturbed, and two reported sound problems. The rest reported no distractions or technical problems. Notably, some participants reported having problems getting the iAACT to work on their smartphones, which they resolved by using a computer instead.

3.3. Session 1

3.3.1. Costly avoidance

We fitted trial-by-trial choice to approach or avoid aversive stimuli using a generalized linear mixed effects model with a random intercept (subject) and reward level, trial number and aversiveness ratings as fixed variables. All of the fixed effects contributed to the approach behavior (Table 2), such that higher reward level, earlier trials and lower aversiveness ratings were associated with more approach of aversive stimuli. The positive relationship between reward level and approach behavior is further illustrated in Table 3, by showing proportion of approach trials for both sessions and tests of differences and correlations between sessions, and in Fig. 2, which depicts approach behavior for different reward levels.

3.3.2. Trait anxiety and costly avoidance

Including only subject as random effect and STAI-T scores as fixed effect in the model, we found a negative relationship between trait anxiety level and approach behavior (Table 4; Fig. 3). However, adding STAI-T to the model with reward level, trial number and aversiveness ratings, did not reveal a contribution of trait anxiety to approach behavior. The model fit was not better than for the original model without STAI-T $\chi^2(1) = 2.90$, $p = 0.089$).

3.4. Session 2

The same pattern of results as in session 1 was found in session 2. Reward level, trial number and aversiveness ratings contributed to approach behavior in model 1 (Table 2). STAI-T was related to approach behavior in a simple model, but adding STAI-T to the model with reward level, trial number, and aversiveness ratings did not reveal an independent contribution of trait anxiety to approach score (Table 4, Fig. 3). The addition of STAI-T did not result in a better model fit $\chi^2(1) = 2.95$, $p = .086$).

3.5. Temporal stability/Test-retest reliability

As a measure of iAACT test-retest reliability, we found that the proportion of approaches to aversive stimuli was highly correlated between sessions across all reward levels and for each individual reward level (Table 3). Paired Wilcoxon signed rank tests revealed

Table 2
Results from generalized linear mixed effects models of participant's trial-by-trial choice to approach or avoid aversive stimuli.

	Session 1				Session 2			
Model 1		AIC	BIC	-loglik		AIC	BIC	-loglik
		2654.8	2687.0	1322.4		1236.0	1264.6	613.0
	b	***SE***	***Z***	***p***	***b***	***SE***	***Z***	***P***
Reward level	1.27	0.05	23.19	< .001	1.79	0.10	18.24	< .001
Trial number	-0.05	0.01	-8.20	< .001	-0.04	0.01	-3.76	< .001
Aversiveness rating	-1.53	0.27	-5.61	< .001	-1.24	0.35	-3.54	< .001

Note. AIC: Akaike Information Criteria. BIC: Bayes Information Criteria. loglik: log likelihood.

Table 3
Proportion of approach trials for both sessions as well as tests of differences and correlations between sessions.

	Session 1 (n = 186)			Session 2 (n = 92)			Between sessions (n = 92)			
	M	*Mdn*	*IQR*	*M*	*Mdn*	*IQR*	V^a	*P*	r^b	*P*
All rewards	0.69	0.78	0.55	0.71	0.72	0.48	973.5	0.669	0.73	< .001
1 point	0.48	0.40	1.0	0.40	0.20	1.0	568.5	0.004	0.65	< .001
5 points	0.59	0.80	0.80	0.58	0.70	0.80	571.5	0.232	0.66	< .001
10 points	0.71	1.0	0.60	0.75	1.0	0.40	365	0.276	0.58	< .001
20 points	0.82	1.0	0.20	0.89	1.0	0.0	94	0.110	0.48	< .001
50 points	0.86	1.0	0.0	0.90	1.0	0.0	80.5	0.222	0.54	< .001

Note. a: Paired Wilcoxon signed rank test, b: Spearman's rank-order correlation. IQR: Interquartile range.

