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SpeakApp-Kids! Virtual reality training to reduce fear of public speaking in children – A proof of concept

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ABSTRACT

Virtual reality exposure therapy (VRET) is a promising tool to reduce public speaking anxiety in adults, while treatment and prevention of public speaking anxiety in children has been largely neglected. We examined whether repeated brief exposures to a virtual audience embedded in a prototype of the Virtual Reality (VR) SpeakApp-Kids! helped to reduce (1) self-reported state anxiety during three public speaking practice sessions, (2) state anxiety during the actual presentation that followed, and (3) general public speaking anxiety from the first practice session until after the actual presentation in children aged 9–12 years ($n = 40$). First, we found a decrease in state anxiety during the first two practice sessions. Also in line with our expectations, pupils in the SpeakApp-Kids! condition reported lower state anxiety during the actual presentation than the control (at home) condition ($n = 49$). Finally, we found a larger decrease in general public speaking anxiety from the first practice session until one week after the actual presentation for the SpeakApp-Kids! condition, as compared to the control children preparing their presentations as usual. Taking limitations into account, this VR SpeakApp-Kids! is a promising tool to be developed further as it has potential to serve as an educational tool for speech practice and thereby reducing public speaking anxiety. More importantly, it has potential to prevent public speaking anxiety from developing in the first place.

1. Introduction

A large proportion of elementary school children experiences some degree of nervousness when it comes to public speaking (Van Niekerk et al., 2017). In middle childhood, self-esteem is focused around the evaluation by peers, with public speaking directly tapping into the fear of negative social evaluation by others, also called social anxiety (Kim et al., 2018). With an early onset in childhood (Van Niekerk et al., 2017), public speaking anxiety symptoms can gradually increase and eventually manifest in work, educational, or academic settings and can thus impair someone's professional life in a significant way, at which point it would be diagnosed with the more general term social anxiety disorder (APA, 2013). Considering the large impact on multiple life areas and the lasting effects of anxiety disorders (Mohammadi et al., 2020; Zaboski, 2020), research about ways to prevent public speaking anxiety from developing in children is in common interest of children themselves as well as educational practice. Addressing public speaking anxiety in childhood is essential, because speaking skills and confidence can take a lifetime to fully develop, stressing the importance to gradually develop them throughout primary and secondary education (Kellam, 2018). Yet, research on its prevention is scarce.

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1.1. Development and classical treatment of public speaking anxiety

Public speaking anxiety is considered a specific form of social anxiety disorder and is regarded as the fear of "unsatisfactory evaluations from audiences" (Schlenker & Leary, 1982, p. 646). Public speaking anxiety can be experienced in a particular setting (Bodie, 2010), for example when having to give a presentation in front of an audience. Such public speaking situations have the potential to elicit an immediate state of anxiety (state anxiety), which is characterized by nervousness, a rapid heartbeat, and sweaty hands (Westenberg et al., 2009). State anxiety can occur during several phases of speaking publicly, namely before, during, and after a speech (Finn, Sawyer, & Schrodt, 2009; Westenberg et al., 2009). In 12- to 15-year-olds, state anxiety tends to be higher *during* a speech compared to before or after it (Westenberg et al., 2009). Repeated negative experiences in one or more of these speech phases can turn situationally bound state anxiety into general public speaking anxiety, when fears generalize or individuals describe themselves as being always anxious in public speaking situations (Bodie, 2010; Lipton et al., 2020).

