Smartglass-guided exposure for anxiety disorders: A proof-of-concept study

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Abstract

Exposure is a highly effective treatment for pathological fear and anxiety, but rarely used in routine care. Issues of practicability and lack of therapists in rural areas are main barriers for the dissemination of exposure. Smartglass devices may enable therapists to guide exposure from their own office via real-time feedback and may thereby increase practicability. The present study explored the technological usability and clinical feasibility of Smartglass-guided exposure in a behavioral approach test in spider fearful individuals ($N=40$).

Fearful individuals were asked to start the Smartglass themselves and established a connection to a therapist, who guided the exposure test from afar. Clinical severity of spider fear was assessed via questionnaire. Technological usability was assessed with established measures of usability, user experience, and user acceptance. Exploratory, individual characteristics of exposure were collected (e.g., within-session fear reduction, duration, safety behavior).

Overall, fearful individuals (94.9%) and therapists (100%) were able to establish a connection. Usability of Smartglass-guided exposure was evaluated as positive. Within-session fear reduction was large ($d=1.91$). Adverse events were minimal. There were, however, some associations between exposure characteristics and usability evaluation (e.g., lower user-friendliness and longer exposure duration). Two case examples further highlight chances and risks of Smartglass-guided exposure.

These findings provide first evidence that Smartglass-guided exposure could be useful in exposure therapy. Smartglass-guided exposure may ultimately help to increase practicability of exposure and increase dissemination, also in rural areas. These findings are promising for future research on the long-term outcome of evidence-based exposure in treatment seeking patients.

Introduction

Anxiety disorders are characterized by intense and persistent anxiety and avoidance behavior, which are out of proportion to actual threat. They are among the most prevalent mental disorders (Jacobi et al., 2014; Kessler et al., 2010), with the global twelve-month prevalence for any anxiety disorders estimated to be ~14% (Baxter et al., 2013). Anxiety disorders are typically associated with severe individual impairments and high socioeconomic costs (Craske et al., 2017; Gustavsson et al., 2011; Wittchen et al., 2011). Without adequate treatment, most anxiety disorders show a “waxing and waning” pattern and thus tend to become chronic conditions (Craske et al., 2017). Optimizing the treatment of anxiety disorders is therefore an important goal for public health.

During the last decades, numerous studies provided comprehensive evidence for exposure-based cognitive-behavioral therapy (CBT) as an effective treatment. Exposure-based CBT consistently yielded large effects compared to no treatment or placebo treatments in randomized controlled clinical trials (e.g., Carpenter et al., 2018; Hofmann & Smits, 2008; Olatunji et al., 2010; Watts et al., 2015) as well as in more naturalistic settings (e.g., Hoyer et al., 2017; Noack, Schmidt, et al., 2019; Stewart & Chambless, 2009). Moreover, recent meta-analyses yielded a superiority of exposure-based CBT compared to other psychological treatments, e.g., psychodynamic therapy (Marcus et al., 2014; Tolin, 2010). One of the core active ingredients for exposure-based CBT are exposure exercises (Arch & Craske, 2009; Craske, 1999; Pittig et al., 2016). Exposure alone showed high effect sizes in the treatment of anxiety and panic (Bakker et al., 1998; Norton & Price, 2007) and effect sizes are higher for CBT with compared to without exposure exercises (Carpenter et al., 2018). As a consequence, exposure-based CBT is the first-line psychological treatment for anxiety disorders (e.g., Bandelow et al., 2014; Clark, 2011; Katzman et al., 2014).

Exposure exercises can be conducted in various ways. They all have in common that a patient is confronted with an individually fear- and anxiety-relevant stimulus or situation in the absence of real danger. These exercises aim to overcome pathological avoidance and thereby initiate novel learning about the non-occurrence of expected threat. For disorders, such as specific phobia, panic disorder with agoraphobia, or social anxiety disorder, exposure is typically conducted *in vivo*, meaning that the individual is confronted with an external stimulus or situation (e.g., using public transportation or facing a spider). Exposure *in vivo* can be conducted accompanied or unaccompanied by the therapist. Accompanied exposure has the advantage that the therapist can guide the exercise, identify dysfunctional avoidance or safety behaviors, motivate the patient, and provide feedback. Indeed, therapist-accompanied compared to unaccompanied exposure showed better long-term treatment outcomes in panic disorder with agoraphobia, even when unaccompanied exposure was planned and discussed in detail beforehand and afterwards (Gloster et al., 2011). Guided compared to unguided exposure also showed better outcomes for specific phobia (Andersson et al., 2013) and obsessive-compulsive disorder (Abramowitz, 1996). Combined, these findings highlight that therapist-accompanied exposure should be a key element in exposure-based CBT for anxiety disorders.

In contrast, exposure is rarely used in routine care settings. Estimates of utilization rates are difficult to assess and thus vary considerably. For patients with post-traumatic stress disorder, only 17% received exposure (Becker et al., 2004) and only 29.3% of patients with OCD reported exposure as part of their behavioral treatment (Böhm et al., 2008). For anxiety disorders in general, supportive and pharmacological treatment is most frequent, whereas exposure is rarely utilized (estimated at about 10-30% of cases; Becker-Haimes et al., 2017;

Trask et al., 2016; Whiteside et al., 2016; Wolitzky-Taylor et al., 2015). We recently assessed the self-reported use and potential barriers of exposure from the perspective of CBT therapists working in private practice (Pittig et al., 2019). Overall, therapists indicated to use any kind of exposure in less than half of their cases with principal anxiety disorder (46.8%). This utilization rate may even be overestimated because therapists being more in favor of exposure may have been more likely to respond to a survey on exposure therapy (Pittig & Hoyer, 2017). In sum, there is an ongoing gap in the dissemination of evidence-based exposure therapy to routine care.