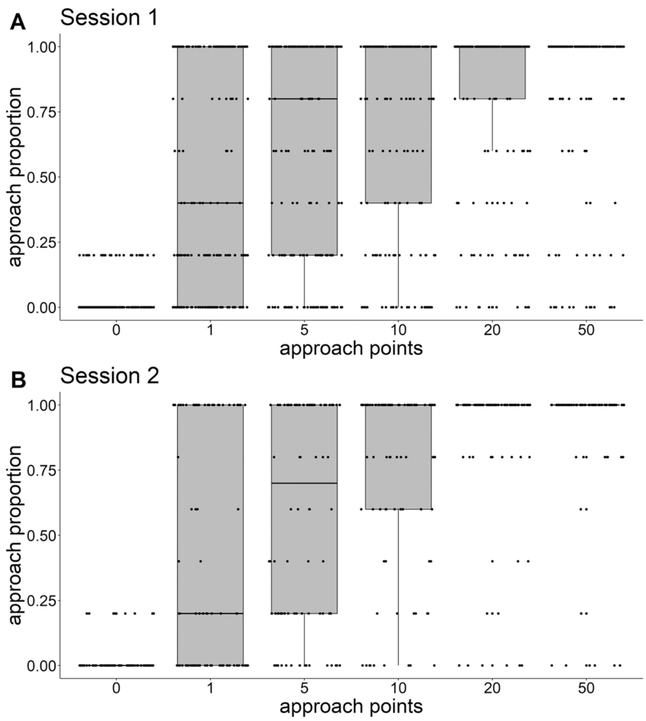

Fig. 2. Approach behavior for different reward levels. Boxplots of approach proportion for each reward level during (A) Session 1 (n = 186) and (B) Session 2 (n = 92). Filled circles denote individual values for each subject. Mixed effects models revealed associations between reward level and approach behavior for both Session 1 and Session 2.

higher approach proportion to 1-point rewards during session 1, but no difference was detected for any other reward level or total approach proportion. Between-session correlations were also high for trait anxiety ($r(90) = 0.83$, $p < .001$) and ratings of aversive images ($r(88) = 0.65, p < .001$), with no difference in trait anxiety between sessions ($t(91) = 1.03, p = .308$), but aversiveness ratings were lower at session 2 than at session 1 ($t(88) = 4.56$, $p < .001$).

3.6. Psychopathological symptoms IDAS-II and costly avoidance

To explore the association between approach behavior and current internalizing symptoms of psychopathology, we used generalized linear mixed effects models with subject as random effect and scores from all IDAS subscales as a fixed effect. We performed this analysis for all 19 subscales separately. False Discovery Rate (FDR)-corrected *p*-values were caculated to correct for multiple comparisons. We found associations mainly for anxiety/fear related subscales including social anxiety ($b = -0.59; Z = -2.50; p_{FDR} = .049$), claustrophobia ($b = -0.84$; $Z = -2.61$; $p_{FDR} = .049$), traumatic intrusion ($b = -0.52$; $Z = -2.50$; $p_{FDR} = .049$), and traumatic avoidance ($b = -0.69$; $Z = 3.16$; $p_{FDR} = .019$). Furthermore, we found an association between approach behavior and symptoms of increased appetite ($b = -0.72$; $Z = -3.26$; $p = .019$). We did not find an association for the remaining subscales (all p_{FDR}'s $> .23$), which included panic, general depression and related subscales, mania-related subscales, and OCD-related subscales. Descriptive statistics and association between approach behavior and all subscales of IDAS-II are presented in Supplementary Table S2.

Table 4
Results from generalized linear mixed effects models of the influence of trait anxiety on participant's trial-by-trial choice to approach or avoid aversive stimuli.

	Session 1				Session 2			
Model 2		AIC	BIC	-loglik		AIC	BIC	-loglik
		3688.8	3708.1	-1841.4		2033.3	2050.5	1013.7
	b	***SE***	***Z***	***p***	***b***	***SE***	***Z***	***p***
STAI-T	-0.05	0.02	-1.98	.048	-0.06	0.03	-2.39	.017
Model 3		**AIC**	**BIC**	**-loglik**		**AIC**	**BIC**	**-loglik**
		2653.9	2692.5	1321.0		1235.1	1269.4	611.5
	b	***SE***	***Z***	***p***	***b***	***SE***	***Z***	***p***
Reward level	1.27	0.05	23.19	< .001	1.79	0.10	18.24	< .001
Trial number	-0.05	0.01	-8.20	< .001	-0.04	0.01	-3.76	< .001
Aversiveness rating	-1.51	0.27	-5.55	< .001	-1.11	0.35	-3.17	.002
STAI-T	-0.05	0.03	-1.69	.090	-0.07	0.04	-1.71	.088

Note. AIC: Akaike Information Criteria. BIC: Bayes Information Criteria. loglik: log likelihood. STAI-T: Spielberger State-Trait Anxiety Inventory – Trait version.