The classical treatment for a variety of anxiety disorders in children and adults, including social anxiety, is exposure therapy, as part of cognitive behavioral therapy (Abramowitz, Deacon, & Whiteside, 2019; Sigurvinsdottir et al., 2020; Vinograd & Craske, 2020; Zaboski, 2020). During exposure therapy, individuals are repeatedly confronted with situations that evoke the negative emotion (e.g., an audience), thereby changing maladaptive cognitions and attenuating physiological fear responding (Abramowitz et al., 2019; Craske et al., 2014). In fact, increased numbers of repeated exposures to the same stimulus are suggested to lead to greater attenuation of anxiety (Craske et al., 2014). This can be attributed to the increase in psychological comfort as a result of increasing levels of familiarity, and changing maladaptive cognitions as a result of the experience that nothing threatening happens (Abramowitz et al., 2019). While old fear associations subsist, new, more benign evaluations of the situation are learned about the formerly feared stimulus (e.g., Craske et al., 2008). Regarding public speaking anxiety, this means that even though fear associations about unsatisfactory evaluations from the audience remain, the body 'learns' that no negative evaluation occurs or that occasional negative evaluation is not as bad as one has feared. This results in less physiological fear responding in an acute public speaking situation as well as reduced anticipatory anxiety when thinking of a (nearby) speech in general.

1.2. Virtual reality in the treatment of public speaking

A major pitfall of classical cognitive behavioral therapy for the treatment of public speaking anxiety is the necessity to organize an audience for the purpose of exposure on a regular basis. Fortunately, virtual reality exposure therapy (VRET) offers a solution by providing permanently available virtual audiences (e.g., Carl et al., 2019; Emmelkamp, Meyerbröker, & Morina, 2020; Hinojo-Lucena et al., 2020; Lindner et al., 2019; Morina, IJntema, Meyerbröker, & Emmelkamp, 2015; Stupar-Rutenfrans, Ketelaars, & Van Gisbergen, 2017; Yadav et al., 2020). In their study, Stupar-Rutenfrans et al. (2017) found a reduction of public speaking anxiety in university students, after they were repeatedly exposed to live videos of real audiences that were embedded in a 360° smartphone application, creating realistic anxiety experiences. Furthermore, Yadav et al. (2020) found that both self-reported and physiological public speaking anxiety symptoms were alleviated after systematic public speaking presentation sessions in front of both a real and virtual audience. Importantly, virtual audiences effectively elicit a fear response (e.g., Kahlon et al., 2019; Lindner et al., 2019; Owens & Beidel, 2014) comparable to that in real life. In adults, it has consistently been shown that practicing a speech when being exposed to a virtual audience helps to reduce public speaking anxiety (e.g., Frisby et al., 2020; Kothgassner & Felnhofer, 2020; Lindner et al., 2021). Moreover, one recent study by Kahlon, Lindner, and Nordgreen (2019) suggested that VRET can also be used to treat fear of public speaking in adolescents. In fact, numerous studies have shown that VRET can effectively establish positive changes of emotions and subjective experiences in real-life situations. VRET treatments of anxiety disorders in general, and public speaking anxiety in particular, are equally effective as conventional exposure therapy (Carl et al., 2019; Morina et al., 2015), at least when adolescents and adults are concerned.

1.3. Virtual reality in early prevention of public speaking anxiety in children

Unlike in adults, VR treatment and especially prevention of public speaking anxiety in children has been neglected in research and practice (Hunt, Wright, & Simonds, 2014; Hinojo-Lucena et al., 2020; Kothgassner & Felnhofer, 2020). To the best of our knowledge, only one study by Kahlon et al. (2019) has explored, in a non-randomized feasibility and pilot trial, the effect of a one-session (90 min) VRET intervention for adolescents (13-16-year-olds) with public speaking anxiety. In a setup prototypical for these kind of studies, participants had to complete several exposure exercises in front of custom-build age- and setting appropriate VR audiences with 10 minimally moving virtual agents. They concluded that the intervention contributed to the decrease in public speaking anxiety symptoms from pre- to post treatment.

Especially the prevention of public speaking anxiety from developing is important, and has potential to reduce the necessity to treat public speaking anxiety in adults in the future. Virtual reality technologies are increasingly implemented in educational practice to develop children's 21st century skills, including communication and expression (Araiza-Alba et al., 2021a, 2021b) and therefore, it is surprising that VRET research in children is rare. The advantage of virtual learning environments is that they can be used for the individual learner at a time and place that is convenient for the user. In addition, learning content that is not readily available for demonstration in real life becomes permanently available and explorable, allowing more interactive learning experiences, processes and understanding. As such, the learner only needs a smartphone, the presentation software App and a cheap (cardboard) smartphone holder or an advanced virtual reality headset (Van Ginkel et al., 2019).