During the last years, different attempts to increase the dissemination of exposure were made. Although trainings for evidence-based exposure therapy increase utilization rates to some degree (Broicher et al., 2017; Pittig & Hoyer, 2017; Sholomskas et al., 2005), they do not suffice (e.g., Becker et al., 2004). This lack of transfer even after comprehensive training may result from multiple barriers on different levels. For example, therapists' negative beliefs about exposure have frequently been reported to impede its utilization. Most frequently, patients are believed to be at risk of decompensating and to be unable to handle distress evoked during exposure (Deacon et al., 2013; Farrell et al., 2013; Pittig et al., 2019). Moreover, use of exposure is impeded because it is also strenuous for therapists (Pittig et al., 2019). Besides this individual level, barriers in the health care system are frequently reported (Pittig & Hoyer, 2017). These systemic barriers, for example, include an unfavorable ratio of effort and financial payoff or lack of available therapists in rural areas. Finally, substantial issues of practicability were the most strongly agreed upon barriers hindering the use of exposure in routine care (Pittig et al., 2019). In this study, 70% of surveyed therapists agreed that general time management is too unpredictable to schedule other patients after exposure. Thus, a multilevel approach targeting individual, systemic, and practical barriers is necessary to optimize the dissemination of exposure.

While practicability is already seen as problematic for exposure in general, therapist accompanied exposure challenges practicability even more. Accompanied exposure exercises, such as using public transportation to destinations far from the patient's home, exposing to trauma-related places, or conducting behavioral experiments in public, typically require more time and effort for planning and travelling to the specific location. For example, ~35% of the therapists indicated that they do not have time to leave their offices for accompanied exposure (Pittig et al., 2019). In addition, ~21% of the therapists indicated that there are no appropriate places in the near surrounding (e.g., malls, airports). In this case, accompanied exposure would require substantial travel for both patient and therapist. Finally, accompanied exposure is crucially impeded in rural areas with low density of available therapists. Increasing practicability, decreasing timely travelling to exposure locations, and making it easier to guide exposure from afar may thus help therapists to more easily incorporate accompanied exposure in routine practice and to deliver exposure in rural areas.

Novel technologies represent an exciting opportunity for this endeavor. For example, many attempts were made to conduct exposure in virtual reality (VR) (e.g., Carl et al., 2019; Diemer et al., 2014; Gromer et al., 2018). However, virtual reality to date requires expensive equipment and is oftentimes limited to few and artificial scenarios. Importantly, VR-scenarios do not fully resemble real-life situations. Developments in telecommunication technology may address these gaps. For example, exposure guided via online videoconference, where the therapist could observe exposure conducted in the patient's home from the therapist's office, demonstrated high feasibility and was effective to reduce symptoms in obsessive-compulsive

disorder (Goetter et al., 2014; Netter et al., 2018). However, videoconferences are limited by the stationarity of the device and the limited camera angle. Novel *Data- or Smartglass technology* may solve this problem. Smartglasses are devices that are wearable like normal glasses. They include head-mounted displays that allow presentation of different information directly in the user's field of vision (i.e., augmented reality). In addition, some systems include a video camera and microphone and thereby allow real-time bidirectional audio communication, while a real-time video of the user's field of vision can be recorded and streamed. For exposure, a therapist could view a real-time video of the exposure exercise from the patient's perspective, hear all comments of the patients, and give feedback or instruction either via presenting text messages in the field of vision or via audio communication. Combined, Smartglass-guided exposure may allow therapists to accompany real-life exposure exercises from their own offices, while still being able to view and communicate with the patient in real-time. This may substantially reduce time and effort required for accompanied exposure, increase the availability of accompanied exposure in rural areas, and ultimately increase the overall dissemination of exposure.

To the best of our knowledge, there are currently no investigations of Smartglass-guided exposure. It thus remains unclear whether Smartglass devices are accepted and usable to guided exposure and whether usability of Smartglass devices may impair exposure. Thus, a first step is to explore the technological usability of Smartglass-guided exposure in a standardized exposure test. To this end, we conducted a proof-of-concept study using a behavioral approach test in spider fearful individuals as a paradigmatic model for exposure in anxiety disorders (e.g., Olatunji et al., 2008; Zoellner et al., 2000). The major aim was to assess the usability, acceptance, and user experience of Smartglass-guided exposure from the perspective of fearful individuals and therapists (see Noack, Eckelt, et al., 2019). In addition, we explored the association between usability and characteristics of exposure (e.g., initial fear, fear reduction, duration, safety behavior). To this end, spider fearful individuals underwent a single behavioral approach session to a spider stimulus, which was accompanied by a therapist via Smartglass device. Finally, we report two case examples to provide a clinical description of the procedures and highlight chances and risks of Smartglass-guided exposure.

Methods

Participants

In total, 40 fearful individuals from the student and staff body of the Technische Universitaet Dresden were included in the study. The local ethics committee approved all procedures (EK506122017). All participants provided written informed consent. They were informed that the study examines interventions targeting spider fear, but the use of Smartglasses was not announced to not bias the sample in terms of attitudes towards novel technologies. Inclusion criteria were significant fear of spiders as measured by the short version of the Fear of Spider Questionnaire (Pössel & Hautzinger, 2002), legal age, and sufficient language skills to understand instructions and questionnaires. For the Fear of Spider questionnaire, previous research indicated a non-overlapping distribution of non-fearful individuals and individuals with diagnosed spider phobia, with phobic individuals showing FSQ scores > 14 (Rinck et al., 2002). All fearful participants in the present sample fulfilled this criterion. Exclusion criteria were any mental disorders except spider phobia and nicotine abuse, any serious medical condition, and pregnancy, all assessed by a screening questionnaire and a structured interview. One participant refused to conduct the exposure exercise after inclusion, thus, data from 39 participants were used in all analyses. Sociodemographic and questionnaire data are displayed in Table 1. Whereas fearful participants showed high levels of spider fear, they did not differ from a normative healthy sample in terms of general psychopathology (as assessed with the Brief Symptom Inventory; see Franke et al., 2011).

