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Using Motion Tracking to Measure Avoidance in Children and Adults: Psychometric Properties, Associations with Clinical Characteristics, and Treatment Related Change

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Abstract

Avoidance is implicated in many areas of psychopathology, particularly anxiety and its disorders. Accurate, reliable, valid, and objective measurement of avoidance behavior poses methodological challenges. Two key technological advances, increased computing power and the advent of motion-tracking technology, offer novel solutions to these challenges. We describe a series of three studies using a novel motion-tracking system to measure avoidance in children and adults. The first study examined behavioral avoidance of spider stimuli in large samples of children and adults (N=200 each; the adults were the mothers of the children). Behavioral avoidance was associated with self-rated fear of spiders and increased state anxiety from before to after the task. The second study examined avoidance of threat faces in children and adults (N=35 each; the adults were the mothers of the children) and test-retest reliability in the adults. Avoidance of threat faces was associated with broadband anxiety symptom severity. Test-retest correlations in behavioral avoidance measured 6 weeks apart was high and significant. The third study examined behavioral avoidance of spiders in clinically anxious children (N=25) before and after cognitive-behavioral therapy for childhood anxiety disorders. Behavioral avoidance was significantly reduced following cognitive-behavioral therapy and reduction in behavioral avoidance correlated significantly with improvement in child-rated anxiety symptoms. Taken together these studies provide strong support for the promise of motion-tracking technology to enable a new phase of behavioral avoidance research with sensitive, valid, reliable, and cost- and time-effective measurement of behavioral avoidance across the lifespan.

Introduction

Avoidance behavior (also sometimes termed ‘escape’) describes active or passive behaviors that prevent or curtail fear-evoking, distressing, or otherwise undesirable situations. Theory and empirical research have long recognized the importance of avoidance and emphasized the basic distinction between aversive (avoidance) systems oriented *away* from stimuli and

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appetitive (approach) systems oriented *towards* stimuli (see Elliot (2008) for a comprehensive historical review). This distinction is also reflected in the Research Domain Criteria (RDoC) proposed by NIMH, which distinguishes between positive valence systems such as approach motivation, and negative valence systems, such as fear and avoidance (Insel et al., 2010; Sanislow et al., 2010). Disruptions in the systems responsible for avoidance are implicated in many areas of psychopathology. Most avoidance research has focused on anxiety and its disorders, but data also implicate avoidance in depression as well as externalizing behavior problems (Chu, Skinner, & Staples, 2014).

Despite the broadly accepted role of avoidance in abnormal behavior and psychopathology, researchers aiming to study avoidance behavior face major methodological challenges. Two areas of technological advancement offer new solutions for overcoming many of these challenges. The steady increases in readily accessible computing power, sometimes described as Moore's law on the one hand (Moore, 1965), and the advent of cost-efficient and easily deployable and accurate motion-tracking technology on the other hand, open the door for a new phase in the study of behavioral avoidance. In the current paper, we briefly point to some of the challenges that have hindered avoidance research and present a framework for using motion-tracking technology to measure behavioral avoidance, including a brief discussion of the 'behind the scenes' development of this novel hardware-software pairing. We then describe a series of three studies using the motion-tracking system to measure avoidance in both children and adults. Together, the studies provide data on the internal and external validity and test-retest reliability of the avoidance measure and its associations with the behavioral inhibition and behavioral activation system. Finally, we describe treatment related changes in behavioral avoidance in a sample of clinically anxious children who received treatment for primary anxiety disorders.

Challenges in Behavioral Avoidance Research

Demand Characteristics and Social Desirability.—This problem applies primarily to the classical (and most broadly used) behavioral avoidance tests, in which subjects are asked to either progressively approach a feared stimulus (e.g., walk closer and closer to a spider), or are asked to enter and withstand a situation that causes them fear (e.g. give an oral presentation). The risk that subjects would modify their typical behavior either in deference to the researcher's request, or to advance a goal such as receiving treatment, was identified almost immediately. A mere few years after the early behavioral avoidance test studies were published, Miller and Bernstein (1972) reported on the impact of demand in a study of 28 claustrophobic subjects. The subjects were confined to a small dark chamber under conditions of both low and high demand characteristics (e.g., the researcher saying 'The door to the chamber can be opened from the inside, but please go as far through the procedure as you can'). The effects of the demand characteristics were highly significant, with subjects remaining in the chamber considerably longer on average under the high demand condition. Other studies confirming the effects of demand characteristics soon followed (Smith, Diener, & Beaman, 1974) and the issue has remained a concern over the years and across domains of anxiety being studied (Barrett, Healy, & March, 2003; Rosqvist, 2006).

Standardization.—Despite the numerous studies that have employed behavioral avoidance tests no standard has emerged for how they should be conducted (Barrett et al., 2003; Chu et al., 2014). Tests have varied in essentially every aspect, including duration of the exposure, distance from stimuli, the prompts used, the setting of the test, and the actual stimuli or situation. This variability poses a major challenge to the replication and extension of research findings. The high degree of variability in a field that would clearly benefit from more standardized procedures underscores the difficulty of standardizing behavioral avoidance tests.

Even in approach-avoidance tests that have greater capacity for standardization, methods have varied a great deal. In most studies subjects pull or push a lever in response to valenced words, but in other studies subjects move an on-screen manikin representing themselves toward or away from a stimulus, and in other studies the subject may be asked to move valenced words toward or away from their own name (Cacioppo, Priester, & Berntson, 1993; Chen & Bargh, 1999; Krieglmeier, De Houwer, & Deutsch, 2011; Markman & Brendl, 2005).

Data.—Classical behavioral avoidance tests often generate a single datum by which the avoidance is indexed, for example the number of feet from a stimulus at which a subject halted their approach. Repeating a behavioral avoidance test many times over would be extremely time consuming and is generally not be feasible. It is also likely that repeated consecutive behavioral tests would lead to desensitization in the subject, or to the development of cognitive or attentional strategies that would modify subject behavior, and as such is not desirable. Nevertheless, limiting the data to a single point (or to a very small number of points) also hinders the application of advanced data analytic methodologies that could be implemented to study subtle questions of avoidance. For example, examining the speed at which subjects move toward or away from different stimuli, or identifying behaviors such as hesitation in approaching feared stimuli.