While most VRET research on public speaking anxiety uses constructed audiences of virtual agents (e.g., Kahlon et al., 2019), a

disadvantage is that feelings of presence (degree to which virtual environments are not experienced as virtual [Lombard et al., 2000]) could be negatively influenced by non-realistic appearance and/or movements of such audiences (Von der Pütten et al., 2010), including the lack of facial expression (Kang, 2016). Thereby, virtual agents might not raise sufficient anxiety to induce the equal level of anxiety when exposed to an actual audience (Kahlon et al., 2019). In addition, constructed audiences lead children to the impression that they are rather part of a computer game, a setting they are much more familiar with, than in a 'real life' situation. This could hamper the sufficient arousal of fear necessary for a successful exposure session (Baker et al., 2010). Here, using recorded real audiences rather than constructed ones could be another big advantage.

As a first attempt to address public speaking anxiety in childhood, Van Langen, Kuurstra, Ketelaar, and Lange (2018) developed filmed audiences that could be suitable for VRET in children. Their main goal was to create realistic virtual audiences that could be distinguished based on more or less threat-evoking behavior. An inattentive audience is suggested to evoke more public speaking anxiety as opposed to an attentive audience (Pertaub, Slater, & Barker, 2002) and could therefore serve as a valuable addition in an exposure/threat hierarchy. Therefore, Van Langen et al. (2018) made recordings of an audience of a class of 23 9-to-11-year-olds by means of a 360° camera. A dramatic-arts teacher instructed the audience to behave either attentively or inattentively. The virtual audiences were embedded in a software application, a prototype of the so-called SpeakApp-Kids! and could be used with a smartphone in a head-mounted device. This made it possible to view the audience and the classroom in 3D, as if the presenter was actually standing in the classroom. After implementing the videos in the App, a class of 25 children (17 boys, $M_{age} = 9.36$ years) put on the virtual reality headset with the SpeakApp-Kids! and rated the virtual audiences with regard to the audience's attitude towards the presenter, and how anxious they would feel if presenting in front of that class. Findings showed that the two virtual audiences (i.e., attentive versus inattentive) could be clearly distinguished based on their behavior. However, the rating children did not report feeling more anxious when imagining to present in front of the inattentive class than when imagining giving a speech in front of the attentive audience. Yet, based on imagined presentation, they did report that both virtual audiences are representative of audiences they are used to in class, in real life. It still needed to be shown whether children practicing a speech with this prototype of SpeakApp-Kids! experience less anxiety during the actual talk when compared to children preparing the usual way. In addition, it is unknown whether such preparation with the SpeakApp-Kids! leads to reduced fear of public speaking in general. In students, however, similar approaches with virtual reality rehearsals to practice a speech *have* been studied (e.g., Boetje & Van Ginkel, 2020; Frisby et al., 2020). Boetje and Van Ginkel (2020) found that graduate students, both anxious and non-anxious, gained benefits from practicing a speech in front of a passively watching/listening audience of virtual humans in a virtual classroom. Similarly, in the study by Frisby et al. (2020), students practiced their required final informative speech in a basic communication course, but in front of a previously recorded 360° video of a passively watching/listening audience of college students in a classroom. The authors suggested that the virtual reality experience supports students, whether highly anxious or not, to comfortably practice their speeches out loud in front of a realistic audience in an educational setting. It was also suggested that the level of comfort perhaps alleviated the anxiousness and apprehension associated with public speaking. To the best of our knowledge, however, no comparable applications focused on children in educational settings, have been published recently.