Table 1. Sociodemographic and questionnaire data

	<i>Fearful individuals (n = 39)</i>	
Female (%)	37	(94.8)
Age	30.15	(9.36)
Experience with computer devices	3.18	(0.88)
<i>Brief Symptom Inventory (BSI-18)</i>		
Global Severity Index (GSI)	4.33	(3.91)
Anxiety	2.26	(1.87)
Depression	1.15	(1.63)
Somatization	0.92	(1.40)
<i>Spider fear questionnaire (FSQ-S)</i>		
Total	39.03	(19.21)
Avoidance and safety behavior	35.46	(17.38)
Fear of injury	3.56	(3.25)

Note. Means (and standard deviations) for the sample of fearful individuals. Experience with computer devices compared to others (e.g., tablets, smartphones) was assessed via a 7-point Likert scale item (0 = *very little* to 6 = *very much*).

Therapists

In total, sixteen therapists participated in the study. Therapist were on average 37.19 years ($SD = 9.94$), eight were females (50%). All therapists were already experienced in conducting exposure for anxiety disorders as part of their postgraduate training in behavioral therapy. 43,8% of the therapist had already completed this training and training was ongoing for the remaining therapist. On average, therapists had 10.13 years of experience of working as a therapist ($SD = 9.80$) and 8.31 years of experience in conducting exposure ($SD = 9.08$; range =

1 to 27 years). Years of experience with exposure did not correlate with any measure of the exposure exercise ($r_s < .20$, $p_s > .22$). Finally, therapist reported average experience with computer systems compared to others, $M = 3.75$ ($SD = 0.93$).

For the study, therapists did not receive any additional technical or clinical training except brief written instructions on how to set up the required software and their main tasks during exposure. Therapists were instructed to answer questions regarding the exposure rational at the beginning, monitor subjective distress throughout exposure, and motivate the individual to approach the spider as close as possible. The study did not use a fully standardized protocol for approaching the spider or assessing subjective levels of anxiety to allow examination of feasibility under more naturalistic conditions. Therapists were also instructed to identify safety behaviors, provide feedback to make individuals aware of their use of safety behaviors, and ask them to refrain from safety behaviors when they occurred. Safety behaviors were defined as any kind of unnecessary actions taken to prevent, escape from, or reduce the severity of a perceived threat and anxiety (see Telch & Lancaster, 2012).

Measures

Clinical measures comprised general psychopathology and fear of spiders. General psychopathology was assessed with the Brief Symptom Inventory (BSI-18, Franke et al., 2011), which includes a General Severity Index (GSI) as well as subscales for general anxiety, depression, and somatization. The BSI-18 showed good internal consistency, especially for the GSI score (Cronbach's $\alpha = 0.93$) and convergent validity (Franke et al., 2011). Spider fear was assessed with the short version of the Fear of Spiders Questionnaire (FSQ-S, Pössel & Hautzinger, 2002). The short version comprises 14 items (7-point Likert scale, 0-6) and showed high internal consistency (Cronbach's $\alpha = 0.94$) and 1-month retest reliability ($r = .75$) as well as high construct validity (Pössel & Hautzinger, 2002). In addition to a total sum score, items can be divided into the subscales Fear of Injury (FSQ Fear) and Avoidance and Safety Behavior (FSQ Avoid).

Usability, user experience, and user acceptance regarding Smartglass-guided exposure were assessed with three instruments. General usability was assessed with the System Usability Scale (SUS, Brooke, 1996; Røed-Heugren & Rummel, 2013). The SUS consists of ten items, each scored on a scale from 0 to 100 (e.g., "I found the system unnecessarily complex." or "I think that I would need the support of a technical person to be able to use this system."). A mean score is calculated for interpretation. The SUS showed high reliability (Cronbach's $\alpha = 0.91$) and is sensitive to usability-related modification of systems (Bangor et al., 2009). Normative data were derived from over 200 usability tests of various technological systems (see Bangor et al., 2009). As a result, SUS scores can be translated into an adjective ranking highlighting the overall usability of the system (i.e., *worst imaginable*, *awful*, *poor*, *OK*, *good*, *excellent*, *best imaginable*).

User experience was assessed with the User Experience Questionnaire (UEQ, Laugwitz, B et al., 2008). The UEQ contains 26 items in six subscales, which showed sufficient to high reliability (Cronbach's $\alpha = 0.65$ - 0.89) and good construct validity (Laugwitz, B et al., 2008). Each item consists of two opposing attributes and is scored on a 7-point Likert scale (-3 representing most negative answer, 0 representing neutral, +3 representing most positive answer). The subscale *Attractiveness* is a valence subscale measuring the overall like or dislike of the system (e.g., "annoying vs. enjoyable"). Three subscale assess the pragmatic quality of the system: *Ease-of-use* (i.e., how easy it is to learn how to use the system, e.g., "difficult vs.

easy to learn”), *Dependability* (i.e., whether the user feels in control of the system, e.g., “unpredictable vs. predictable”), and *Efficiency* (i.e., whether the user can solve their task without unnecessary effort, e.g., “impractical vs. practical”). Finally, two subscales assess the hedonic quality of the system: *Novelty* (i.e., whether the system is innovative and interesting, e.g., “dull vs. creative”) and *Stimulation* (i.e., whether it is exciting and motivating the use the system, e.g., “demotivating vs. motivating”). In addition to raw scores, normative data were derived from 246 evaluations of various products (e.g., business or smartphone applications, web shops). Benchmarks (*bad* to *excellent*) are assigned based on scores of the specific product in relation to the normative data (*excellent* $\triangleq$ among best 10%; *good* $\triangleq$ 10% are better, 75% are worse; *above average* $\triangleq$ 25% are better, 50% are worse; *below average* $\triangleq$ 50% better, 25% are worse; *bad* $\triangleq$ among the worst 25%; see Schrepp et al., 2017).