Ecological Validity.—The question of the validity of behavioral avoidance tests as analogs for avoidant behavior outside of the laboratory setting is also one that has been raised since the early days of research in this area (Lick, Sushinsky, & Malow, 2016). The issue was emphasized in a call from NIMH for research on the accuracy, reliability, and validity of these methods in 1981 and remains a challenge to this day (Barlow & Wolfe, 1981). The ecological validity of approach-avoidance tests, as well as classical behavioral avoidance tests, has been questioned. Approach-avoidance tests overcome some of the challenges we have mentioned here. They are less vulnerable to demand characteristics and though not yet standardized, they are more amenable to standardization. And they provide many data points such that subject behavior can be examined over the accumulation of many trials rather than a single exposure. However, questions about the relevance of approach-avoidance test to more typical behaviors have been raised and the tests are thought to tap primarily into semantic, rather than behavioral, systems. This has been partially addressed by modifying the approach-avoidance test such that the subject presses keys to manipulate an on-screen character and cause them to move toward or away from a stimulus (De Houwer, Crombez, Baeyens, & Hermans, 2001; Mogg, Bradley, Field, & De Houwer, 2003).

Motion-Tracking for Assessment of Behavioral Avoidance

The past decade has seen the introduction of highly accurate motion-tracking technology, able to record a subject's location with a high degree of precision, as they move freely around a space. The pairing of motion-tracking technology with a software platform developed specifically for studying behavior has numerous advantages for researchers interested in studying behavioral avoidance and can address the problems described above.

Description and Purpose.—We developed the Yale Interactive Kinect Environment Software platform (YIKES) with this purpose in mind. Our aim was to provide researchers with the ability to engage subjects in highly standardized tasks that would create the opportunity for continuous avoidance and approach behaviors, capturing participant location accurately throughout to provide high-resolution data while minimizing demand characteristics and not focusing the participant explicitly on the question of avoidance. In YIKES, participants play a game while standing in front of a large LCD screen, on which they see themselves in a game-like environment rather than the actual room they are in (see Figure 1). Alternatively, the YIKES task can be projected on a wall instead of using a screen. Virtual objects can be made to drop from the top of the screen while the subject walks freely from side to side to 'catch' these objects by positioning themselves below them.

The application reads an input file, a table stored in comma-separated value (CSV) format which allows for the creation of a deterministic scenario, repeating the exact same experiment for each participant. Elements of the task environment are decided by the researcher and stored in the CSV input file, including the background, images (still or moving) which can be displayed anywhere on the screen, or whether or not to display a score and how to calculate it. In addition, a number of parameters are set for each falling object, including the exact moment it falls, the position where it falls, its velocity, and drag coefficient.

YIKES also enables more advanced tasks, such as introducing logical sequences that are determined based on participant behavior (e.g., causing the 'game' to be harder or easier based on performance, or causing objects to fall further from an image if a participant is not approaching the image).

During each run of the task, participant behavior is recorded and saved to an output file, also in CSV format. This file contains the participant's position for each timestamp, at a frequency of 30 Hz.

Technological Choices.—YIKES was originally developed for Windows 7 using the C# programming language in Unity, a cross-platform game engine developed by Unity Technologies. An iterative development approach using rapid prototyping techniques was applied allowing for efficient trial and error iteration. When YIKES was initially developed in 2012, the first-generation Microsoft Kinect device was used as the location capturing device. This device contains an RGB camera (producing color images at 640×480 pixels) and a range camera (producing greyscale images in which the pixel values represent the depth of the points in the scene, at a limited resolution of 320×240 pixels). A plug-in was

developed in the C++ programming language to allow accessing the Kinect from within Unity through the Microsoft Kinect software development kit (SDK).

The Kinect SDK uses the range images to detect the participant within its field of view, since the nature of these images facilitates distinguishing the participant from their background, and to generate a skeletal representation of the participant. Based on this information, the participant position is determined and a cutout of the participant is created using the color images, allowing the player to be displayed on the screen against backgrounds defined in the input file.

In March 2016, one month before the first-generation Kinect was discontinued by Microsoft, YIKES was redesigned to allow using the second-generation Kinect. This increased the resolution of the color images to 1920×1080 pixels and the resolution of the greyscale range images to 512×424 pixels, leading to a higher quality cutout image. Additional changes and features in the updated YIKES included support for Windows 10, storing more detailed coordinates (including all joint positions of the skeletal representation of the player), replaying the recorded movement of the player as a skeletal representation, and connecting with the Empatica E4 wristband to register and store heart rate information.

Automating Data Analysis.—Because each of the output CSV files can easily contain tens of thousands of time-location points, analyzing all the data recorded from a sample of participants can prove to be a challenging task. To allow for easier processing of this big data a tool was written to preprocess the output CSV files. This data preprocessor automates the extraction of relevant information, saving the data in a series of new summary CSV files. For example, the average speed at which the players move towards or away from neutral and phobic stimuli, and the average distances at which they turned away from neutral or phobic stimuli, can be calculated separately and stored in summary CSV files. Another example of a CSV file generated by the data preprocessor contains the locations of all falling objects from the input CSV file with annotations on whether they were caught or missed.

We next describe a series of three studies conducted using YIKES to measure avoidance behavior in both children and in adults. The first study focused on avoidance of spider images and examined behavioral avoidance and self-reported measures of fear of spiders. To further establish the validity of the task a state anxiety questionnaire was administered before and after the task. It was expected that avoidance would be associated with increased state anxiety following the task. Self-reports of depression symptoms were also collected to examine discriminant validity.

The second study focused on avoidance of a more general anxiety stimulus, threat (angry) faces. We used stimuli that have been widely used in anxiety tasks and demonstrated to trigger anxiety response (e.g., Bar-Haim, 2010; Waters, Bradley, & Mogg, 2014). Avoidance was examined in relation to broadband anxiety rating scales in children and in adults. We also examined whether behavior on the YIKES task would be associated with self-ratings of behavioral activation and inhibition in the children and adults. To examine test-retest reliability participants (adults only) repeated the task 6 weeks after the initial administration.

In the third study, we provide the first evidence for the motion-tracking YIKES system as indicator of clinical change. Behavioral avoidance was examined before and after cognitive-behavioral therapy for childhood anxiety in 25 clinically anxious children participating in a clinical trial for childhood anxiety disorders.

Method - Study 1

Participants

Participants were 200 children (ages 7–17, Mean: 10.9; 53% males) and 200 adults (ages 28–60, Mean: 45.8). The participating adults were the mothers of the participating children. Children presented to an anxiety and mood disorders program in the eastern United States. Most children (71%) met criteria for at least one anxiety disorder based on a clinician administered semi-structured interview, the Anxiety Disorders Interview Schedule Child and Parent versions (Silverman, Saavedra, & Pina, 2001). Generalized anxiety disorder (51.6%), social phobia (47.6%), separation anxiety disorder (27.4%), and specific phobia (16.5%) were the most common childhood anxiety diagnoses. Other diagnoses included attention deficit hyperactivity disorder (25%), obsessive-compulsive disorder (16%), depression (6%), and oppositional defiant disorder (5%).

