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Usability of a Smartphone Application to Support the Prevention and Early Intervention of Anxiety in Youth

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Mental, emotional, and behavioral disorders are common in youth with anxiety problems being among the most prevalent, typically failing to spontaneously remit, and placing some youth at risk for additional difficulties. Mobile health (mHealth) might be a novel avenue to strengthen prevention efforts for child anxiety, since program effects are generally small. However, although a significant number of mHealth tools have been developed, few have been evaluated in terms of usability (or even clinical effectiveness). Usability testing is the first level of evaluation in responsible mHealth efforts as it is one of the main barriers to usage and adoption. As such, the objective of this research was to evaluate the usability of a smartphone application (app) corresponding to an indicated prevention and early intervention targeting youth anxiety. To accomplish this, 132 children (M_{age} = 9.65, 63% girls) and 45 service providers (M_{age} = 29.13, 87% female) rated our app along five established dimensions of usability (ease of use, ease of learning, quality of support information, satisfaction, and stigma). Findings showed that the app was highly and positively rated by youth and providers, with some variations (lower ratings when errors occurred). Path analyses also showed that system understanding was significantly related to greater system satisfaction, but that such relation occurred through the quality of support information offered by the app. Together, this has research and clinical implications as it highlights avenues for advancing youth care via mHealth usability evaluation, including prior to establishing effectiveness.

Anxiety disorders are among the most common psychiatric problems in children with prevalence rates ranging from 5 to 10% and as high as 25% in adolescents (Angold, Costello, & Erkanli, 1999; Kessler et al., 2005). Moreover, anxiety disorders cause significant impairment, fail to spontaneously remit, and are prospectively linked to clinical depression and problematic substance use for some youth (Aschenbrand, Kendall, Webb, Safford, & Flannery-Schroeder, 2003; Beidel et al., 2007; Cummings, Caporino, & Kendall, 2014). As a result, considerable strides have been made to develop strategies for the prevention of anxiety disorders (Anticich, Barrett, Silverman, Lacherez, & Gillies, 2013; Lowry-Webster, Barrett, & Dadds, 2001; Pina, Zerr, Villalta, & Gonzales, 2012). Despite progress, effect sizes for anxiety prevention are relatively small to moderate, often attenuating over time (Fisak, Richard, & Mann, 2011; Teubert & Pinquart, 2011).

We believe, however, that prevention effects could be dramatically improved by increasing the dosage of intervention skills targeting components theorized to disrupt pathways associated with child anxiety disorder development (e.g., reducing avoidant coping; Essau, Conradt, Sasagawa, & Ollendick, 2012; reducing negative self-talk: Kendall & Treadwell, 2007; Treadwell & Kendall, 1996). This possibility is supported by past research showing that program homework, or out-of-session skills practice, is a significant predictor of program response in child-focused intervention for anxiety and depression (Cummings, Kazantzis, & Kendall, 2014; Hudson & Kendall, 2002; Stice, Shaw, Bohon, Marti, & Rohde, 2009). In fact, increasing dosage of intervention homework could be achieved via mobile health (mHealth) tools because these can offer (a) on-demand access to review strategies, (b) notifications designed to promote practice, (c) gamification to increase engagement and appropriate use of strategies for managing anticipated anxiety-provoking situations, (d) personalized and tailored intervention schedules, and (e) data-driven corrective feedback. Despite these advantages, the large majority of mHealth tools (for anxiety or otherwise) have not been studied (Curioso & Mechael, 2010; Nilsen et al., 2012). Further, research evaluating the usability of these technologies is severely lacking. For example, in a review of the available smartphone applications (apps) for youth anxiety on Google Play and Apple App Store, we identified 55 apps, including the Mayo Clinic Anxiety Coach app (Whiteside, 2016), but no corresponding usability research was found in the literature.

Keywords: anxiety; child; usability; smartphone; prevention

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With regard to apps not publicly available (i.e., downloadable by any potential user), our search of the literature showed only three studies reporting on usability for apps targeting child behavior problems (Dixon, Dehlinger, & Dixon, 2013; O'Malley, Dowdall, Burls, Perry, & Curran, 2014; Tang, Jheng, Chien, Lin, & Chen, 2013), with one focused on clinically anxious youth (Pramana, Parmanto, Kendall, & Silk, 2014). Usability testing has been identified as an essential process in mHealth tool development to ensure maximum usage and engagement in the target population and implementing necessary design iterations prior to clinical effectiveness testing (Brown, Yen, Rojas, & Schnall, 2013; Matthews, Doherty, Coyle, & Sharry, 2008). Thus, the objective of this research was to evaluate the usability of a smartphone app corresponding to an indicated prevention and early intervention program targeting youth anxiety.