User acceptance was assessed with the Technology Usage Inventory (TUI, Kothgassner et al., 2012). The TUI contains 30 items in eight subscales, which showed acceptable to high reliability (Cronbach’s $\alpha = 0.70$ - 0.89) and good construct validity (Kothgassner et al., 2012). Most items are scored on a 7-point Likert scale (1-7), with higher scores indicating more approval for the corresponding item. Items of the subscale *Intention-to-use* are scored on a scale from 0 – 100. Subscales either refer to the specific technology used, in this case the Smartglasses device, or to novel technology in general. The following five specific-technology subscales were assessed: *User-friendliness* (i.e., how user-friendly the specific technology is evaluated, e.g., “Overall, this technology is easy to use”), *Usefulness* (i.e., how useful the specific technology is evaluated, e.g., “Using this technology would make many things more comfortable.”), *Curiosity* (i.e., how curious the user is regarding the specific technology, e.g., “I want to know more about this technology.”), *Skeptical* (i.e., how skeptical and concerned the user is regarding the specific technology, e.g., “Using this technology comes with a certain risk.”), *Intention-to-use* (i.e., the extent to which the user would actually use the specific technology, e.g., “Would you use this technology?”). In addition, two general-technology subscales were assessed: *Interest* (i.e., how interested the user is regarding novel technology in general, e.g., “I keep myself informed about novel technologies.”), *Anxiousness* regarding technology (i.e., how anxious and overwhelmed the user is regarding novel technology in general, e.g., “I worry about being overwhelmed when using novel technology.”). The subscales *Immersion* and *Accessibility* were not analyzed, because the former is restricted to VR technology and the latter assesses how easy it is to acquire the specific technology. Normative data only exist for acceptance of virtual reality from a small sample (Kothgassner et al., 2012).

Smartglass device

A M100 model from Vuzix® was used. This Smartglass consists of a glassless frame, which can be worn in addition to prescription glasses. The device includes a microphone for bidirectional audio communication as well as a video camera allowing real-time video transmission. Moreover, it includes a 432 * 240 pixels display to present information in the user’s field of vision. This display was used to present therapist’s instructions during exposure. The Smartglass was linked to a smartphone carried by the participant, which allowed accessing the internet. To assure data safety and security, audio and video communication was conducted via encrypted communication and endpoint authentication.

Procedures

The study was designed as a pre-experimental proof-of-concept study to evaluate the usability, user experience, and acceptance of Smartglass-guided exposure. To gain controlled insights into these factors and their association with exposure, a structured and standardized behavioral approach task consisting of three phases was conducted: Preparation, exposure, and evaluation phase. A research assistant observed therapists and fearful individuals during preparation and exposure to note any problems and completed an unstructured interview about problems, adverse events, and suggested improvements with both therapists and fearful individuals.

During the preparation phase, fearful individuals received three types of written instructions. First, they were instructed about fear in general and the exposure rationale (e.g., definition and function of fear, exposure rationale, no safety behavior during exposure). Second, they received a step-by-step written instruction on how to setup the Smartglass device and establish a connection to the therapist. A written instruction was chosen as a conservative assessment whether participants were able to start the device and establish a connection to the therapist without further help. Third, participants received a written instruction about the general procedure of the exposure task. Before the exposure phase, fearful individuals had the opportunity to ask the therapist remaining questions about the rationale and the task via audio connection. The behavioral approach test took place in a dimly lit room containing a brightly lit platform. On the platform, an exoskeleton of a tarantula was placed serving as spider stimulus. An exoskeleton instead of a living spider was chosen as a living spider may have resulted in unstandardized exposure situations (e.g., moved uncontrollably in the room before the participant entered). At the beginning, participants stood 6 meters away from the spider stimulus. During exposure, therapists instructed participants to gradually approach the spider stimulus, motivated participants, and assessed their anxiety levels (0 to 100). Apart from assessing anxiety levels at the beginning and immediately before ending exposure, therapists were instructed to assess anxiety levels and motivate individuals to move closer at their convenience. In addition, therapists rated if the participant used any safety behavior, what kind of safety behavior (e.g., calming thoughts, directing attention away from spider), and the overall extent of safety behaviors operationalized as percentage of time safety behavior was used in relation to the overall duration of exposure (*0 = never to 100 = during the whole exposure time*). Relevant exposure data of this phase were self-reported fear at the beginning and immediately prior to stopping exposure, final distance to spider stimulus, total duration of exposure, and clinician-rated extent of safety behaviors. To explore the usability of smartglass-guided assistance, distance or duration of exposure was not a criterion for ending the exercise. Instead, therapists were instructed to allow for enough time for anxiety to decrease by a minimum of 20 (on a scale from 0 to 100) but could continue if judged as sensible. In this regard, the behavioral approach test was not conducted as a habituation-based exposure. In the evaluation phase, participants completed the usability, user experience, and acceptance measures as well as additional open feasibility questions (e.g., "Were you able to start the device and establish a connection to the therapist?", "Were you distracted by the device during the task?"). Afterwards, there was time to discuss the exposure task, further treatment wishes and options, as well as any remaining questions.

Therapists completed the three phases for each participant they treated in the study. They were seated in front of a computer in a therapy room close to the experimental room. During preparation, therapists received step-by-step written instruction on how to setup the

computer and establish a connection to the fearful individual. During exposure, they observed the exercise via real-time video of the perspective of the fearful individual and could hear any comment made via headphones. They provided written instructions, which were presented in the fearful individual's field of vision as text message. Text messages were used to prohibit small-talk or unrelated discussion with the therapist or similar safety behavior during exposure. Therapist completed the usability and acceptance measures once after their last exposure of the study.