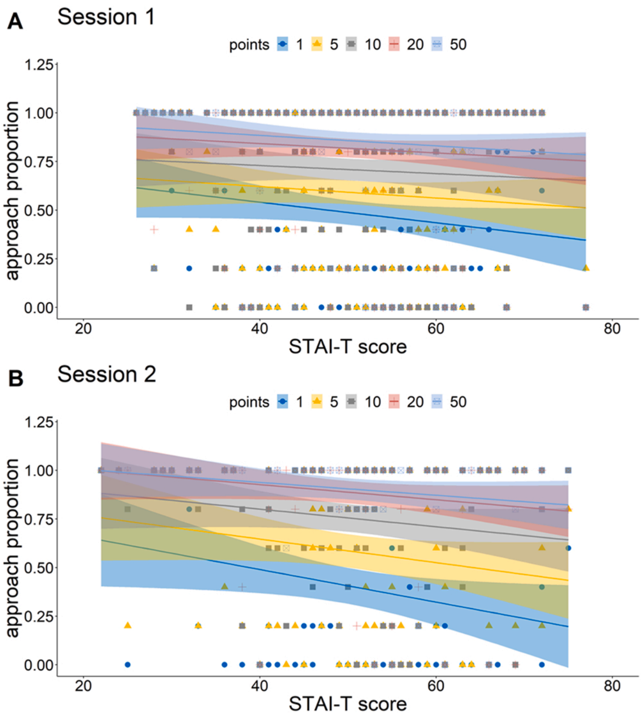

Fig. 3. Approach behavior as a relation of reward level and trait anxiety. Scatter plots of approach proportion and trait anxiety (Spielberger State-Trait Anxiety Inventory – Trait version; STAI-T) for each reward level during (A) Session 1 (n = 186) and (B) Session 2 (n = 92). Colors denote reward levels with symbols representing individual subjects and lines linear fit lines. Shaded areas are the 95 % confidence intervals. Mixed effects models revealed contributions of both reward level and trait anxiety to approach behavior, although this was more robust for Session 2.

4. Discussion

The current study aimed to explore the feasibility of an internet-delivered approach-avoidance conflict task to provide a scalable and cost-effective method to study approach-avoidance behavior in mixed-outcome situations (i.e., approach-avoidance conflicts). Suggesting the feasibility of the iAACT, our results were in line with previous findings from AACTs conducted in the laboratory (for review, see Pittig et al., 2020). Specifically, results showed that avoidance of aversive stimuli was reduced when introducing competing rewards (i.e., points) for approach behavior and that this effect was augmented with increasing reward levels (i.e., 1, 5, 10, 20, 50 points). Also, similar to results from laboratory AACTs (Pittig et al., 2014; Pittig & Scherbaum, 2020), our findings showed a positive association between trait anxiety and costly avoidance. Importantly, results from the follow-up session (session 2) support previous findings indicating that the effects of competing rewards on approach behavior are stable over time (Mdn = 46, IQR = 13.5 days; Smith et al., 2021). The consistency in results between the current iAACT and AACTs conducted in the laboratory shows promise that approach-avoidance behavior can be successfully studied experimentally via the internet. This notion is further supported by the positive feedback and few problems reported by participants that conducted the iAACT. Our findings thus add to accumulating results showing the feasibility and tolerability of using remotely-delivered tasks to conduct psychological research (e.g., Aubé et al., 2019; Björkstrand et al., 2022; Purves et al., 2019) and interventions (e.g., Van Dessel et al., 2018; Weil et al., 2017; Wittekind et al., 2015). However, the feasibility and validity of the current and future iAACTs need to be further investigated by directly comparing the results of a specific AACT delivered remotely vs. in the laboratory to ensure that the two modes of delivery indeed render interchangeable results (Purves et al., 2019). Furthermore, future studies should also examine the feasibility of the current internet-delivered AACT in clinical samples.