The REACH mHealth Application

REACH for Success (hereafter referred to as REACH) is an indicated prevention and early intervention program targeting anxiety in youth. REACH is an exposure-based cognitive-behavioral protocol delivered in six sessions, each 20–30 minutes in length, and administered in a group format. REACH uses the core exposure-based cognitive and behavioral procedures common to the protocols typically evaluated via randomized controlled trials (RCTs; e.g., Barrett & Turner, 2001; Kendall, 1994; Pina et al., 2012). This first generation of the REACH app was designed to provide support for out-of-session practice of intervention skills rather than act as a standalone platform, as some have suggested that implementation of child anxiety interventions probably requires interventionist involvement (e.g., relevant to training in cognitive restructuring; Pramana et al., 2014). Our efforts in developing the REACH app were guided by a user and subject matter expert-centered design (Galer, Harker, & Ziegler, 1992) that utilized personas, iterative prototyping, and expert feedback from an advisory board comprising practicing social workers, school psychologists, and counselors (see Patwardhan et al., 2015, for more details). At this phase of development, the REACH app was self-contained; it did not rely on communication services (e.g., cellular or Internet connection). Instead, the focus was on leveraging the device as a vehicle for supporting intervention homework (i.e., skills practice) and data collection. In terms of technology features, we included speech capture, thematic and age-appropriate media, gaming (e.g., progressive reward incentives), notifications presented to the target user in fixed (daily time-based) and adaptive schedules (based on user interactions), password-based authentication for adults (e.g., interventionists, parent, teacher), on-device database to store user responses and actions (e.g., to estimate alarm fatigue, motivation, clinical content such as subjective units of distress associated with an anxiety-provoking situation), and a data export feature (csv files).

Interaction Design and Information Modeling

Turning to user interaction design and content, and as shown in Figure 1, when a user selects the REACH app from the home screen, the landing page shows five activities (Relaxation, Daily Diary, S.T.O.P, Show That I Can [S.T.I.C], and Worryheads). In the design, Relaxation is delivered via audio (e.g., breathing, muscle relaxation; see Figure 1a) while Daily Diary and S.T.O.P (Silverman & Kurtines, 1996; Silverman & Pina, 2008) are fillable forms that use speech capture, keyboard, or both with each response stored in a SQLite database on the device (see Figure 1b and c). S.T.I.C (Kendall & Barmish, 2007) scenarios present a list of events or situations that are typically anxiety provoking to youth (e.g., read aloud in front of the class, ask the teacher a question or for help) based on the Anxiety Disorders Interview Schedule for Children (Silverman & Albano, 1996; see Figure 1d) with a password-based unlock feature for adults who provide electronic "stamps of approval" when S.T.I.C.s are successfully completed by users. Worryheads is an activity with preselected ambiguous situations and possible negative thoughts ("S" and "T," respectively) based on the Children's Negative Cognitive Errors Questionnaire (Leitenberg, Yost, & Carroll-Wilson, 1986) in response to which the user is asked to select an appropriate alternative thought from a prepopulated menu (see Figure 1e).

A gender-neutral and animated avatar character in the form of a blob guides the five activities, delivers notifications, and praises the user (see Figure 1f). In addition, the user can tap directly on the blob and be taken to a table-oriented layout of progressive and leveled "tricks" the blob can perform (see Figure 1g), only when the user completes homework (e.g., listens to Relaxation). The design of the blob incorporated proven mHealth intervention methodology known as the *proteus effect*, which posits that animated representations that reward the user for positive behavior provide increased motivation to perform activities that promote the desired behavior change (Yee & Bailenson, 2007). Overdue activities are highlighted by a soft gold pulsing glow on the landing page to provide a visual cue for the user (see Figure 1h). Further, and as shown in Figure 2, the app includes a specific multitap sequence combined with a password that unlocks configuration settings controlling the export of data, establishing a start date (see Figure 2a), enabling/disabling activities (see Figure 2b), modifying the planned dosage (e.g., number of times Relaxation should be practiced) for

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Figure 1. REACH smartphone app content and activites.

that week (see Figure 2c), assigning notification time (see Figure 2d), and scheduling trick release (see Figure 2e).

REACH Usability Evaluation

The International Organization for Standardization (ISO) 9241-210 standard (ISO, 2009) and the ISO and International Electrotechnical Commission (IEC) 9126 standard (ISO/IEC, 2001) guided the initial user experience design of the REACH app. Based on these standards, we operationalized usability as the degree to which a user of the app can achieve the goals of the REACH protocol with effectiveness, efficiency, and satisfaction. According to the ISO/IEC standards and conceptual models of mHealth development, usability is a characteristic of quality of use and has several measurable dimensions (Brown et al., 2013; Matthews et al., 2008; Nielsen, 1994). The dimensions include ease of use, ease of learning, quality of support information, satisfaction, and social acceptability—these are the dimensions we examined via quantitative analytics. With this approach, we wanted to answer two pragmatic questions: Is the REACH app usable? and Which aspects of the youth user experience could be targeted to improve the REACH app?