Most children and mothers were non-hispanic (85% and 88%, respectively) and white (81% and 79%, respectively). Family income was below \$80,000 in 20% of cases, between \$80,000 and \$125,000 in 27% of cases, between \$125,000 and \$150,000 in 17% of cases, and above \$150,000 in 36% of cases.

Procedure

The study was approved by the University Institutional Review Board and signed consent and assent were obtained from all adults and children prior to any additional procedures.

Children and adults first completed questionnaires and interviews. Child questionnaires were administered in the presence of a research assistant who was trained to answer questions and clarify questionnaire items when necessary. Children and adults then participated in the 6 minutes YIKES behavioral avoidance task.

Measures

Fear of Spiders.—Children and adults (their mothers) completed respective versions of the Spider Phobia Questionnaire. The SPQC/SPQ (Kindt, Brosschot, & Muris, 1996; Klorman, Weerts, Hastings, Melamed, & Lang, 1974) include statements (29 for the child version and 31 for the adult version) to which participants respond either yes or no. For example, “Even a toy spider in my hand scares me a bit” (SPQC) and “If a picture of a spider crawling on a person appears on the screen during a motion picture, I turn my head away” (SPQ). Scores are calculated as the sum of positive responses (after reverse coding certain items). The internal consistency, reliability, and construct validity of the child and adult versions of SPQ have been demonstrated (Kindt et al., 1996; Klorman et al., 1974; Lebowitz, Shic, Campbell, MacLeod, & Silverman, 2015). Internal consistency in the current sample was $\alpha=.89$ for children, and $\alpha=.93$ for adults.

State Anxiety.—The State-Trait Anxiety Inventory - State Version (STAI-S) (Spielberger, Gorsuch, & Lushene, 1970) was administered immediately before and immediately after the behavioral avoidance task. STAI-S includes 20 items relating to current feelings of anxiety each rated on a 4-point Likert-type scale from ‘not at all’ to ‘very much so’. STAI-S has been used in many studies of anxiety and has been shown to be sensitive to change related to behavioral tasks (Logan & Goetsch, 1993). Internal consistency in children was $\alpha=.92$ before the task and $\alpha=.93$ after the task. Internal consistency in adults was $\alpha=.93$, both before and after the task.

Depression.—Children completed the Child Depression Inventory (CDI) (Kovacs, 1992), and adults completed the Beck Depression Inventory (BDI) (Beck, Steer, & Brown, 1996). In these widely used rating scales, participants select the statement that best describes them from sets of possible statements. Internal consistency for the CDI was $\alpha=.90$ and internal consistency for BDI was .89

Behavioral Avoidance – YIKES Task.—Children and adults completed identical YIKES tasks. Participants were alone in the room (after a brief practice task in the presence of research assistant) and stood in front of a 55" liquid crystal display (LCD) on which their image was displayed, overlaid on a game environment. The game required participants to walk to the right and to the left to catch balls that appeared to fall from the top of the screen (See Figure 1). The locations of the falling balls was a random uniform distribution and was laterally counterbalanced to ensure that the locations of the falling balls would not bias participant movement in either direction. Throughout the game, spider images and neutral images were displayed on alternating sides of the screen, such that at any given moment a participant was either moving toward a spider image and away from a neutral image or vice versa (Fig 1 A1 and B1). The two images in each pair (one neutral, one spider) appeared simultaneously. Each pair was displayed on-screen for 1 minute and then was immediately replaced with another pair, in which the neutral image would appear in place of the spider image and vice versa.

A score was displayed on-screen throughout the game and increased with every ball the participant caught. Participants' motion in the direction of the spider images and in the direction of the neutral images were compared to derive an index of avoidance behavior. To calculate this index we first identified all the times each participant changed direction while moving toward a spider image and all the times they changed direction while moving toward a neutral image by estimating extreme points on the location-time curve. Next we calculate the average distance from the spider image at which participants turned away from the spider and the average distance from the neutral image at which participants turned away from the neutral image. Comparing these average distances yields the index of avoidance. In brief, to the degree that a participant turns away from the spider images at a greater average distance compared with the neutral images, that participant is maintaining greater distance from the spider image and is exhibiting behavioral avoidance.

Results – Study 1

Table 1 summarizes the means and standard deviations for measures completed by children and adults in all three studies. Average distance maintained from spider images in study 1 ranged from 16cm to 70cm in children and from 26cm to 72cm in adults. (These distances refer to distance in the actual room between participant location and the location they would have been standing for their on-screen figure to be adjacent to the image.) Average distance maintained from neutral images ranged from 10cm to 87cm in children and from 23cm to 68cm in adults. The difference in average distance maintained from spider images compared with neutral images (i.e., behavioral avoidance) ranged from -16cm to 54cm (Mean= 4cm; SD=8.3cm) in children, and from -20cm to 35cm (Mean=7.8cm; SD=7.1) in adults. Males and female children did not differ significantly on any of the study variables. Age was not associated with any of the study variables in children or in adults. The presence or absence of any particular diagnosis was also not associated with any of the study variables, apart from depression which, as expected, was significantly associated with CDI and BDI scores in children and adults respectively. There were no missing data.

Children:

Behavioral avoidance measured with YIKES was significantly positively associated with self-rated fear of spiders in the children: children who scored higher on the SPQC turned away sooner (i.e., at greater average distance) when moving toward spider images than when moving toward neutral images ($r=0.4$, $p<.001$).

Behavioral avoidance was weakly correlated with children's state anxiety before the task ($r=.19$, $p<.01$) and much more strongly correlated with children's state anxiety after the task ($r=.44$, $p<.001$). Furthermore, increase in state anxiety following the task (calculated as the post-task score minus the pre-task score) was also significantly positively correlated with behavioral avoidance ($r=.35$, $p<.001$), further validating the YIKES task. In other words, children who exhibited more avoidance during the task also reported greater increases in state anxiety following the task.

Depression scores were only weakly associated with behavioral avoidance ($r=.17$, $p<.05$) and the association was not significant after correcting for the multiple correlations, supporting the discriminant validity of the task. The associations between avoidance and anxiety measures remained significant after the correction for multiple correlations.

Adults:

A very similar pattern of results emerged for the adults (the mothers of the children participants). Behavioral avoidance measured with YIKES was significantly positively associated with self-rated fear of spiders: participants who scored higher on the SPQ turned away sooner (i.e., at greater average distance) when moving toward spider images than when moving toward neutral images ($r=0.4$, $p<.001$).