Statistical Analysis

For usability (SUS) and user experience (UEQ), mean scores were separately calculated for fearful individuals and therapists and compared to corresponding normative data. For the UEQ, comparison to normative data was done using the data analysis tools provided by the authors (see <https://www.ueq-online.org/>). For user acceptance (TUI), raw data are reported only. No comparison to normative data was done, because normative data only exist for acceptance of virtual reality from a small sample (Kothgassner et al., 2012). Moreover, subjective fear reduction was analyzed by comparing self-reported fear at the beginning and immediately prior to stopping exposure (end) with paired samples t test and the corresponding Bayesian test using JASP 0.9.2 (JASP Team, 2018). In addition to average fear reduction, individual responses were descriptively analyzed. Moreover, associations between usability and characteristics of exposure were analyzed to explore whether usability may influence exposure. As no data exist so far, these analyzes were exploratory. To this end, a Spearman's correlation matrix was calculated between exposure data (self-reported fear, duration, distance to spider stimulus), clinical data (FSQ-S, BSI), and usability data (general usability, user experience, user acceptance). The resulting correlation matrix is illustrated as a heatmap using corrplot package in R (R Core Team, 2019; Wei & Simko, 2017). In addition, correlation analyzes were also conducted in a Bayesian framework. Specifically, we computed Bayesian Factor (BF) as recommended for hypothesis testing (Doorn et al., 2019). BF_{01} indicate how much more likely the data come from the null hypothesis than from the alternative hypothesis, thus providing relative evidence for the null hypothesis (i.e., no correlation). As no prior knowledge exists, we used JASP default priors. Finally, unstructured assessment of specific problems and improvements was summarized to inform future research.

Results

Table 2. Usability (SUS), user experience (UEQ), and user acceptance (TUI)

	<i>Fearful individuals</i> (<i>n</i> = 39)		<i>Therapists</i> (<i>n</i> = 16)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<i>Usability</i> (SUS, 0 to 100)	61.92	(18.75)	88.28	(8.00)
<i>User Experience</i> (UEQ; -3 to 3)				
Attractiveness	1.01	(1.16)	1.55	(0.67)
Stimulation	1.69	(1.11)	1.78	(0.71)
Novelty	1.80	(0.93)	1.44	(0.93)
Ease-of-use	0.85	(1.32)	2.13	(0.56)
Dependability	1.05	(1.09)	1.69	(0.70)
Efficiency	1.10	(0.91)	1.67	(0.82)
<i>User acceptance</i> (TUI; 1 to 7)				
User-friendly	4.91	(1.19)	5.81	(0.83)
Useful	3.08	(1.37)	5.06	(1.22)
Curious	3.91	(1.54)	4.45	(1.34)
Skeptical	3.39	(1.21)	2.72	(0.93)
Interested (general)	4.74	(2.11)	4.42	(1.20)
Tech anxious (general)	2.49	(1.39)	2.69	(1.09)
Intention (0-100)	41.97	(26.39)	75.08	(19.67)

Note. Means (and standard deviations). ^a Benchmark classification was done according to normative data and procedures published for the SUS and UEQ. For the SUS, average scores are classified into seven categories (*worst imaginable, awful, poor, OK, good, excellent, best imaginable*; see (Bangor et al., 2009). For the UEQ, average scores are classified into five categories (bad, below average, above average, good, excellent; see (Schrepp et al., 2017).

General feasibility and adverse events

In the preparation phase, 37 out of 39 fearful participants (94.9%) successfully activated the Smartglass device and established a connection to the therapist by using the written instructions without help of a research assistant. All therapists successfully established a connection and agreed that their instructions were followed during exposure. During evaluation, 38 fearful individuals (97.4%) indicated that they could read and follow the therapist's instruction during exposure. Moreover, 26 individuals (66.7%) indicated that they felt distracted during exposure. Main indicated reasons related to distraction "when reading instructions" and "when focusing on display". Finally, 32 fearful individuals (82.1%) indicated that they felt some degree of safety during exposure due to the Smartglass, although all indicated that therapist's actual presence would have provided more safety. As mentioned above, one of 40 participants (2.5%) refused to conduct exposure. This participant needed assistance in starting the Smartglass device and subsequently refused to conduct the behavioral approach task, but did not indicate whether the Smartglass affected the decision to refuse. One participant reported additional mild anxiety "to break the device". Another participant felt mildly irritated by the "foreign object". In sum, adverse events were minimal.

Usability ratings

Table 2 shows general usability, user experience, and user acceptance data (see also Noack, Eckelt, et al., 2019).

General usability (SUS).

General usability was rated medium to high by fearful participants and high by therapists. In comparison to normative data, ratings can be classified in an adjective ranking (*worst imaginable, awful, poor, OK, good, excellent, best imaginable*; see Bangor et al., 2009). Participants' ratings were between *OK* and *good* and can conservatively be labeled *OK*. Therapists' ratings were between *excellent* and *best imaginable* and can conservatively be labeled *excellent*. Therapist general usability ratings were higher compared to fearful individuals, $t(53) = 5.40$, $p < .001$, $d = 1.60$, $BF_{10} > 1000$.

User experience (UEQ).

All ratings from both groups were on average positive and thus above neutral (i.e., > 0). Compared to normative data of various technological systems, ratings can be classified in five categories (*bad, below average, above average, good, excellent*; see Schrepp et al., 2017). Ratings of fearful individuals were classified with the benchmark *below average* for the subscales Attractiveness, Ease-of-use, and Dependability. Furthermore, ratings were classified as *above average* for the subscale Efficiency and *excellent* for the subscales Stimulation and Novelty. Therapists again indicated higher ratings on most subscales. Therapists' ratings were classified as *good* for the subscales Attractiveness and Efficiency and *excellent* for all other subscales (i.e., Ease-of-use, Dependability, Stimulation, Novelty). Therapist ratings were significantly higher compared to fearful individuals for Efficiency, Ease-of-use, and Dependability, $ts(53) > 2.19$, $ps < .033$, $ds > 0.65$, $BF_{s10} > 1.98$, but not for the other subscales, $ts(53) < 1.73$, $ps > .09$, $ds < 0.51$, $BF_{s01} > 1.02$. In sum, ratings for all scales were on average positive. Lowest ratings were found for attractiveness and two out of three pragmatic qualities in fearful individuals. Hedonic qualities and all ratings by the therapists, however, were good to excellent.

User acceptance (TUI).

For the specific-technology subscale, high ratings were found for User-friendliness for both fearful individuals and therapists. Moreover, therapist indicated high ratings for the subscale Usefulness. Therapist ratings were significantly higher compared to fearful individuals for User-friendliness, Usefulness, and Intention, $ts(53) > 2.74$, $ps < .009$, $ds > 0.81$, $BF_{s10} > 5.55$, but not for the other subscales, $ts(53) < 1.99$, $ps > .05$, $ds < 0.59$, $BF_{s01} > 1.43$.