Conducting usability evaluation in the early phases of technology design and development is important for several reasons. First, poor usability is one of the main barriers to adoption and usage, especially in the case of mobile apps for youth users (Chiu & Eysenbach, 2010; Sheehan, Lee, Rodriguez, Tiase, & Schnall, 2012). Second, poor usability typically reflects difficult to learn, poorly designed, and complicated systems to the extent that these systems can lead to reduced engagement and usage because critical content may not be presented effectively (Jaspers, 2009; Maguire, 2001). Third, usability evaluation can inform the need for additional input from users and/or experts (e.g., prevention specialists, health care professionals), the nature of iterations that might be considered, the necessity for user training and support, and the extent to which greater in-depth testing is required prior to examination in larger-scale RCTs (Jacobs & Graham, 2016; Jaspers, 2009; Zapata, Fernandez-Aleman, Idri, & Toval, 2015). Collectively, this evaluation of usability for the REACH app was viewed as a necessary initial step to ensure the functionality is optimized to be appropriately designed, acceptable, and usable with the target population prior to evaluating clinical effectiveness (Brown et al., 2013; O'Malley et al., 2014; Wolf et al., 2013).

Methods

Participants

A total of 177 users (132 youth, 45 providers) from public schools participated in the present study. Youth

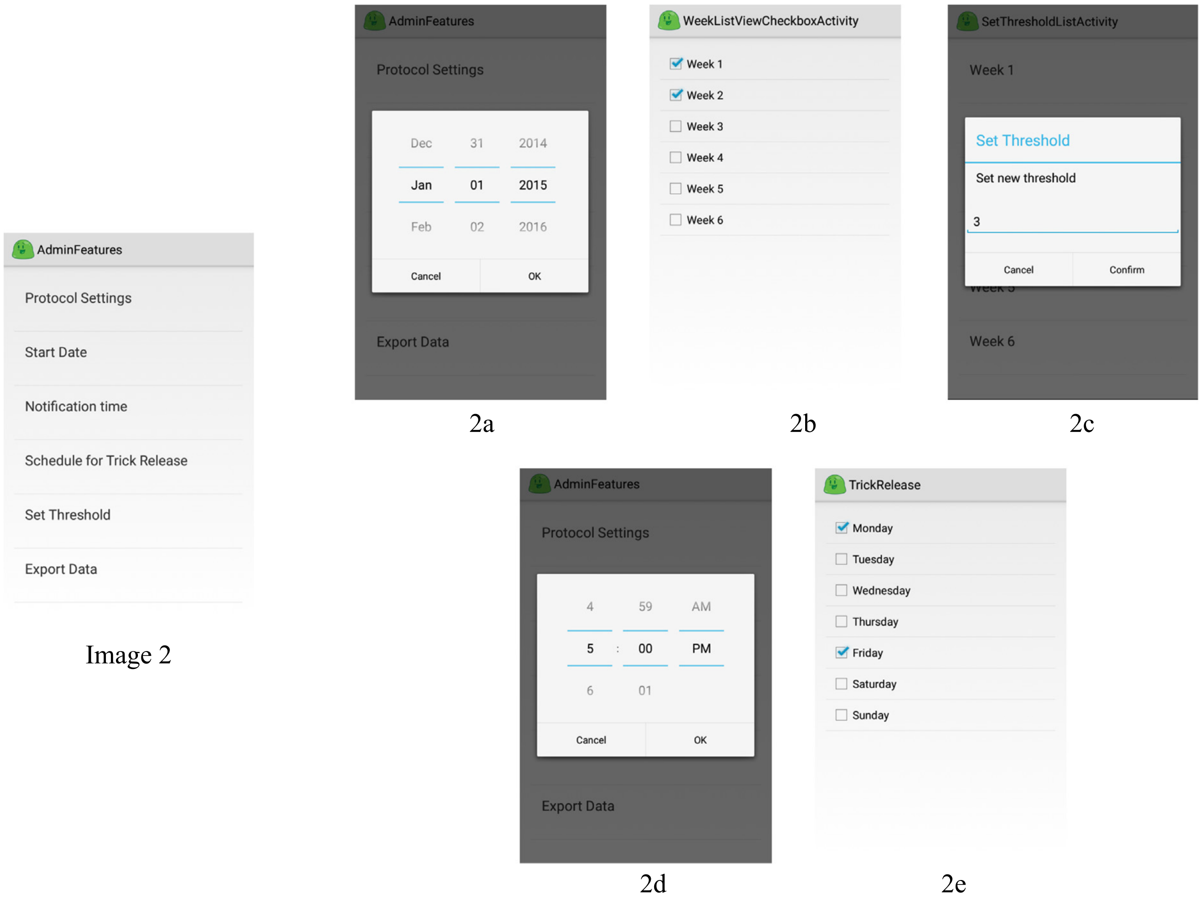

Fig. 2. REACH app admininstration options.