1.4. The rationale of this study

We will examine whether brief repeated exposures to a virtual audience in three SpeakApp-Kids! training sessions (a) reduce children's state anxiety during practice of the oral presentation from one practice session to the next, (b) contribute to lower state anxiety during the actual oral presentation in the classroom that followed (i.e., in front of their teacher and peers), and (c) reduce children's general public speaking anxiety from the first practice session until after the actual presentation. The hypotheses are as follows:

1. There is a reduction of state anxiety of children in the virtual reality exposure condition from the first to the second training session, and from the second to the third training session.
2. During the actual presentation, state anxiety of children in the virtual reality exposure condition is lower than that of children in a control (at home) condition who practice their presentations as they usually do.
3. General public speaking anxiety of children in the virtual reality exposure condition reduces from baseline measurement until after the actual presentation, while that of children in a control (at home) condition does not change.

2. Methodology

2.1. Participants

One hundred six children and their parents were contacted and informed about the study via letter and email and were asked to provide consent. Eventually, 89 children (45 boys, 44 girls) had consent(ed) to participate in the study. At the beginning of the study, all children attended the fourth, fifth, or sixth grade of a primary school located in the Netherlands. On average, children were 10.46 years old ($SD = 0.88$ years, range = 9–12 years).

Based on class composition, children were allocated to either the SpeakApp-Kids! condition or the control condition. Randomization of condition was established between, rather than within, class, to minimize disruption regarding the school curriculum and daily routines. As part of the regular school curriculum, teachers instructed children to prepare an individual oral presentation of 15–20 min in length about a self-selected book (SpeakApp-Kids! condition) or a news item (control condition; see Appendix A) These speech topics along with the timing of the teacher instruction were curriculum determined. Teachers considered the two assignments as similar in terms of expectations regarding public speaking skills. All children were instructed to prepare their presentation at home as they would usually do, which they then would deliver on a particular date in time (ranging from 5 to 10 weeks after instruction). This study was approved by the Ethics Committee of the Faculty of Social Sciences of Radboud University (ECSW-2019-141).

2.2. SpeakApp-Kids!

The virtual audiences that were used in the public speaking practice sessions were identical to those developed and validated by Van Langen et al. (2018). For the recordings of the audiences, 23 pupils (47% girls, aged 9–11 years) first watched a television show (evoking an attentive attitude), and, second, a digital analogue clock (evoking an inattentive attitude). The audience was instructed to behave accordingly. When the audience watched the videos, it was recorded with a 360º video camera (GoPro OmniTM; www.gopro.com). Both recordings included ordinary background sounds in a classroom (e.g., coughing, shifting of seats). Completion of the audience recordings was followed by embedment in a virtual reality environment and installation in an Android application (Autopano Pro Version 4.4.0, http://www.kolor.com). The SpeakApp-Kids! with the virtual audiences was used on a Samsung Galaxy S7 Edge and utilized on a head-mounted device (Samsung Virtual Reality Gear).

For the purpose of the current study, a PowerPoint slide was implemented on the digital board that hung in the (filmed) classroom of the SpeakApp-Kids! behind the speaker (Van Langen et al., 2018). This PowerPoint slide showed eight key words that were related to the topic of the presentation and assigned by the teacher (i.e., title, author, illustrator, other books written by the author, background information about the author, genre, main characters, and summary of the book). During all practice sessions, pupils saw the same PowerPoint slide.

2.3. Measures

2.3.1. State anxiety

Visual analogue scales (VASs; Davey, Barratt, Butow, & Deeks, 2007; Westenberg et al., 2009) were used to assess different aspects of state anxiety (see Appendix B). Children were asked to indicate how nervous they felt, how fast their heart was beating, and how sweaty their hands were on a 10 cm horizontal line ranging from "not at all" to "very much". The point that the child marked was measured in millimeters from the left anchor, with greater distances indicating higher levels of state anxiety. Before state anxiety was assessed for the first time, the researcher presented three exemplar items to familiarize children with the response procedure of the VASs. In addition, and similar to the assessment of state anxiety, subjective retrospect accounts of nervousness, heartbeat, and palmary sweat were assessed during a standard situation that is considered independent of public speaking, namely watching television. As a manipulation check, this measurement served as a proxy to verify whether state anxiety during the first practice session was higher than state anxiety in a standard situation.