In line with results from laboratory AACTs (Pittig et al., 2014; Pittig & Scherbaum, 2020). we found that higher levels of trait anxiety (STAI-T scores) were associated with less approach behavior in both sessions (i.e., in the simple model; Table 4). Notably, although our, and previous findings indicate that trait anxiety is associated with elevated costly avoidance, the relationship between trait anxiety and approach-avoidance behavior appears to be complex, and other factors may have a more pronounced impact on approach-avoidance behavior than trait anxiety. For instance, a recent laboratory AACT found that approach-avoidance behavior in individuals with psychopathological conditions, compared to healthy individuals, was better explained by higher decision uncertainty than by emotional conflict. The current AACT did not include specific measures for decision uncertainty. However, a great advantage of iAACTs is that it would be simple to add measures and conduct rapid data collection with few additional costs. For instance, measures for decision uncertainty (e.g., subjective ratings) could be easily added to the current iAACT to explore if the association between trait anxiety and costly avoidance is moderated by decision uncertainty.

A secondary aim of the study was to explore the relationship between approach-avoidance behavior and internalizing symptoms of psychopathology (e.g., depressive and anxiety symptoms) at a dimensional level. Results showed that costly avoidance was associated with higher levels of social anxiety, claustrophobia, symptoms of traumatic avoidance and intrusions, and appetite gain (see Supplementary Table S2 for results for all IDAS-II subscales). Overall, these results suggest that reduced approach behavior during incentive conflict is specifically related to fear and anxiety symptoms. However, these analyses were exploratory, and the relationship between psychopathological symptoms and approach-avoidance behavior as well as the clinical utility of AACTs needs to be further investigated (Smith et al., 2021).

In order to assess the temporal stability of approach-avoidance behavior and test-retest reliability of the iAACT, participants were invited to repeat the procedure with different stimuli six weeks after the first session. Notably, participants completed the follow-up session (session 2) on average, approximately seven weeks after session 1 (Mdn = 46, *IQR* = 13.5 days). Results from session 1 mirrored the results of session 2 with high correlations for approach behavior across reward levels. These findings fit nicely with a laboratory AACT which reported long-term stability of computational parameters during approach-avoidance conflict at three weeks and 1-year follow-ups (Smith et al., 2021). We also extend these findings by showing preliminary evidence that the relationship between trait anxiety and approach-avoidance behavior is stable over time. Taken together, current and previous findings suggest that the effects of competing rewards on approach behavior to aversive stimuli are robust and stable over time, both when assessed remotely and in a laboratory setting.

The current results show promise that iAACTs can be used to study approach-avoidance behavior outside of the lab. A better understanding of the mechanisms underlying individual differences in approach-avoidance behavior tendencies could help us unravel the etiology of anxiety disorders and how to improve treatment techniques such as exposure therapy. The high prevalence of anxiety disorders urges us to speed up this process. Internet-delivered AACTs could be an essential tool in achieving this enterprise as internet-delivered tasks are generally less time-consuming and require fewer resources than laboratory studies. The cost-effectiveness and flexibility of iAACTs could facilitate testing of multiple research questions (in parallel or sequentially) in shorter time periods, for instance, scrutinizing factors that can be manipulated to boost approach behavior in order to inform treatment development (e.g., exposure therapy). However, internet-based experiments also have caveats that need to be considered, for instance, high attrition levels and the loss of experimental control compared to that in laboratory studies. Nevertheless, remotely-delivered experimentsin general, could revolutionize psychological research in multiple research areas by facilitating large-scale data collection while minimizing costs (Björkstrand et al., 2022; Purves et al., 2019).

4.1. Limitations

Some limitations should be considered when interpreting the current finding. First, although participants were instructed to undertake the task in a quiet place and minimize the risk of being interrupted or distracted, experimental control of the context in which the task is conducted is lost in internet-delivered experiments, which increases the risk of introducing confounding variables. For instance, participants may not have complied with instructions, such as not using high enough volume or avoiding looking and/or hearing the aversive images and sounds by looking away or taking off/not using headphones. However, participants reported high levels of compliance with instructions and only a few reported distracting events or interruptions during the task. Importantly, similar results (i.e., behavioral tendencies) were observed in the iAACT as in previous laboratory AACTs, suggesting that participants indeed conducted the experiment as intended. Despite the loss of experimental control, an advantage of the iAACT is that participants conducted the experiment in their "natural" environment, which may increase the ecological validity of individuals' approach-avoidance behavior compared to when doing the task in an unfamiliar laboratory setting. Nevertheless, an important future direction is to investigate the feasibility and validity of iAACTs by directly comparing results when a specific AACT is delivered remotely vs.