ages ranged from 8 to 12 years old ($M = 9.65$, $SD = 0.82$), 63% were female, 29% were Hispanic/Latino, and 71% were Non-Hispanic/Latino (32% White, 23% other or mixed ethnicity/race, 10% African American/Black, 5% Asian/Pacific Islander, 1% Native American). The median household income for the youth participants' families was $46,460. Turning to providers, 26 were bachelor's-level behavior interventionists, 13 served youth as school psychologists or school social workers, and 6 were master's- or PhD-level clinicians working in community mental health clinics or the local children's hospital. Providers were about 30 years old ($SD = 6.32$), 87% were female, and 80% were Non-Hispanic/Latino. Last, providers reported working with youth between 2 and 22 years ($M = 8.30$, $SD = 5.83$).

Smartphone Device and REACH App

Motorola Moto E smartphone devices running the Android (Google, Mountainview, CA) operating system were used to evaluate the REACH app. This smartphone was an attractive option for preliminary evaluations of mHealth tools because it is low cost (less than $50),[1] could be used with a pay-as-you-go monthly service contract, and is sufficiently representative of a typical Android smartphone in terms of display and computational power. Further, the REACH app was developed for Android version 4.4 (KitKat), which is compatible with approximately 80% of Android devices currently in use (Android Developer Dashboard, 2016), and included new API features leveraged in the REACH app, such as animations.

Usability Measures

The Usefulness, Satisfaction, and Ease of Use (USE) Questionnaire (Lund, 2001) and the Reactions to

[1] More information about the Motorola Moto E device can be found at https://www.motorola.com/us/products/moto-e-gen-2.

Program Scale (RPS; Stigma subscale; Rapee et al., 2006) were slightly modified and combined into one measure to assess the five dimensions of usability outlined by the ISO/IEC and typical standards noted in the literature (Brown et al., 2013; Matthews et al., 2008; Nielsen, 1994): ease of use, quality of support information, ease of learning, satisfaction, and social acceptability. The latter was measured as stigma and via RPS items given the mental health content nature of the REACH app. Consistent with past research, alpha reliabilities were excellent in the present sample and responses to items were summed to yield the following indices: system ease of use (11 items, α = 0.90), quality of support information (3 items, α = 0.78), system ease of learning (4 items, α = 0.91), system satisfaction (4 items, α = 0.88), and stigma (4 items, α = 0.83) scale scores. The overall usability score (22 items, α = 0.93) was calculated by subtracting stigma scores from a sum of the system ease of use, quality of support information, system ease of learning, and system satisfaction scores.

Procedures

All study procedures were approved by the university's Institutional Review Board. Teachers employed by one of our partner school districts sent home letters explaining the study to caregivers of students in regular classrooms (i.e., no special education) corresponding to the third, fourth, or fifth grade. These grade levels represent the target age for our REACH intervention. Students whose caregiver provided consent were invited to participate but were not screened for anxiety (no additional recruitment approach was used). Further, and to gain some sense as to the usability of the REACH app from school interventionists, providers (e.g., school psychologists, school social workers, school counselors) were also invited. From those contacted, 34% of caregivers provided child consent to give feedback on the app and every child with parent consent provided assent; approximately 61% of providers provided consent. No caregivers, children, or providers refused to participate. The rates of caregiver consent reflect the two-week time frame used for conducting research (from consent letter distribution to completion), which occurred prior to the end of the K–12 academic year.

Youth with consent/assent were escorted by a school liaison to a classroom where usability evaluation procedures were implemented by three trained research assistants; providers assembled at a classroom or office for the study. Usability evaluation activities with both youth and providers were conducted in a group format. Participants were given an envelope containing a questionnaire and smartphone device preloaded with the REACH app. Instructions and usability items were read aloud across nine administrations of the procedures (six with youth, three with providers). Participants were directed to (a) listen to the Relaxation mp3, (b) play the Worryheads game, (c) respond to Part 1 of the survey, (d) write a Diary or S.T.O.P. entry, (e) respond to Part 2 of the survey, (f) interact with the blob, and (g) respond to Part 3 of the survey. Procedures a, b, c, and f lasted 2 minutes each while responding to survey items and were not timed; each implementation of the testing procedures lasted 20–30 minutes. A total of 29 users encountered one or more difficulties related to software, hardware, and/or user knowledge during the evaluation procedures. When difficulties occurred, users were assisted by a trained research assistant who resolved the issue. Every such instance was documented by a research assistant, including participant identification and nature of the issue, and was considered in the analyses.