Exposure measures and their association with usability

On average, fearful individuals final distance to the spider stimulus was 75.26 cm ($SD = 101$, Range: 3 to 590) and exposure lasted 15.95 min ($SD = 7.32$, Range: 7 to 39). Average clinician-rated extent of safety behavior was 19.62%, i.e., on average safety behaviors occurred during approximately 20% of the time spend in exposure. However, the relative amount of time varied largely between individuals ($SD = 27.98$, Range: 0 to 100). For example, some individuals used no safety behavior at all, while other directed attention away from the spider, used paced breathing, made repeated reassuring statements (e.g., "The door is right here, I can leave quickly."), reported reassuring or distracting thoughts when asked by the therapist (e.g., mental

imagery of the spider being trapped in a terrarium), or personalized the spider to perceive it as less unpleasant (e.g., giving the spider a name). Therapists were mostly able to identify and discuss the use of safety behavior, although some safety behaviors may have remained unnoticed. Self-reported fear at the beginning and end of exposure is depicted in Figure 1. Fear was significantly lower at the end ($M = 38.85$, $SD = 21.07$) compared to the beginning of the exercise ($M = 75.44$, $SD = 21.04$), $t(38) = 11.92$, $p < .001$, $d = 1.91$, $BF_{10} > 1000$. Average fear reduction (beginning – end) was 36.59 ($SD = 19.17$, Range: 0 to 90). Descriptively, every participant except one showed lower fear at the end compared to beginning of exposure (see Figure 1). In sum, Smartglass-guided exposure resulted in significant within-session reduction of fear with a large effect size.

Moreover, exploratory associations between exposure characteristics, clinical, and usability data are shown in Figure 2. Spearman's rho correlations are illustrated as heatmap with blue indicating significant positive correlation, red indicating significant negative correlation, and white cells indicating nonsignificant correlation (i.e., $p > .05$). Color intensity illustrates effect size. This approach allows exploratory investigation of correlation within and between the different categories of data, i.e., exposure, clinical, and usability data. Overall, the heatmap illustrates frequent significant correlations within the same category. For example, self-reported fear at the beginning and end of exposure positively correlated with final distance to the spider stimulus and exposure duration. Moreover, most usability scores were inter-correlated with in the expected direction. Importantly, exposure data also showed frequent correlations with clinical measures of spider fear (except the clinician-rated extent of safety behavior). Specifically, higher questionnaire-assessed fear of spiders was associated with higher fear at the beginning and end of exposure, a longer duration of exposure, and a higher final distance to the spider stimulus.

Most importantly, there were three significant associations between exposure and usability data, while most other correlations did not show a significant association (see lower left area in Figure 2). For non-significant associations, Bayesian analyses indicated that the majority of the corresponding BFs were between 3-5, providing direct support that the probability of the data coming from the null hypothesis (i.e., no correlation) is three to five times more likely than data coming from the alternative hypothesis (for more details see Table S1 in supplemental material). Regarding the significant associations, higher fear at the end of exposure was positively associated with being more skeptical about the use of the Smartglass device after the behavioral approach test ($r = .49$). In addition, lower user-friendliness ratings were associated with longer duration ($r = -.32$) and lower usefulness ratings with greater final distance to the spider stimulus ($r = -.36$). In sum, task characteristics were consistently associated with severity of fear, but there were also some associations with usability evaluation.

Figure 1. Subjective fear ratings at the start of the guided exposure session and immediately prior to stopping exposure (end). Bold black line represents averaged fear levels (with standard error of the mean). Light lines represent individual participants.

Figure 2. Correlation matrix (Spearman's rho) for exposure, clinical, and usability data as well as experience with computer devices (Exp. com. devices). Correlations are illustrated as a heatmap with blue indicating significant positive correlation, red indicating significant negative correlation and white cells indicating nonsignificant correlation (i.e., $p > .05$). Effect size is illustrated by intensity of blue/red color, see legend on right side. "Fear reduc." = fear reduction calculated as fear at the beginning minus end of exposure.

Case example: Sarah

Sarah was a 27-year-old student. She reported moderately severe fear of spiders (FSQ total score = 33) and mild symptoms of depression. She indicated that she never received any form of psychological treatment and did not take any psychoactive medication. Her study therapist was a 31-year-old female in advanced postgraduate training for behavioral therapy. The therapist had five years of experience in face to face exposure, but Sarah was her first case in the study. The therapist had no prior experience with Smartglasses. Sarah was able to setup the Smartglass and establish a connection to the therapist without problems.

After brief introduction and repetition of the exposure rationale, the behavioral approach test began. Sarah reported a high level of anxiety (75/100). During the first minutes, Sarah repeatedly visually avoided the spider, which was evident to the therapist as her point of view changed to the wall. The therapist provided immediate feedback and labelled this behavior as a safety behavior (“I notice that you are facing the wall. As we discussed, this is probably a safety behavior meant to distract yourself from what you fear.”). Next, the therapist asked Sarah to focus the spider and redirect attention to it. After several steps towards the spider, the therapist noticed a paced and deep breathing pattern via audio feedback. The therapist inferred about the function of breathing and Sarah indicated that it was meant to reduce her anxiety. The therapist again labelled it as a safety behavior and asked Sarah to stop it. During the rest of the task, Sarah managed to stepwise approach the spider to a final distance of 26 cm. After remaining at this distance for a few minutes, her subjective anxiety strongly decreased to a low level (15/100, anxiety reduction = 60). In total, the behavioral approach test took 25 min.

In the unstructured interview, Sarah indicated no issues during the task. She rated the overall usability as *excellent* (85/100). Most subscales of the UEQ were *good* or *excellent*, only ease-of-use was rated as *below average*. She judged the exercise as great success, felt motivated by the digital presence of the therapist, and thought that she would not have approached the spider as far without the therapist. She also emphasized that she did not purposefully engaged in safety behaviors and that the therapist’s feedback and instruction were necessary to drop these behaviors.