in the laboratory (Purves et al., 2019). Another important future direction is to conduct follow-up assessments during extended periods of time (e.g., six months, one year). It should also be noticed that differences in the device used to conduct the iAACT (computer, smartphone, tablet) could potentially have affected the result (e.g., aversiveness of images could be higher when displayed on a larger screen). However, one study found a larger effect on approach-avoidance behavior in an approach-avoidance task when conducted on a smartphone compared to on a computer screen (Zech et al., 2020). Also, in the current study, the vast majority reported that they performed the experiment on a computer (session 1: 79 %; session 2: 92 %), and we did not find any differences in aversiveness ratings between devices and results on approach proportion remained when controlling for device type. Although, future studies should further explore the influence of device type on iAACTs using a more even distribution and head-to-head comparisons of device types. Investigating the effects of device type is pivotal as the utility of remote-delivered experiments would increase if they prove to be reliable irrespective of the device used to complete them.

Another issue worth mentioning is that although different stimuli (images) were used in the two sessions to reduce the influence of habituation effects, unexpectedly, stimuli in session 2 were rated as less aversive than those used in session 1. As stimuli were not counterbalanced between sessions, the familiarity with the task/repetition effect may have influenced the aversiveness rating in session 2. However, associations between reward level and approach behavior remained when controlling for aversiveness ratings statistically. It is also noteworthy that we chose to let participants conduct aversiveness ratings after the experiment in order to collect aversiveness ratings on all images from all participants (i.e., if rated during the experiment, aversiveness ratings from "avoiders" would be lost). It is possible that this may have influenced participants' responses. For instance, a habituation effect may have occurred for images seen during the experiment, i.e., approached images, leading to lower aversiveness ratings for previously seen images compared to images first seen during the rating procedure. Notably, results on the proportion of approach trials remained irrespective of aversiveness ratings. Future studies should consider conducting aversiveness ratings immediately after the presentation of each stimulus during the experiment to reduce the risk of habituation effects. A further limitation is that we did not measure the incentive value of points at the subjective level, i.e., how rewarding participants experienced receiving points at each reward level (0, 1, 5, 10, 20, 50 points), Although, the incentive value of points can be inferred by results showing that approach behavior increased when it entailed receiving a higher number of points. Future studies on iAACTs should counterbalance stimuli between sessions and assess the incentive value of the rewarding outcome for the approach (e.g., points). It is also worth noticing that only 50.7 % of the participants chose to complete session 2. Self-selection bias could therefore have influenced the result. However, we found no differences between those who did and did not complete session 2.

Lastly, when interpreting the results of the study, it is important to consider that different types of approach-avoidance tasks exist (e.g., incentive-based [points, money, etc.] and movement-based [e.g., simulate arm movement toward or away from the stimulus using a computer mouse]), and that there is variation in human approach-avoidance behavior in the different tasks (Krypotos et al., 2018). It has been suggested that using arm movement increases the face validity of approach-avoidance tasks, as movement is often involved in real-life approach-avoidance situations (Krypotos et al., 2018; Rinck & Becker, 2007). The current iAACT did not focus on movement and did not require movement other than a button press to approach-avoid the stimulus. Instead, the iAACT focused on incentive-based (points) approach-avoidance behavior and comparisons with results of studies with similar incentive-based AACTs performed in the laboratory. Future studies should explore if adding movement to the current iACCT (e.g., using computer mouse movement forward/backward to zoom into/out from the image; (Aubé et al., 2019) impacts the results. Notably, the findings of the current iAACT were in line with those observed in the movement-based iVAAST (Aubé et al., 2019).

5. Conclusions

The current study examined the feasibility of a novel internet-delivered approach-avoidance conflict task. Our results suggest that the AACT could be successfully conducted remotely via the internet and may thus provide a scalable and cost-effective method to study fear and anxiety-related approach-avoidance behavior. The current study also adds to the field by conceptually replicating previous results from AACTs conducted in the laboratory. Consistent with previous findings, our results support that avoidance can be reduced by introducing competing rewards, and that trait anxiety is associated with elevated costly avoidance. Importantly, our results also suggest that these effects are stable over time.

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CRediT authorship contribution statement

JMH: Writing - original draft, Conceptualization, Interpretation of results; **JV**: Formal analyses, Interpretation of results, Writing - review & editing; **MG**: Conceptualization, Writing - review & editing; **JB**: Conceptualization, Methodology, Interpretation of results, Writing - review & editing; **AF**: Conceptualization, Methodology, Formal analyses, Interpretation of results, Investigation, Writing - review & editing.

Declaration of Competing Interest

Authors declare no conflict of interest.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.lmot.2022.101848.

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