Results

Preliminary Analyses

Preliminary analyses were conducted to identify outliers that might be distorting trends in the data, evaluate missing data, and test data distributions. No meaningful outliers were found and thus all cases were retained. Less than 1% of data were missing, and missingness was not correlated with any sociodemographic characteristics or focal variables. Therefore, missingness was assumed to have occurred at random (missing completely at random; Enders, 2011). Four of the focal variables exceeded conventional cutoffs of |2| for skewness and/or |7| for kurtosis (West, Finch, & Curran, 1995): system ease of use (–2.31 skewness, 6.87 kurtosis), quality of support information (–2.08 skewness, 5.03 kurtosis), system ease of learning (–2.82 skewness, 9.12 kurtosis), and system satisfaction (–2.21 skewness, 5.20 kurtosis). To maintain assumptions of normality moving forward, bootstrapping methods were used for all preliminary analyses and primary tests of significance in SPSS version 22 (i.e., analysis of variance [ANOVA] tests, independent *t* tests) and in Mplus version 7.1 (i.e., path model analysis). Table 1 presents means and standard deviations for the focal variables, as well as correlations controlling for event errors/assistance during the testing protocol. As shown in the table, the overall usability score was good ($M = 33.35$, possible range is 0–40) and mean estimates for the five dimensions of usability were excellent with stigma being low ($M = 2.41$, possible range is 0–10). Correlations among the usability dimensions were in the expected directions with most coefficients being statistically significant and stigma negatively correlated with system satisfaction and system ease of use.

Does the REACH App Targeting Anxiety Yield Adequate Usability Ratings?

Relevant to the first research question, focusing on youth participants, the app was highly and positively rated

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Table 1
Means, Standard Deviations, and Correlations for the Five Usability Dimensions

	Mean	*SD*	1	2	3	4	5
Overall usability	35.76	4.68					
1. System ease of use	9.04	1.58	–	.67**	.80**	.40**	-.15
2. Quality of support information	8.93	1.49		–	.69**	.34**	-.06
3. System ease of learning	9.04	1.58			–	.30**	-.09
4. System satisfaction	9.09	1.41				–	-.29**
5. Stigma	2.41	2.05					–

Note. *N* = 177; overall usability ranges from 0 to 40; system ease of use, quality of support information, system ease of learning, system satisfaction, and stigma range from 0 to 10; correlations between dimensions of usability controlling for event errors/assistance during usability protocol.
* $p < .05$, ** $p < .01$.

on overall usability (*M* = 33.30 out of 40, *SD* = 5.88) and each usability dimension (possible range is 0–10): system ease of use (*M* = 8.57, *SD* = 1.53), quality of support information (*M* = 8.99, *SD* = 1.52), system ease of learning (*M* = 8.96, *SD* = 1.72), and system satisfaction (*M* = 9.18, *SD* = 1.47). In addition, stigma was low (*M* = 2.39 out of 10, *SD* = 2.15) suggesting adequate social acceptability. Next, ANOVAs were conducted to estimate the influence of sociodemographic characteristics on each of the usability dimensions. Results showed no influence of grade (third vs. fourth vs. fifth), sex (boys vs. girls), or ethnicity/race (Hispanic/Latino vs. non-Hispanic/Latino) on any of the usability ratings for youth. There were no significant two- or three-way interactions among grade, sex, and ethnicity (e.g., sex: boys, girls by ethnicity; Hispanic, non-Hispanic). There also were no statistically significant age differences in ratings of any usability dimension, overall usability, or stigma.

For ease of interpretation, and based on a traditional "grade" scale, the REACH app earned an "A+" from 7% of youth, "A" from 27%, "A–" from 14%, "B+" from 8%, "B" from 5%, and failing grades of "C–" or less from 17% (or 23 youth). Focusing on youth who rated the app with "C–" or less, 10 youth encountered one or more software, hardware, and/or user knowledge errors during the testing protocol. Of those, 3 youth encountered software errors, 3 hardware error, and 4 user knowledge errors. Software errors included app suddenly quitting in the middle of use (2 youth) and extraneous notifications or pop-ups interfering with using the app (1 youth). Hardware errors included Android smartphone restarting in the middle of use (2 youth) and headphone jack of smartphone not working properly (1 youth). User knowledge errors were having difficulty finding correct buttons or activities within the app (3 youth), no knowledge of the Android operating system (4 youth), and could not turn on or unlock the Android smartphone device (2 youth). Table 2 presents results from independent *t* tests showing that youth who encountered a software, hardware, or user knowledge error during the

Table 2
Results of *T* Test for Outcome Measures by Having Errors During Testing Protocol for Youth