Case example: Julia

Julia was a 47-year-old full-time employee. She reported highly severe fear of spiders (FSQ total score = 64) but no indicators of comorbid symptoms. She never received any form of psychological treatment and did not take any psychoactive medication. Her study therapist was 45 years old and licensed for behavioral therapy. He had 14 years of experience in face to face psychotherapy and exposure. Julia was his seventh case in the study. At the beginning Julia had some problems to adapt to the Smartglass because of her additional own glasses and high anticipatory anxiety. Nevertheless, she was able to start the device by herself.

The task started after answering Julia’s questions regarding the rationale. Julia responded with a very high level of fear (90/100). Immediately she began to alternately talk to herself or the spider to calm down (“You won’t hurt me, will you?”, “I’m going to be fine, the door is right here.”). The therapist labeled this behavior as safety behavior and he asked Julia to try stopping it. He also instructed Julia to not engage in comparable internal “mental talk”. He repeated these instructions several times until Julia was able to refrain from this safety behavior for the last third of exposure. Despite persistent high level of fear, Julia was able to approach the spider step by step. At the end of the 31 minutes lasting session, she reached a final distance of 65 cm and felt a noticeable decrease of fear (65/100).

In the unstructured interview, Julia indicated that she was too nervous to fully concentrate on setting up the device and thus desired direct help from the research assistant. She also indicated that she was repeatedly distracted from the exercise because she had to readjust the glasses. She rated the overall usability as *ok* (65/100). While most scores on the UEQ subscales were *good* or *excellent*, dependability was rated as *bad*. It thus seems likely that her focus was not fully on the clinical but also on the technical aspects during the exercise, which may have limited the success of the exercise. Julia reported that the reduction of her safety behavior worked and that she did not engage in internal self-talk. Moreover, she reported her wish for a higher rate of conversation with the therapist. The therapist interpreted this as reassurance seeking. Communicating via Smartglass made it easier for him to resist this wish in comparison to a face-to-face exposure.

Discussion

Smartglass-guided exposure enables the therapist to guide exposure from the therapist's office via real-time feedback and may thereby increase the practicability of guided exposure and ultimately its dissemination. The present study explored the usability of Smartglass-guided exposure in a naturalistic behavioral approach task. Overall, usability, user experience, and acceptance were evaluated positively. Therapists showed more positive evaluations compared to fearful individuals in some usability measures. Smartglass-guided approach resulted in significant fear reduction at the end of exposure with a large effect size ($d = 1.91$). Questionnaire-assessed severity of fear was consistently associated with individual characteristics of the behavioral approach test such as individual fear levels, duration of exposure, or final distance to the feared stimulus. While most subscales of usability were not associated with characteristics of the task, exploratory findings revealed associations with being skeptical about the Smartglass device and its perceived usability and user-friendliness. Combined, these findings provide preliminary evidence that Smartglass-guided exposure is feasible, but that usability may influence exposure. Overall, Smartglass-guided exposure is thus a promising tool to increase the practicability of exposure and disseminate exposure to rural areas, but attention to perceived usability is warranted.

Fearful individuals and therapists evaluated the usability of the Smartglass as positive. Average raw usability ratings were mostly in the positive range of the specific subscales, indicating overall positive evaluation of usability. Therapists' ratings were mostly higher compared to fearful individuals. Moreover, all therapists and almost all fearful individuals were able to start the required devices and established a connection using written instruction and subsequently complete the task. When compared to normative data from ratings of various technological systems, overall usability was evaluated as *OK* by fearful individuals and *excellent* by therapists. Taken together, these findings support the general usability of Smartglass-guided exposure.

Usability ratings of fearful individuals were lower compared to therapists. This difference was presumably linked to the different tasks assigned to fearful individuals and therapists. Only fearful individuals had to set up the Smartglass device. In addition, negative affect during exposure may have carried over to usability ratings. Lower usability experience in fearful individuals raises the questions whether average usability is enough, especially regarding the willingness of fearful individuals or patients to use Smartglass-guided interventions for clinical exposure. Low usability experience may shift the patient's focus from clinical to technological

aspects of the interventions, which, in the worst case, may reduce success of exposure or result in treatment drop-out. It is therefore important to note two aspects of the usability ratings. First, normative evaluation is mostly based on comparison to commercial products (smartphones, web shops, business applications), which underwent substantial product development. Average benchmarks of these normative data are typically positive. Likewise, raw overall usability in fearful individuals was positive, yet not better than the average commercial product in the normative database. Second, it has to be emphasized that the usability ratings in the present study are specific for the device and procedure. As there is ongoing technological development to increase usability of Smartglass devices, usability may thus be increased. For example, lowest usability ratings were found in fearful individuals for ease-of-use and dependability of the specific system. These technological aspects can be expected to be further developed in future devices. In addition, we limited the introduction of the system to written instruction for the sake of standardization. This procedure represents a conservative estimate of usability. Face-to-face introduction, for example, by the therapist in a prior session or online, may increase ease-of-use and usability. Summarized, Smartglass devices seem to be a feasible and promising approach for guiding exposure exercises from afar. However, increasing the usability of novel devices may especially improve the experience of fearful individuals.

Clinical feasibility of Smartglass-guided exposure was explored in an open behavioral approach test. Every fearful individual encountered the same task; however, the outcome was not predefined. Fearful individuals showed high levels of fear at the beginning. Fear decreased during Smartglass-guided exposure as indicated by significantly lower fear levels at the end of exposure. Indeed, all but one participant showed a decrease in fear. Similar to videoconference-guided exposure (Goetter et al., 2014; Netter et al., 2018), Smartglass-guided exposure is thus effective for fear reduction, at least in the short-term. Other clinical characteristics besides fear levels, i.e., final distance to the spider, exposure duration, and clinician-rated use of safety behaviors, considerably varied between fearful individuals. Correlational analyses yielded positive associations between the clinical severity of spider fear (assessed via questionnaire) and these exposure characteristics. It has to be noted that this proof-of-concept study used a behavioral approach task and did not include a comprehensive evidenced-based exposure protocol (e.g., Abramowitz et al., 2019; Neudeck & Wittchen, 2012). The findings thus offer first evidence for the usefulness of Smartglasses for exposure, but replication in exposure therapy for clinical anxiety are needed.