As in the children, behavioral avoidance was weakly correlated with state anxiety before the task ($r=.14$, $p<.05$) but much more strongly correlated with state anxiety after the task ($r=.34$, $p<.001$). And, also as in the children, increase in state anxiety following the task was

significantly correlated with behavioral avoidance ($r=.25$, $p<.001$), further validating the YIKES task.

Depression scores were again weakly correlated with behavioral avoidance ($r=.2$, $p<.01$), although in the adults the relation remained significant after the correction for multiple correlations. A significant correlation also emerged between behavioral avoidance in the adults (mothers) and their children ($r=.27$, $p<.05$).

Method - Study 2

Participants

Participants were 35 children (ages 7–15, Mean: 9.4; 51% males) and 35 adults (ages 36–49, Mean: 41.2). The participating adults were the mothers of the participating children. There was no overlap between participants in Study 1 and Study 2. Children presented to an anxiety and mood disorders program in the eastern United States. Most children (76%) met criteria for at least one anxiety disorder, based on a clinician administered semi-structured interview, the Anxiety Disorders Interview Schedule Child and Parent versions (Silverman et al., 2001). Generalized anxiety disorder (56.3%), social phobia (49.9%), separation anxiety disorder (27.8%), and specific phobia (20.1%) were the most common childhood anxiety diagnoses. Other diagnoses included attention deficit hyperactivity disorder (19%), obsessive-compulsive disorder (14%), depression (3%), and oppositional defiant disorder (3%).

Most children and adults were non-hispanic (86% and 89%, respectively) and white (80% and 82%, respectively). Family income was below \$80,000 in 36% of cases, between \$80,000 and \$125,000 in 24% of cases, between \$125,000 and \$150,000 in 20% of cases, and above \$150,000 in 20% of cases.

Procedure

Procedures are as described in Study 1.

Measures

Anxiety.—Children completed the Multidimensional Anxiety Scale for Children (MASC) (March, Parker, Sullivan, Stallings, & Conners, 1997), a widely used checklist for childhood anxiety. The MASC includes items covering a broad range of anxiety symptoms and domains, which children rate for frequency on a scale from zero to three. Total anxiety scores were used and internal consistency was $\alpha=.90$. Adults completed the Beck Anxiety Inventory (BAI) (Beck, Epstein, Brown, & Steer, 1988), a widely used scale for anxiety symptoms in adults. Internal consistency for the BAI was $\alpha=.95$.

Behavioral Inhibition and Behavioral Activation.—Children and adults completed respective versions of the Behavioral Inhibition Scale and Behavioral Activation Scale (BIS/BAS) (Carver & White, 1994; Hart & Hope, 2004). Behavioral inhibition (BIS) is calculated from 7 items and assesses sensitivity to aversive stimuli (e.g., worrying about making mistakes). Behavioral activation (BAS) includes three subscales: Reward Responsiveness (5

items), Drive (4 items) and Fun Seeking (4 items), and assesses sensitivity to anticipated/acquired rewards, motivation to achieve desired goals, and willingness to approach new appetitive stimuli respectively. The BAS subscales load on a shared overall BAS factor. Internal consistency for the child BIS scale was $\alpha=.69$ and for the child BAS, $\alpha=.76$. Internal consistency for the adult BIS scale was $\alpha=.74$, and for the adult BAS, $\alpha=.76$.

Behavioral Avoidance – YIKES Task.—The method of measuring avoidance is as described in Study 1, with the difference being that in this study participants completed a task designed to look like a tennis court and their objective was to catch falling objects that looked like tennis balls. The stimuli that appeared on either side of the screen were sets of paired emotional face stimuli with each pair including one neutral and one threat (angry) face. These stimuli have been previously used in numerous anxiety studies.(Mogg, Bradley, Id, & Bradley, 1999).

Results Study 2

Children.

Behavioral avoidance of the angry faces in children was significantly correlated with self-rated overall anxiety symptoms on the MASC ($r=.325$, $p<.01$).

Behavioral avoidance on the YIKES task was positively correlated with children's scores on the BIS ($r=-.47$, $p<.01$), and was negatively correlated with the Reward Responsiveness subscale of the BAS ($r=-.41$, $p<.05$).

Adults:

Behavioral avoidance of the angry faces was significantly correlated with self-rated anxiety symptoms on the BAI ($r=.33$, $p<.01$).

Behavioral avoidance on the YIKES task was negatively correlated with the Drive and Reward subscales of the BAS ($r=-.36$, $p<.05$; $r=-.33$, $p<.05$, respectively) and with the overall total BAS score ($r=-.33$, $p<.05$). Behavioral avoidance on the YIKES task was not significantly associated with the Fun Seeking subscale of BAS and in contrast to the children, was also not significantly associated with the BIS score.

Test-Retest Reliability of YIKES

Five participants were lost to the second time-point, and thus test-retest data was collected on 30 adult participants. Behavioral avoidance at Time 1 and at Time 2 six weeks later was strongly and significantly correlated ($r=.7$, $p<.001$) and not significantly different, supporting the test-retest reliability of the motion-tracking task, see Figure 2.

Methods - Study 3

Participants

Participants in Study 3 were 25 clinically anxious children (ages 7–14, Mean =10.7; 48% males) enrolled in a twelve-week treatment study for childhood anxiety disorders. There was no overlap between participants in Study 3 and Study 1 or Study 2. All children presented

with primary DSM-5 anxiety disorders and received cognitive-behavioral therapy for anxiety through a larger clinical trial. Anxiety disorder diagnosis was established through semi-structured clinician-administered interview using the Anxiety Disorders Interview Schedule Child and Parent versions (Silverman et al., 2001). No participating children met criteria for spider phobia. The primary anxiety disorders were: generalized anxiety disorder (36%), social phobia (27%), separation anxiety disorder (23%), and specific phobia (14%), but comorbidity was high as in common in childhood anxiety samples. Comorbid diagnoses included attention deficit hyperactivity disorder (20%), obsessive-compulsive disorder (14%), depression (11%), and oppositional defiant disorder (4%).

Most children were non-hispanic (84%) and white (80%). Family income was below \$80,000 in 11% of cases, between \$80,000 and \$125,000 in 45% of cases, between \$125,000 and \$150,000 in 17% of cases, and above \$150,000 in 27% of cases.

Procedures

Procedures are similar to those described in Studies 1 and 2. Children were assessed at a baseline evaluation and the same measures were administered following twelve weeks of cognitive-behavioral therapy. Children received a standardized cognitive-behavioral therapy protocol delivered by trained clinicians following procedures used in other clinical trials (Silverman, Kurtines, Jaccard, & Pina, 2009).