	Experienced Errors (Software, Hardware, or User Knowledge)								
	Yes			No					
	M	*SD*	*n*	*M*	*SD*	*n*	*T Value*	*df*	95% CI
Overall usability	33.03	7.97	23	36.53	3.92	109	3.14*	130	[1.29, 5.71]
System ease of use	8.15	2.11	23	8.87	1.17	109	2.29*	130	[0.10, 1.34]
Quality of support information	8.35	2.19	23	9.15	1.29	109	2.34*	130	[0.12, 1.47]
System ease of learning	8.17	2.41	23	9.13	1.48	109	2.49*	130	[0.20, 1.72]
System satisfaction	8.36	2.23	23	9.39	1.17	109	3.18*	130	[0.39, 1.66]
Stigma	3.42	2.79	23	2.15	1.93	109	-2.64*	130	[-2.23, -0.32]

Note. Software errors = app suddenly quit, extraneous notifications or pop-ups interfering with using the app; hardware errors = device suddenly restarted/turned off, headphone jack did not work; user knowledge errors = difficulty pressing or finding correct app buttons; did not understand how to use the app; user could not turn on device.
* $p < .05$; ** $p < .01$.

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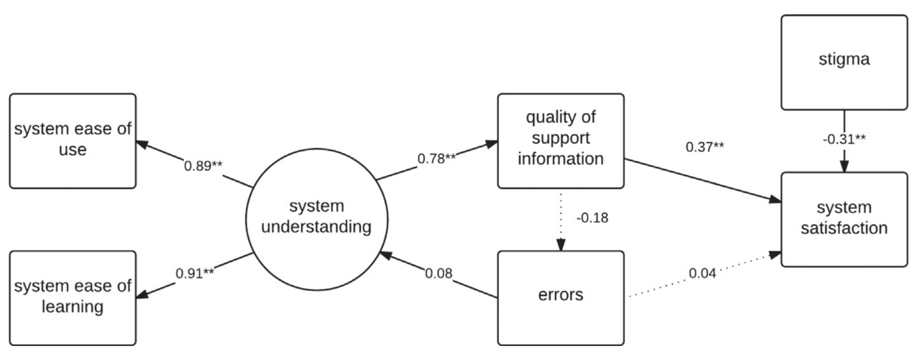
testing protocol rated usability significantly lower than youth who did not encounter any errors (no significant differences among hardware, software, or user knowledge errors were found).

Focusing on providers, the REACH app was highly and positively rated in terms of overall usability (32.54 out of 40, *SD* = 3.87) and along each usability dimension (possible range is 0–10): system ease of use (*M* = 9.12, *SD* = 1.07), quality of support information (*M* = 8.74, *SD* = 1.37), system ease of learning (*M* = 9.27, *SD* = 0.99), and system satisfaction (*M* = 8.83, *SD* = 1.19). In addition, concerns of stigma for youth when using the app was low (*M* = 2.48 out of 10, *SD* = 1.75), possibly suggesting high social acceptability. Errors were encountered by six providers (errors: two software, two hardware, two user knowledge) but results from independent *t* tests showed that users who encountered a software, hardware, or user knowledge error during the testing protocol did not rate usability significantly lower than providers who encountered no errors, possibly due to lack of statistical power.

Which Aspects of the Youth User Experience Could Be Targeted to Improve the REACH App?

Relevant to the second research question, an exploratory path model was tested in MPlus (software version 7.1) to examine relations among system ease of use, system ease of learning, quality of support information, and event errors on the satisfaction variable, controlling for perceived level of stigma (see Figure 3) for youth users. Full information maximum likelihood (FIML; Enders & Bandalos, 2001) was used to calculate path coefficients and handle missing data. In addition, given the moderate to high correlation between scores for system ease of learning and system ease of use (*r* = 0.66), a latent construct of system understanding was created (see Figure 3). For these analyses, path model fit was evaluated against the following established criteria for good and acceptable fit (Hu & Bentler, 1999): a nonsignificant chi-square test of exact fit, root-mean-square error of approximation (RMSEA) less than 0.05 (0.08 for acceptable), comparative fit index (CFI) greater than 0.95 (0.90 for acceptable), and standardized root-mean-square residual (SRMR) less than 0.05 (0.08 for acceptable). Based on our data, the proposed model showed acceptable approximate fit, chi-square fit $\chi(7)$ = 10.40, *p* = 0.17 or ns; RMSEA = 0.06 with 95% CI [0.00, 0.13]; CFI = 0.99, SRMR = 0.06. Moreover, as shown in Figure 3, we evaluated a model to estimate direct effects of the system understanding latent construct, quality of support information, number of event errors, and stigma on the system satisfaction variable.