2.3.2. General public speaking anxiety

A revised version of the Personal Report of Public Speaking Apprehension questionnaire (PRPSA; Paul, 1966; see Appendix D) was used to assess general public speaking anxiety. Based on pilot-testing the PRPSA with two children, two items were removed as these were judged as too difficult to understand for the age category at hand ("I feel that I am in complete possession of myself while giving a speech" and "During an important speech I experience a feeling of helplessness building up inside me"), and one item was added as they judged this as characteristic for public speaking (i.e., "My legs are shaking when I am giving a speech"). This resulted in a 33-item questionnaire, which was translated from English to Dutch. Minor changes were made to make the items more in accordance with the vocabulary as used within the classroom (e.g., 'presentation' instead of 'speech'). Children were asked to indicate the degree to which the statements apply to them on a five-point Likert scale, ranging from 0 (*strongly disagree*) to 4 (*strongly agree*). After recoding the reversed items, general public speaking anxiety was calculated as the sum score of all items, with higher scores indicating higher levels of general public speaking anxiety. This questionnaire demonstrated excellent reliability at baseline (Cronbach's alpha = .95) and posttest (Cronbach's alpha = .94).

2.3.3. Social anxiety

As an explorative factor testing the general concept of social anxiety, which is supposed to underlie public speaking anxiety, social anxiety was assessed with the Social Anxiety Scale for Children - Revised (SASC-R; La Greca & Stone, 1993; see Appendix E). This questionnaire consisted of 22 items (e.g., "I worry about doing something new in front of other kids"). Four items were positive fillers to reduce negative response bias. The SASC-R was translated from English to Dutch. Children were asked to indicate the degree to

which they felt each statement was true for them on a five-point Likert scale, ranging from 0 (*not at all*) to 4 (*all the time*). After removal of the filler items, social anxiety was calculated as the sum score of all items, with higher scores indicating higher levels of social anxiety. This questionnaire demonstrated excellent reliability (Cronbach's alpha = .88).

2.3.4. Speech preparation

As a means to explore whether children in the virtual reality condition and the control (at home) condition differed in their preparation and practice behavior at home, all children were asked seven questions on a five-point Likert scale, ranging from 0 (*strongly disagree*) to 4 (*strongly agree*), directly after their actual presentation: (1) When did you start practicing your presentation? (0–3 days, 4–7 days, 1–2 weeks, 2–3 weeks, 3–4 weeks, more than 1 month, I did not practice at all); (2) How many times have you practiced your presentation? (open question); (3) How many hours have you prepared and practiced your presentation in total? (open question); (4) Have you practiced your presentation with someone else? (yes or no, if yes, please write down all people who you have practiced with); (5) How did you practice your presentation? (open question, with examples, such as reading the text aloud, practicing in front of father, mother, brother, sister, grandfather, grandmother or individually in front of the mirror, practicing with the SpeakApp-Kids!); (6) By practicing my presentation as I did, I gained self-confidence to deliver my presentation; (7) While practicing my presentation, I felt like standing in front of an actual classroom with children. Furthermore, children in the virtual reality condition were asked two additional questions: (1) While practicing with the SpeakApp-Kids! I felt like standing in front of an actual classroom with children; (2) By practicing my presentation with the SpeakApp-Kids! I gained self-confidence to deliver my presentation.

2.4. Procedure

About four weeks before the actual presentation was to be held in class, all participating pupils were asked to fill in the VASs of a standard situation, PRPSA, and SASC-R on paper. Due to the lesson structure of the different classes, children in the control condition