Measures

Following the diagnostic interview, children and parents completed respective versions of the MASC (see Study 2) and children completed the SPQC (see Study 1), and a YIKES behavioral avoidance task identical to the one described in Study 1.

Results - Study 3

Pretreatment and posttreatment measures of behavioral avoidance were significantly correlated ($r=.48$, $p<.01$). Following treatment children showed significantly less behavioral avoidance ($t_{\text{paired}}=7.2$, $p<.001$; Mean change = 8.6; Cohen's $d=1.014$). The degree of reduction in behavioral avoidance was positively correlated with improvement in childhood anxiety symptoms on MASC ($r=.32$, $p<.01$), but not with improvement on the parent version of MASC.

Discussion

Taken together these three studies provide evidence for motion-tracking technology, specifically the YIKES platform, to measure behavioral avoidance across a broad range of ages using a standardized measure that is easily replicated. The large samples of children and adults assessed in Study 1 were facilitated by the automatization of the system. This allowed for a low level of training and for efficient administration. The tasks used in these studies were six minutes long (with an added half minute of practice) and generated many of thousands of data points that could be automatically processed by computer, minimizing effort and preventing bias.

The very similar patterns of results that emerged for both the child and adult samples in Studies 1 and 2 are a promising indication that the tool can be deployed across a very broad age range. Furthermore, the behavioral nature of the task makes it feasible to measure avoidance in non-verbal populations and reduces language and educational biases that can impact more subjective measures such as interviews and questionnaires.

Behavioral avoidance of spiders was associated with self-rated fear of spiders, as was expected. Further supporting the validity of the task was the association between behavioral avoidance and the increased levels of state anxiety subjectively reported by the participants. The significant positive correlation between avoidance in children and mothers is another indicator of convergent validity. Weak or non-significant associations between avoidance and ratings of depression provide evidence of discriminant validity. Interestingly, the weak association between avoidance and depression ratings remained significant in the adult sample. Further research is required to ascertain to what extent this is evidence for the role of avoidance in depression. Behavioral theories of depression have emphasized avoidance in response to distressing experiences (Chu et al., 2014; Jacobson, 2001). Avoidance is conceptualized as maintaining the depression by negatively reinforcing escape from undesirable situations, as in anxiety disorders (Manos, Kanter, & Busch, 2010). Data from adults has supported a link between self-rated depression symptoms and a subjective measure of behavioral avoidance (Kanter, Mulick, Busch, Berlin, & Martell, 2006). If replicated, the current results may provide novel behavioral data supporting a role for behavioral avoidance in depression.

The link between depression and avoidance is also interesting in light of the associations that emerged between behavioral avoidance and the BIS and BAS scales in Study 2. Of note, while children's behavioral avoidance correlated with both BIS and BAS scores, only BAS scores predicted behavioral avoidance in the adults. Grey's biopsychological theory of personality (1970) emphasizes the opposing systems of behavioral activation and inhibition and suggests that behavior is shaped in large part by the activation of one or the other of these systems in response to a given set of circumstances and stimuli. One important methodological consideration in this regard is that participants were able to view their score throughout the YIKES task. It is possible that for some participants, and perhaps adults more so than children, the score, while not linked to any material reward, activated the behavioral activation system and that as a consequence appetitive motivation played an important role in shaping their behavior. Prior research on behavioral avoidance and BIS and BAS scores is scarce, with most studies not implementing actual behavioral avoidance tasks. In children, behavioral avoidance has been linked to BIS scores in a small number of studies. In one study for example, children's avoidance of a box believed to contain an animal about which they had received threatening information was correlated with their BIS scores (Field, 2006). The current results confirm this association but suggest that the behavioral activation system is also implicated in determining avoidant behavior. The finding that in adults only the BAS scores predicted avoidance further advances the hypothesis that the behavioral activation system, more commonly linked to depression than to anxiety, plays a key role in avoidant behavior. Another relevant methodological consideration is the rapid pace of behavior during the YIKES task. It is possible that behavior that occurs in other settings that provide more time for decision-making would differ from that exhibited during YIKES.

The results from Study 2 showing high test-retest reliability, together with the results from Study 3 showing sensitivity to treatment-related change, are encouraging. The high test-retest reliability is particularly encouraging as one concern with repeated measurement of avoidant behavior is the likelihood of desensitization, or the development of cognitive or attentional strategies that change subject behavior over repeated execution of the task. Taken together the test-retest reliability and the sensitivity to change support the usefulness of motion-tracking technology to deliver a sensitive and reliable non-verbal measure of objective avoidance. The finding that treatment-related change in child avoidance behavior was associated with change in child-rated anxiety, and not in parent-rated child anxiety is in line with previous research demonstrating that children's own anxiety ratings predict behavioral avoidance more strongly than do their parents ratings (Lebowitz, 2017). Integrating information from multiple informants to establish the best assessment of treatment-related change poses a challenge for clinicians and clinical researchers. Research has begun to use the YIKES motion-tracking technology to better integrate discrepant information provided by children and parents (Lebowitz, 2017), and the current results further advance this promise of applying the technology to address difficult questions of assessment and change.

An interesting difference between YIKES and other BATs is the lack of explicit instruction to approach the feared stimulus. This is a strength of YIKES, as it reduces the impact of demand characteristics described above, but also raises the question of participant motivation to approach the feared stimulus. Difficulty approaching a feared stimulus when there is a requirement to do so is clinically relevant, as it is linked to functional impairment in the individual's life. Does spontaneous avoidance in the absence of a clear instruction to approach also reflect clinically meaningful impairment? This question is partially addressed by clear instruction on YIKES to catch as many balls as possible and the presence of the score counter on-screen further strengthens this. The flexibility of the YIKES system allows for additional research to examine the impact of more explicit approach instructions on avoidance behavior.

These studies are not without limitations. The adult sample comprised the mothers of the children who presented for anxiety evaluations and as such has two significant limitations. First it is not a random sample and is neither a 'normal control' sample nor a 'clinical' one. Parents of anxious children are more likely than the general population to have elevated anxiety as well (Beidel et al., 2007; Jones, Lebowitz, Marin, & Stark, 2015; Lieb et al., 2000; Turner, Beidel, & Costello, 1987). Second, all the adults were women and thus it is not possible to determine whether a similar pattern of results would have emerged for adult men. This second concern is somewhat mitigated by the high degree of concordance between the adult and child results. Despite the large age and developmental differences, and despite the child sample being approximately split between males and females, results were similar, making it more likely that the adult results would generalize to a more heterogeneous and typical sample. This is further bolstered by the lack of significant differences in behavioral avoidance between male and female children. One more general question is how easy or challenging it will prove to adapt the YIKES system for the variety of anxiety and fear domains. For example, it is not obvious what stimuli would be best suited for measuring separation anxiety. Although the finding that a relatively 'generic'

stimulus such as threatening faces elicited measurable avoidance is promising in this regard, there may be limitations in measuring certain fears.