We used the products of coefficients estimator and bias-corrected bootstrap sampling distributions provided by RMediation (Tofighi & MacKinnon, 2011) to estimate the significance of indirect effects of quality of support information as well as the effects of number of event errors on the system understanding and system satisfaction relations. In terms of findings relevant to the tested variable relations, system ease of use (e.g., remember how to use it) and system ease of learning (e.g., using it requires no effort) loaded positively on the system understanding latent factor (standardized factor loadings were 0.89 and 0.91). Stigma (e.g., teased or picked on by other kids for having this app) was negatively and



Note. System understanding = latent construct of system ease of use and system ease of learning; solid lines indicate significant path coefficient; dashed lines indicate nonsignificant path coefficient.
**$p < .001$.

Figure 3. Hypothesized model of usability and satisfaction.

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significantly related to system satisfaction (e.g., fun to use). The path from event errors to quality of support information was trivial (or nonsignificant). In terms of the indirect effects, results showed that system understanding had a significant indirect effect on satisfaction via quality of support information (e.g., the instructions and messages are easy to understand; indirect effect = 0.37, 95% CI [0.14, 0.60]) in that for every 1 standard deviation increase in system understanding, system satisfaction increased by 0.37 standard deviation units via quality of support information. System understanding did not have a significant indirect effect on satisfaction via errors (indirect effect = 0.12, 95% CI [−0.03, 0.23]).

Discussion

Principal Findings

Despite the increasing proliferation of mHealth technology, research evaluating the usability of these technologies is severely lacking (Curioso & Mechael, 2010; Nilsen et al., 2012). In fact, the present study is the first of its kind to report findings from an in-depth evaluation of usability corresponding to an empirically informed child anxiety prevention and early intervention smartphone app. For this reason, and in light of our findings, the present study is important as it may set the stage for future research given that poor usability has been identified as one of the biggest barriers to mHealth impact (Matthews et al., 2008; Sheehan et al., 2012). Relevant to the primary objectives of the present study, results showed that each dimension of usability measured for the REACH anxiety prevention and early intervention app was highly and positively rated by 89% of providers and 83% of youth. In addition, stigma associated with using the app was rated low. The REACH app was found to be relatively easy to use and easy to learn, messages deployed by the technology were rated as helpful and clear, and the app yielded high satisfaction and social acceptability. These findings are encouraging and generally similar to those reported in the handful of studies that have reported usability tests of mHealth tools for youth (Dixon et al., 2013; O'Malley et al., 2014; Pramana et al., 2014; Tang et al., 2013). Focusing on knowledge gained for improving the REACH app, some youth (about 17% or n = 22) showed low enthusiasm about the app and this may have occurred for several reasons. First, software, hardware, and user knowledge errors that youth encountered during the evaluation protocol were significantly related to lower satisfaction and thus need to be addressed. Second, lower enthusiasm could be related to the fact that, anecdotally, some youth were expecting a game app for a smartphone rather than a psychoeducational app. Third, lower satisfaction could have been related to the evaluation procedures of usability implemented for this research as some youth probably would have preferred to engage in "unrestricted play" with the app. If the last two points are true, then it would be important to clearly explain to youth the nature and use of the REACH app prior to providing them with the technology. Fourth, there is a possibility that lower satisfaction for some youth could be have been related to the design itself as other approaches might be preferable. For example, some youth might prefer collaborative learning (e.g., peer-to-peer interactions), more human support (e.g., direct and immediate responses from an adult mental health provider), and/or simply more complex graphics and gamification features (e.g., enhanced user-to-blob interaction and progressive reward incentives). These are possibilities that would need to be explored in future research efforts. Nonetheless, our findings are strong and consistent in suggesting that clinicians searching for mHealth apps to enhance aspects of their services should consider not only effectiveness evidence but also usability ratings. To that end, Table 3

Table 3
Some Evidence-Based Considerations in Evaluating the Usability of mHealth Tools

Ease of use
1. It is easy to use.
2. It is simple to use.
3. It is easy to understand.
4. In a few steps, it does what you want.
5. It lets you do several things.
6. Using it requires no effort.
7. You can use it without written instructions.
8. You do not notice any problems as you use it.
9. People using it once or many times would like it.
10. Mistakes can be fixed quickly and easily.
11. You can use it well every time.
Quality of support
12. The instructions and messages are easy to understand.
13. The messages to fix problems are clear.
14. The instructions and messages are clear.
Ease of learning
15. You quickly became good at it.
16. You easily remember how to use it.
17. It is easy to learn to use it.
18. You learn to use it quickly.
Satisfaction
19. You are happy with the app.
20. You would tell a friend about the app.
21. The app is fun to use.
22. This app works the way you would want it to work.

Note. Considerations listed are items adapted from the usefulness, satisfaction, and ease of use questionnaire (USE; Lund, 2001). A modified version of these items were rated by participants for this research using a 10-point rating scale (i.e., 1 = *not at all* to 5 = *somewhat* to 10 = *very much*).

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offers a list of usability indicators based on ISO and IEC standards (ISO, 2009; ISO/IEC, 2001), the USE Questionnaire (Lund, 2001), conceptual models of mHealth evaluation (e.g., Health IT usability evaluation model; Brown et al., 2013), and the research we report in this study.