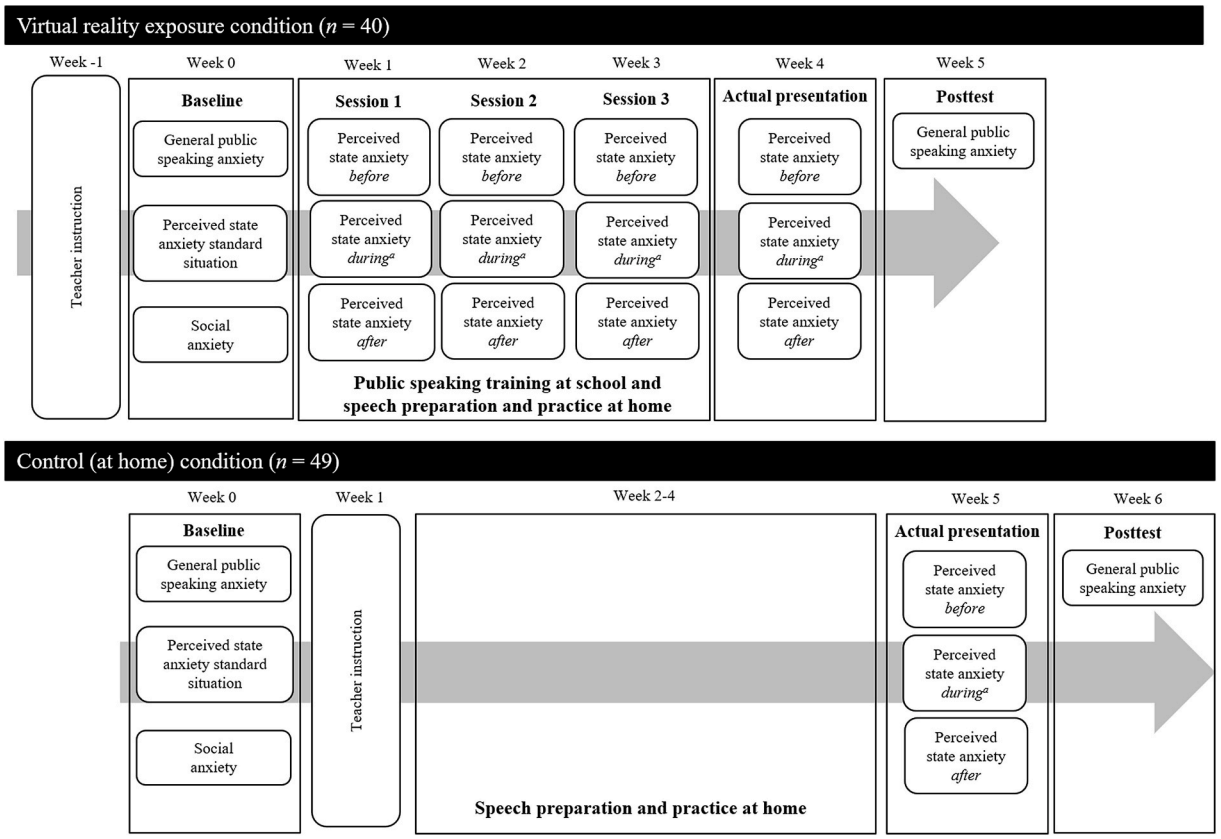

Fig. 1. Procedure of data collection for the virtual reality exposure condition and control (at home) condition. [a]Perceived state anxiety during (practice of) the presentation is asked directly after the presentation. Measurements regarding before and after (practice of) the presentation are included for completeness, but are not further analyzed in the current study.

filled in these questionnaires before receiving instructions for the presentation from their teacher, while children in the SpeakApp-Kids! condition filled in the questionnaires afterwards. In the days following that, the researcher picked up the children in the SpeakApp-Kids! condition one by one and led them to an empty classroom for the training. Here, children were asked to fill in the state anxiety measure regarding the first speech phase of the speech practice (i.e., before). Next, in an instruction phase (2 min), children were told that they would practice the first 4 min of their presentation twice in front of a virtual audience. They were also instructed to present as much as they knew about the book, using the key words on the digital board behind them as a mnemonic. Additionally, an actual video-camera was placed on eye-level of the children, approximately 2 m in front of them. To mimic an actual presentation situation, children were told that their presentation would be video recorded and evaluated on clarity at a later point in time, by a teacher and age peers unknown to them. However, the camera was not turned on, as this was part of the cover story (Bush, Bittner, & Brooks, 1972; Westenberg et al., 2009). Finally, children were told that they could take off the virtual reality gear at any given time, for example, if they felt dizzy or nauseous.