These studies focused on only two kinds of stimuli, spiders and emotional faces. Spiders were selected because fear of spiders has been the focus of other behavioral avoidance studies, is relatively straightforward to trigger, and has established rating-scales for children and adults (Kindt & Brosschot, 1999; Klein, Becker, & Rinck, 2011; Lebowitz, 2017; Lebowitz, Shic, Campbell, Basile, & Silverman, 2015; Lebowitz, Shic, Campbell, MacLeod, et al., 2015; Olatunji, Cisler, Meunier, Connolly, & Lohr, 2007; Renaud, Bouchard, & Proulx, 2002). The emotional faces were selected because they have been used in numerous previous anxiety studies as a more generic anxiety trigger. YIKES enables the researcher to select stimuli at will and more research is required to extend these findings to avoidance of other stimuli as well.

These studies also focused on *behavioral* avoidance, a central but not exclusive component of avoidance overall. Other forms of avoidance such as *experiential* avoidance have also been linked to anxiety and other disorders (Borkovec & Inz, 1990; Hayes, Wilson, Gifford, Follette, & Strosahl, 1996). Experiential avoidance occurs when individuals act to avoid internal experiences such as physical sensations, emotions, or thoughts (also termed *cognitive* avoidance). Experiential avoidance can lead to behavioral avoidance, as individuals seek to avoid the situations or stimuli that trigger the aversive internal experiences, but can also manifest internally through emotional or cognitive processes which are not readily measurable in YIKES. The expectancy model developed by Reiss (Reiss, 1991; Reiss & McNally, 1985) suggests that phobic avoidance is motivated in part by harm avoidance and in part by avoidance of internal sensations, a phenomenon termed anxiety sensitivity. Previous research using YIKES found that behavioral avoidance was best explained through the interaction of fear of the stimulus itself and the level of anxiety sensitivity (Lebowitz, Shic, Campbell, Basile, et al., 2015). Additional research is required to further elucidate the relations between behavioral and experiential avoidance and how to best integrate behavioral measures such as YIKES with measures of experiential avoidance.

Future research is also required to assess the incremental validity of approaches to measuring behavioral avoidance. The current studies relied on YIKES and on subjective measures that are not avoidance-specific. Research combining additional subjective and/or objective measures such as Whiteside's Child Avoidance Measure (Whiteside, Gryczkowski, Ale, Brown-Jacobsen, & McCarthy, 2013) or other BATs is necessary to identify the strengths and challenges inherent to each approach and the cost to benefit ratio of implementing multiple assessment procedures.

Despite these limitations the set of three studies provide strong support for the promise of motion-tracking technology to enable a new phase of behavioral avoidance research with sensitive, valid, reliable, and cost- and time-effective measurement of behavioral avoidance across the lifespan.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

- Bar-Haim Y (2010). Research review: Attention bias modification (ABM): a novel treatment for anxiety disorders. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 51(8), 859–870. doi: 10.1111/j.1469-7610.2010.02251.x
- Barlow DH, & Wolfe BE (1981). Behavioral approaches to anxiety disorders: A report on the NIMH-SUNY, Albany, research conference. *Journal of Consulting and Clinical Psychology*, 49(3), 448–451. doi: 10.1037/0022-006x.49.3.448 [PubMed: 7276334]
- Barrett P, Healy L, & March JS (2003). Behavioral avoidance test for childhood obsessive-compulsive disorder: a home-based observation. *American Journal of Psychotherapy*, 57(1), 80–100. [PubMed: 12647571]
- Beck AT, Epstein N, Brown G, & Steer RA (1988). An inventory for measuring clinical anxiety: psychometric properties. *Journal of Consulting and Clinical Psychology*, 56(6), 893–897. [PubMed: 3204199]
- Beck AT, Steer RA, & Brown GK (1996). BDI-II, Beck depression inventory : Manual (2nd ed.). Boston: Psychological Corp.; Harcourt Brace.
- Beidel DC, Turner SM, Sallee FR, Ammerman RT, Crosby LA, & Pathak S (2007). SET-C versus fluoxetine in the treatment of childhood social phobia. *Journal of the American Academy of Child and Adolescent Psychiatry*, 46(12), 1622–1632. doi: 10.1097/chi.0b013e318154bb57 [PubMed: 18030084]
- Borkovec TD, & Inz J (1990). The nature of worry in generalized anxiety disorder: a predominance of thought activity. *Behaviour Research and Therapy*, 28(2), 153–158. doi: 10.1016/0005-7967(90)90027-g [PubMed: 2183759]
- Cacioppo JT, Priester JR, & Berntson GG (1993). Rudimentary determinants of attitudes: II. Arm flexion and extension have differential effects on attitudes. *Journal of Personality and Social Psychology*, 65(1), 5–17. doi: 10.1037/0022-3514.65.1.5 [PubMed: 8355142]
- Carver CS, & White TL (1994). Behavioral-Inhibition, Behavioral Activation, and Affective Responses to Impending Reward and Punishment - the Bis Bas Scales. *Journal of Personality and Social Psychology*, 67(2), 319–333. doi: 10.1037/0022-3514.67.2.319
- Chen M, & Bargh JA (1999). Consequences of automatic evaluation: Immediate behavioral predispositions to approach or avoid the stimulus. *Personality and Social Psychology Bulletin*, 25(2), 215–224. doi: 10.1177/0146167299025002007
- Chu BC, Skriner LC, & Staples AM (2014). Behavioral avoidance across child and adolescent psychopathology In Ehrenreich-May J & Chu BC (Eds.), *Transdiagnostic treatments for children and adolescents: Principles and practice*. (pp. 84–110). New York, NY: Guilford Press.
- De Houwer J, Crombez G, Baeyens F, & Hermans D (2001). On the generality of the affective Simon effect. *Cognition and Emotion*, 15(2), 189–206. doi: 10.1080/0269993004200051
- Elliot AJ (2008). Approach and avoidance motivation In Elliot AJ (Ed.), *Handbook of Approach and Avoidance Motivation* (pp. 3–17). New York, NY: Taylor and Francis.
- Field AP (2006). The behavioral inhibition system and the verbal information pathway to children's fears. *Journal of Abnormal Psychology*, 115(4), 742–752. doi: 10.1037/0021-843X.115.4.742 [PubMed: 17100531]
- Gray JA (1970). The psychophysiological basis of introversion-extraversion. *Behaviour Research and Therapy*, 8(3), 249–266. doi: 10.1016/0005-7967(70)90069-0 [PubMed: 5470377]