Broadly, and of plausibly greater interest to other investigators working in mHealth, is a core finding from the present study—that is, our results suggest that future efforts toward improving satisfaction with technology probably need to carefully consider the dynamic relations between system understanding and support information. This is the case because path analyses of youth-reported data indicated that greater system understanding (i.e., system ease of use, system ease of learning) was significantly related to greater system satisfaction, but that such relation occurred via the quality of support information offered by the app (e.g., the instructions are easy to understand, messages are helpful in fixing mistakes). Although ratings of the quality of support information and system understanding for the REACH app were high, moving forward it would be important to continue evaluating the messages and instructions offered by the app as a means of further optimizing and improving its overall usability and satisfaction. While no direct test of these relations has been conducted to date, these findings appear consistent with conceptual models of mHealth technologies suggesting that information need, learnability (e.g., ease of learning), and efficiency of smartphone apps (e.g., ease of use) are critical to improving user satisfaction, usability, and adherence during efficacy or effectiveness stages of testing (Brown et al., 2013; Harrison et al., 2013; Matthews et al., 2008). Also, findings from the present study showed that some youth and providers experienced roadblocks when trying to use the technology (e.g., did not know how to navigate the app menus). Therefore, it might be the case that brief training in using devices of choice and even the app could help decrease the frequency of operational errors and their impact on usability. For example, in an evaluation of a smartphone app for adolescent depression, youth were provided with a training session outlining the functions of the app prior to the start of the intervention (Mohr, Burns, Schueller, Clarke, & Klinkman, 2013). This is consistent with human computer interaction "best practices," suggesting that short training sessions with users could be highly beneficial to minimizing barriers to usage (Matthews et al., 2008).

Limitations and Future Directions

Contributions notwithstanding, limitations are noteworthy. First, our findings are limited in that usability was ascertained via self-reported ratings during a brief standardized demonstration protocol. While this methodology is consistent with past research (e.g., Jaspers, 2009), user interaction data during the course of days or in the context of an intervention would probably provide valuable in-depth information that could inform future iterations. For example, completion time (amount of time to start and end an activity), transition time (time to transition from one activity to another), and click-tracing sequence data (how user navigated from one activity to another; Hilbert & Redmiles, 2000) could help identify inefficiencies in design organization (e.g., button locations not intuitively placed for users) and whether user interactions follow the anticipated design sequences (Jaspers, 2009). Second, whereas youth and provider ratings of overall usability, satisfaction, and acceptability were high, users did offer suggestions to enhance the REACH app. Some suggestions most likely would not impact research results, such as giving the user the ability to customize the colors and name of the blob. However, other suggestions could very well enhance the impact of the app, including increasing reward features for game play and adding progress indicators toward achieving goals. These types of feedback mechanisms could encourage greater engagement with the app. Finally, users suggested the app be made available on platforms besides Android devices, which we interpret as meaning the users would like to run the app on their own devices and platforms instead of having devices with a specific operating system provided to them. These are important design improvement areas for the next generation of the REACH app, some of which are consistent with the broader mHealth literature (e.g., Georgsson & Staggers, 2016; Luxton, McCann, Bush, Mishkind, & Reger, 2011). Finally, it is important for future research to examine natural patterns of usability (or engagement) with the REACH app: how would children use the app with various degrees of interventionist involvement—across settings (e.g., at home, on weekends, in session), in their day-to-day life, or over time? Could REACH app usability have moment-to-moment impact on child anxiety and its associated impairment?

Conclusions

The present study is the first to report findings from an in-depth evaluation of usability relevant to an empirically informed smartphone app designed to support the prevention and early intervention of youth anxiety. Findings from this research provided strong initial support for the usability of the REACH app and emphasizes the need for conducting this type of testing, early in the development process of mHealth tools, to guide necessary user-informed design iterations prior to applying the technology for intervention purposes (e.g., efficacy, effectiveness). This research identified areas for improvement (e.g., stabilizing app functions,

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customizable features, gamification changes), and offered knowledge about the extent to which users need to be trained and supported (Mohr et al., 2013; O'Malley et al., 2014). Because mHealth apps have great potential for improving the management of public health initiatives, including lessening restrictions in the provision of care (e.g., time, geographical location; Whiteside, 2016), barriers associated with other types of technologies (e.g., web-based tools), and even affecting change in economically disparate populations (Baggett et al., 2010; Comer & Barlow, 2014; Kazdin & Blase, 2011), new and better tools will continue to be found in the research area and consumer marketplace. Moving forward it, therefore, might be viewed as "best practice" to integrate usability testing into the design and development process of mHealth tools to ensure that technologies are usable in ways that can enable sustainability and large-scale diffusion capabilities of evidence-based interventions.

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