After the instruction phase, the researcher prepared the VR gear, allowing children to explore the empty virtual classroom (only in the first practice session, in order to get used to the VR gear; see Appendix F) as well as the PowerPoint slide (2 min). It was verified that children were able to read the key words on the PowerPoint slide. Next, children practiced their presentation twice to the virtual audience, once to the attentive audience and once to the inattentive audience (Van Langen et al., 2018), for the sake of variety (in a randomized order; 8 min). Children were not informed about the type of audience. Within the virtual environment, children were positioned in front of the classroom, with their back towards the digital board and the audience looking at them. Children were able to turn around 360° from the starting position, but not to walk around in class. The researcher sat next to the children during the whole session, available for questions, to give instructions, and to put on and to take off the VR gear. No feedback was provided during the training. The researcher kept an eye on the time and gave a standard prompt when children kept silence for 20 s: "Time is not up yet, please have a look at the PowerPoint slide and see whether you can still tell something." On average, children received two prompts in each of the sessions. After 4 min elapsed, or when three prompts were given, the training phase was terminated. Upon completion of the training phase, the researcher acted as if turning off the camera.

After the training phase, children were asked to fill in the state anxiety measure regarding the second (i.e., retrospect during; hereafter 'during') and third speech phase (i.e., after) of the speech practice (2 min), directly after they finished their speech practice. Finally, children were brought back to the classroom to continue their lessons. The second practice session took place one week later and followed the same regiment. The third and last session took place one week after that. In total, children in the SpeakApp-Kids! condition completed three (times two) brief exposures to the virtual audience. The number of sessions is based on Dubner and Mills's (1984) multiple-exposure assignment, showing that three exposures to the same real audience reduced state anxiety in university students. The children in the control condition had been instructed to practice as usual at home. They did not receive any other instructions.

At the day of the actual presentation, teachers were instructed to present the same PowerPoint slide that was used during the training, and to instruct children to fill in the state anxiety measure regarding the first speech phase of the presentation. Next, children delivered their presentation. Upon completion of the presentation, teachers instructed children to directly complete the state anxiety measure regarding the second and third speech phase of the presentation. The procedure for teachers of children in the control condition was similar to those of children in the SpeakApp-Kids! condition, except that teachers did not present a PowerPoint slide. Instead, children in the control condition presented their own PowerPoint slide containing key words of their own choice as a mnemonic. One week after all presentations were completed, all participating pupils were asked to fill out the PRPSA again. After completion of data collection, children were orally debriefed in the classroom by the researcher, and both children and parents were debriefed by letter. Finally, classes were compensated with a gift voucher. See Fig. 1 for a visualization of the study procedure.

2.5. Data analysis

The data were analyzed with a linear mixed-effects model approach in R (R Core Team, 2017), thereby correcting for multiple measurements and handling missing and dependent, clustered data. To examine the first hypothesis, three repeated measures ANCOVAs were conducted for all three dependent variables (i.e., nervousness, heart rate, palmary sweat), with session number and speech phase as within-subjects variables. To verify that measures of state anxiety were not a consequence of differences in general

Table 1
Participant characteristics.

Measure	SpeakApp-Kids! condition		Control condition	
	M (SD)	n	M (SD)	n
Age (years)	10.72 (0.89)	40	10.38 (0.84)	49
General public speaking anxiety at baseline	62.83 (24.38)	40	46.04 (19.64)	49
General public speaking anxiety posttest	46.75 (24.14)	40	42.14 (19.08)	49
Social anxiety	23.12 (11.72)	40	19.24 (10.34)	49
State anxiety in standard situation				
Nervousness	8.75 (16.10)	40	11.65 (11.92)	49
Heart rate	14.93 (15.70)	40	14.37 (14.95)	49
Palmary sweat	8.95 (16.96)	40	8.61 (14.70)	49

public speaking anxiety at baseline (see Table 1), this measure was included as a covariate. Per dependent variable, all speech phases were included. However, only data from the second speech phase were further analyzed, following Westenberg et al.'s (2009) suggestion that state anxiety tends to be higher *during* a speech compared to before or after. Statistically significant effects were followed up with pairwise post-hoc comparisons with a Tukey correction for multiple testing to test the expectation that, during the speech practice, scores decrease from one session to the next.