- Hart KE, & Hope CW (2004). Cynical hostility and the psychosocial vulnerability model of disease risk: confounding effects of neuroticism (negative affectivity) bias. *Personality and Individual Differences*, 36(7), 1571–1582. doi: 10.1016/j.paid.2003.06.007
- Hayes SC, Wilson KG, Gifford EV, Follette VM, & Strosahl K (1996). Experiential avoidance and behavioral disorders: A functional dimensional approach to diagnosis and treatment. *Journal of Consulting and Clinical Psychology*, 64(6), 1152–1168. [PubMed: 8991302]
- Insel T, Cuthbert B, Garvey M, Heinssen R, Pine DS, Quinn K, ... Wang P. (2010). Research domain criteria (RDoC): toward a new classification framework for research on mental disorders. *American Journal of Psychiatry*, 167(7), 748–751. doi: 10.1176/appi.ajp.2010.09091379 [PubMed: 20595427]
- Jacobson NS (2001). Behavioral Activation Treatment for Depression: Returning to Contextual Roots. *Clinical Psychology: Science and Practice*, 8(3), 255–270. doi: 10.1093/clipsy.8.3.255
- Jones JD, Lebowitz ER, Marin CE, & Stark KD (2015). Family accommodation mediates the association between anxiety symptoms in mothers and children. *Journal of Child and Adolescent Mental Health*, 27(1), 41–51. doi: 10.2989/17280583.2015.1007866 [PubMed: 25958796]
- Kanter JW, Mulick PS, Busch AM, Berlin KS, & Martell CR (2006). The Behavioral Activation for Depression Scale (BADs): Psychometric Properties and Factor Structure. *Journal of Psychopathology and Behavioral Assessment*, 29(3), 191–202. doi: 10.1007/s10862-006-9038-5
- Kindt M, & Brosschot JF (1999). Cognitive Bias in Spider-Phobic Children: Comparison of a Pictorial and a Linguistic Spider Stroop. *Journal of Psychopathology and Behavioral Assessment*, 21(3), 207–220. doi: 10.1023/a:1022873331067
- Kindt M, Brosschot JF, & Muris P (1996). Spider phobia questionnaire for children (SPQC): a psychometric study and normative data. *Behaviour Research and Therapy*, 34(3), 277–282. [PubMed: 8881098]
- Klein AM, Becker ES, & Rinck M (2011). Approach and Avoidance Tendencies in Spider Fearful Children: The Approach-Avoidance Task. *Journal of Child and Family Studies*, 20(2), 224–231. doi: 10.1007/s10826-010-9402-7 [PubMed: 21475709]
- Klorman R, Weerts TC, Hastings JE, Melamed BG, & Lang PJ (1974). Psychometric description of some specific-fear questionnaires. *Behavior Therapy*, 5(3), 401–409. doi: 10.1016/s0005-7894(74)80008-0
- Kovacs M (1992). *Children's Depression Inventory*. New York: Multi-Health Systems.
- Krieglmeyer R, De Houwer J, & Deutsch R (2011). How farsighted are behavioral tendencies of approach and avoidance? The effect of stimulus valence on immediate vs. ultimate distance change. *Journal of Experimental Social Psychology*, 47(3), 622–627. doi: 10.1016/j.jesp.2010.12.021
- Lebowitz ER (2017). Mother and Child Ratings of Child Anxiety: Associations With Behavioral Avoidance and the Role of Family Accommodation. *Parenting*, 17(2), 124–142. doi: 10.1080/15295192.2017.1304784
- Lebowitz ER, Shic F, Campbell D, Basile K, & Silverman WK (2015). Anxiety sensitivity moderates behavioral avoidance in anxious youth. *Behaviour Research and Therapy*, 74, 11–17. doi: 10.1016/j.brat.2015.08.009 [PubMed: 26348546]
- Lebowitz ER, Shic F, Campbell D, MacLeod J, & Silverman WK (2015). Avoidance moderates the association between mothers' and children's fears: findings from a novel motion-tracking behavioral assessment. *Depression and Anxiety*, 32(2), 91–98. doi: 10.1002/da.22333 [PubMed: 25424469]
- Lick JR, Sushinsky LW, & Malow R (2016). Specificity of Fear Survey Schedule Items and the Prediction of Avoidance Behavior. *Behavior Modification*, 1(2), 195–203. doi: 10.1177/014544557712003
- Lieb R, Wittchen HU, Hofler M, Fuetsch M, Stein MB, & Merikangas KR (2000). Parental psychopathology, parenting styles, and the risk of social phobia in offspring: a prospective-longitudinal community study. *Archives of General Psychiatry*, 57(9), 859–866. [PubMed: 10986549]
- Logan AC, & Goetsch VL (1993). Attention to external threat cues in anxiety states. *Clinical Psychology Review*, 13(6), 541–559. doi: 10.1016/0272-7358(93)90045-N