Most usability data were not associated with exposure measures. Analyses, however, yielded preliminary evidence for three significant associations. First, higher fear at the end of exposure was positively associated with being more skeptical about the use of the Smartglass device. This may be interpreted as individuals may being more skeptical before exposure showing less fear reduction. Alternatively, individuals may report being more skeptical after exposure because they benefited less from Smartglass-guided exposure. As correlation analyses do not allow causal interpretation, these interpretations need future investigation (e.g., by assessing skepticalness before exposure). Second, lower user-friendliness ratings were associated with longer exposure duration and lower usefulness ratings with greater final distance to the spider stimulus. These results suggest that Smartglass-guided exposure may benefit from increasing the usability of Smartglass devices. However, the present study was the first to explore the association between perceived usability of Smartglass devices and exposure characteristics. As no prior evidence existed, correlational analyses were exploratory. Thus, the rare significant associations require replication. Importantly, most usability subscales were not

associated with any exposure measure. Bayesian analyses provided direct evidence that the probability of the null hypothesis (i.e., no correlation exists) was three to five times more likely. These results demonstrate that the focus of the Smartglass-guided exposure lied more strongly on clinical aspects.

Clinical implications, improvements, and future directions

The present findings offer important clinical implications. Exposure is rarely utilized in routine care and issues of practicability are the most agreed upon barriers by therapists' working in routine care (Pittig et al., 2019). Smartglass-guided exposure can substantially decrease these barriers. Therapists can remain in their office, making time-consuming travel to suitable locations unnecessary (e.g., far away from the patients home, etc.). This approach reduces time management issues and costs and could ultimately increase dissemination of exposure. In support, therapists reported a high intention to use Smartglasses for exposure. Moreover, Smartglass-guided exposure can be used to guide exposure with large distances between therapist and patient. This offers the opportunity to deliver guided exposure in rural areas with low density of available therapists.

In comparison to unaccompanied exposure, the therapist can still provide feedback, motivate the patient, or give specific instruction by guiding exposure via Smartglass. In this regard, Smartglass-guided exposure may be more beneficial than unaccompanied exposure, especially because adverse events were minimal. Another benefit refers to the therapist's function as a safety signal during exposure. Safety signals are stimuli or characteristics of the exposure situations that can block novel learning during exposure (Helbig-Lang & Petermann, 2010; Lovibond et al., 2009; Pittig, 2019). For example, a patient with panic disorder may associate the non-occurrence of a feared outcome in a mall (e.g., fainting) with the presence of the therapist. This would prevent novel learning that being in the mall itself is not associated with the feared outcome. Most fearful individuals (82.1%) indicated that the connection via Smartglass provided some degree of safety, but that the actual presence of the therapist would have provided more safety. The degree of safety of Smartglass-guided exposure may thus be a good balance between the therapist's presence being a safety signal and the complete absence of the therapist. These implications, however, remain to be tested. Future studies need to directly compare Smartglass-guided to unaccompanied exposure and exposure in the actual presence of the therapist. In addition, the present study only provided evidence for short-term fear reduction within a single exposure exercise. Future research should expand these promising findings to repeated exposure and long-term outcome in clinical samples using evidence-based exposure protocols.

Finally, some concerns, limitations, and improvements need to be mentioned. One specific improvement may relate to the way of instructing participants. A substantial amount of fearful individuals (66.7%) felt distracted by the written instruction displayed in their field of vision. Written instructions thus seem to decrease the attention directed towards the fear-relevant stimulus, which has been shown to impair exposure (Craske et al., 2018). While we aimed to limit safety behavior (e.g., small talk, reassurance seeking) by using written instruction, bidirectional audio communication may thus be better to guide exposure from afar. Although most fearful individuals and therapists were able to start the device, two individuals required help. In real-life settings, a face-to-face introduction of the Smartglass may thus increase ease-of-use for some individuals. Moreover, there are some concerns that need to be addressed. Smartglasses only provide a first-person view from the perspective of the individuals wearing

the device. Some therapists indicated that this restricted view may have prohibited observing the individual's behavior and emotional reactions. This may, for example, pose a risk to miss possible safety behaviors (e.g., holding onto a safety device such as a smartphone or, in this study, the door handle). This risk can be minimized by good preparation of exposure. Patients need to understand the rationale of exposure and the effects of safety behaviors to monitor possible safety behavior together with the therapist. In addition, therapists should repeatedly ask about safety behaviors. In the present study, therapists were able to identify cognitive safety behavior via audio feedback (e.g., reassuring thoughts or imagery), which also cannot even be observed in accompanied exercises. For example, therapists identified safety behaviors such as paced breathing, repeated reassuring statements (e.g., "The door is right here, I can leave quickly."), reassuring or distracting thoughts (e.g., mental imagery of the spider being trapped in a terrarium), or personalization of the spider to perceive it as less unpleasant (e.g., giving the spider a name). Novel devices offer online eye-tracking feedback, which would *further* help to monitor that the individual's attention is directed towards the fear-relevant stimulus. Of course, this requires full transparency and informed consent. Although audio feedback and novel technologies are thus promising to monitor safety behavior, accompanied and Smartglass-guided exposure can also be combined. Therapists could also start with accompanied exposure and switch to Smartglass-guided exposure to increase transfer into the patient's daily life. In this regard, the therapist can adapt the specific form of exposure (accompanied, guided from afar, unguided) to the individual and the course of treatment. Smartglass-guided exposure may function as an interim between accompanied and unguided exposure and thereby increase the flexibility and individualization of exposure therapy. Future research is required to examine this combination of different exposure forms. Finally, we did not conduct a structured assessment of specific phobia diagnosis. Although unlikely, results may differ and should thus be replicated in a diagnosed sample.

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