- Manos RC, Kanter JW, & Busch AM (2010). A critical review of assessment strategies to measure the behavioral activation model of depression. *Clinical Psychology Review*, 30(5), 547–561. doi: 10.1016/j.cpr.2010.03.008 [PubMed: 20444531]
- March JS, Parker JD, Sullivan K, Stallings P, & Conners CK (1997). The Multidimensional Anxiety Scale for Children (MASC): factor structure, reliability, and validity. *Journal of the American Academy of Child and Adolescent Psychiatry*, 36(4), 554–565. doi: 10.1097/00004583-199704000-00019 [PubMed: 9100431]
- Markman AB, & Brendl CM (2005). Constraining theories of embodied cognition. *Psychological Science*, 16(1), 6–10. doi: 10.1111/j.0956-7976.2005.00772.x [PubMed: 15660844]
- Miller BV, & Bernstein DA (1972). Instructional demand in a behavioral avoidance test for claustrophobic fears. *Journal of Abnormal Psychology*, 80(2), 206–210. doi: 10.1037/h0033312 [PubMed: 5077187]
- Mogg K, Bradley BP, Field M, & De Houwer J (2003). Eye movements to smoking-related pictures in smokers: relationship between attentional biases and implicit and explicit measures of stimulus valence. *Addiction*, 98(6), 825–836. doi: 10.1046/j.1360-0443.2003.00392.x [PubMed: 12780371]
- Mogg K, Bradley BP, Id, & Bradley, B. P. O. h. o. o. (1999). Some methodological issues in assessing attentional biases for threatening faces in anxiety: A replication study using a modified version of the probe detection task. *Behaviour Research and Therapy*, 37(6), 595–604. doi: 10.1016/S0005-7967(98)00158-2 10372472 [PubMed: 10372472]
- Moore GE (1965). Cramping more components onto integrated circuits. *Electronics*, 114–117.
- Olatunji BO, Cisler JM, Meunier S, Connolly K, & Lohr JM (2007). Expectancy Bias for Fear and Disgust and Behavioral Avoidance in Spider Fearful Individuals. *Cognitive Therapy and Research*, 32(3), 460–469. doi: 10.1007/s10608-007-9164-8
- Reiss S (1991). Expectancy model of fear, anxiety, and panic. *Clinical Psychology Review*, 11(2), 141–153. doi: 10.1016/0272-7358(91)90092-9
- Reiss S, & McNally RJ (1985). The expectancy model of fear In Reiss S & Bootzin RR (Eds.), *Theoretical issues in behavior therapy* (pp. 107–121). New York: Academic.
- Renaud P, Bouchard S, & Proulx R (2002). Behavioral avoidance dynamics in the presence of a virtual spider. *IEEE Transactions on Biomedical Engineering*, 6(3), 235–243.
- Rosqvist J (2006). Analogue and Virtual Reality Assessment In Hersen M (Ed.), *Clinician's Handbook of Adult Behavioral Assessment* (pp. 43–61): Elsevier Academic Press.
- Sanislow CA, Pine DS, Quinn KJ, Kozak MJ, Garvey MA, Heinssen RK, ... Cuthbert BN (2010). Developing constructs for psychopathology research: research domain criteria. *Journal of Abnormal Psychology*, 119(4), 631–639. doi: 10.1037/a0020909 [PubMed: 20939653]
- Silverman WK, Kurtines WM, Jaccard J, & Pina AA (2009). Directionality of change in youth anxiety treatment involving parents: an initial examination. *Journal of Consulting and Clinical Psychology*, 77(3), 474–485. doi: 10.1037/a0015761 [PubMed: 19485589]
- Silverman WK, Saavedra LM, & Pina AA (2001). Test-retest reliability of anxiety symptoms and diagnoses with the Anxiety Disorders Interview Schedule for DSM-IV: child and parent versions. *Journal of the American Academy of Child and Adolescent Psychiatry*, 40(8), 937–944. doi: 10.1097/00004583-200108000-00016 [PubMed: 11501694]
- Smith RE, Diener E, & Beaman AL (1974). Demand characteristics and the behavioral avoidance measure of fear in behavior therapy analogue research. *Behavior Therapy*, 5(2), 172–182. doi: 10.1016/s0005-7894(74)80132-2
- Spielberger CD, Gorsuch RL, & Lushene RE (1970). *The state-trait anxiety inventory*. Palo Alto, Calif: Consulting Psychologists Press Inc.
- Turner SM, Beidel DC, & Costello A (1987). Psychopathology in the offspring of anxiety disorders patients. *Journal of Consulting and Clinical Psychology*, 55(2), 229–235. [PubMed: 3571678]
- Waters AM, Bradley BP, & Mogg K (2014). Biased attention to threat in paediatric anxiety disorders (generalized anxiety disorder, social phobia, specific phobia, separation anxiety disorder) as a function of 'distress' versus 'fear' diagnostic categorization. *Psychological Medicine*, 44(3), 607–616. doi: 10.1017/S0033291713000779 [PubMed: 23591000]
- Whiteside SP, Gryczkowski M, Ale CM, Brown-Jacobsen AM, & McCarthy DM (2013). Development of child- and parent-report measures of behavioral avoidance related to childhood anxiety

disorders. Behavior Therapy, 44(2), 325–337. doi: 10.1016/j.beth.2013.02.006 [PubMed: 23611081]

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- Motion-tracking technology addresses challenges in measuring behavioral avoidance.
- Behavioral avoidance showed good validity in large samples of children and adults.
- Test-retest reliability for the behavioral avoidance measure was good.
- Anxious children's avoidance decreased following cognitive-behavioral therapy.
- Reduction in avoidance correlated with improvement in anxiety symptoms.

Figure 1.
(A1;A2) Illustrate a participant engaging in the YIKES experiment; and (B1;B2) What the participant sees on-screen.

Figure 2.
Test-Retest Reliability of YIKES: Avoidance Measured 12 weeks apart

Table 1.

Self-ratings and parent-ratings of clinical characteristics for studies 1, 2, and 3.

	Adult/Parent Rating	Child Rating
	Mean (SD)	Mean (SD)
Study 1		
Behavioral Avoidance - Spiders	7.8cm (7.1)	4cm (8.3)
Fear of Spiders ¹	6.5 (5.2)	10.5 (6.4)
State Anxiety Before Behavioral Task ²	33.5 (10.2)	37.7 (13.5)
State Anxiety After Behavioral Task ²	33.6 (10.4)	38.6 (12.9)
Depression ³	7.1 (6.6)	12.1 (8.4)
Study 2		
Behavioral Avoidance - Faces	6.3cm (5.1)	4.4cm (4.1)
Anxiety ⁴	9.3 (9.8)	70.4 (24.6)
Behavioral Inhibition ⁵	21.3 (3.5)	20.7 (4.1)
Behavioral Activation ⁵		
Drive	10.13 (2.5)	10.1 (2.7)
Reward	16.9 (2.2)	16.9 (2.5)
Fun	10.6 (2.3)	11.6 (2.5)
Total	37.7 (3.5)	38.6 (5.9)
Study 3		
Pre-Treatment		
Behavioral Avoidance - Spiders		9.8cm (7.7)
Child Anxiety ⁴	69.3 (17.0)	70.5 (21.2)
Child Fear of Spiders ¹	-	10.9 (4.3)
Post-Treatment		
Behavioral Avoidance - Spiders		1.2cm (5.6)
Child Anxiety ⁴	47.1 (21.9)	41.8 (17.1)
Fear of Spiders ¹	-	9.9 (6.9)

¹ Spider Phobia Questionnaire (adult and child versions);² State-Trait Anxiety Inventory – State Scale (adult and child versions);³ Adult: Beck Depression Inventory. Child: Child Depression Inventory;⁴ Adult: Beck Anxiety Inventory. Child: Multidimensional Anxiety Scale for Children;⁵ Behavioral Inhibition / Behavioral Activation Scale (adult and child versions); Behavioral avoidance of spiders and faces was measured using YIKES (Yale Interactive Kinect Environment Software).