To examine the second hypothesis, three ANCOVAs were conducted for each dependent variable (i.e., nervousness, heart rate, palmary sweat), with condition and speech phase as within-subjects variables, and general public speaking anxiety at baseline as covariate. Again, all speech phases were included, but only data from the second speech phase were further analyzed. Statistically significant repeated measures ANCOVAs were followed up with pairwise post-hoc comparisons with a Tukey correction for multiple testing to test the expectation that, during speech practice, scores from the SpeakApp-Kids! condition were lower than those of the control condition.

To examine the third hypothesis, an ANOVA was conducted, using difference scores of general public speaking anxiety between baseline and posttest, and with condition as between-subjects variable. Difference scores were calculated as general public speaking anxiety at posttest minus general public speaking anxiety at baseline, with positive scores indicating an increase of general public speaking anxiety and negative scores indicating a decrease of general public speaking anxiety. A significant effect was followed up with a pairwise post-hoc comparison. As for all analyses, to determine *p*-values, Type III conditional *F* tests with Kenward-Roger correction for degrees of freedom were used. *P*-values smaller than .05 were considered statistically significant.

3. Results

3.1. Sample

Forty children participated in the SpeakApp-Kids! condition (23 boys, 17 girls) and forty-nine children participated in the control condition (22 boys, 27 girls; see Table 1). Variation in sample size in some of the analyses was due to missing data. Missing data mainly resulted from absence of children at days of data collection, and teachers who forgot to instruct children to complete the set of measures regarding the presentation in class. The conditions did not differ in gender-distribution, X^2 (1) = 0.94, $p = .33$, $d = 0.09$, age, t (78.41) = 1.75, $p = .08$, $d = 0.39$, social anxiety, t (78.53) = 1.64, $p = .11$, $d = 0.35$, and state anxiety in a standard situation (i.e., watching television; nervousness: t (70.27) = −0.95, $p = .35$, $d = -0.21$; heart rate: t (81.73) = 0.17, $p = .87$, $d = 0.04$; palmary sweat: t (77.75) = 0.10, $p = .92$, $d = 0.02$). However, the conditions differed on general public speaking anxiety at baseline, t (74.31) = 3.52, $p < .001$, $d = 0.77$. Two children indicated that they felt dizzy after 3 min during the VR exposure, after which the researcher took off the VR gear. Their data was not used in the final analyses.

3.2. State anxiety during the practice sessions (hypothesis 1)

Results of the manipulation check showed that children's state anxiety *during* the first practice session was significantly higher than their state anxiety in a standard situation (see Table 1; Table 2; nervousness: t (67.69) = 8.49, $p < .001$, $d = 1.90$; heart rate: t (62.45) = 3.80, $p < .001$, $d = 0.86$; palmary sweat: t (65.03) = 3.05, $p < .01$, $d = 0.68$). The main effect of session on state anxiety indicated that, irrespective of speech phase, nervousness, F (2, 304.31) = 28.01, $p < .001$, heart rate, F (2, 302.15) = 9.47, $p < .001$, and palmary

Table 2
Descriptive statistics for state anxiety at all speech phases from the practice sessions and actual presentation.

Measure	SpeakApp-Kids! training *M (SD)*			Actual presentation *M (SD)*	
	Session 1	Session 2	Session 3	SpeakApp-Kids! condition	Control condition
	(n = 40)	(n = 40)	(n = 37)	(n = 36)	(n = 29)
Nervousness					
Before	28.90 (21.05)	19.55 (19.16)	17.92 (20.10)	38.14 (23.38)	16.45 (19.79)
During[a]	47.90 (24.32)	27.48 (23.97)	26.19 (22.58)	37.26 (30.60)	45.03 (22.33)
After	19.93 (23.38)	14.50 (19.23)	12.30 (18.76)	13.78 (22.29)	18.93 (23.54)
Heart rate					
Before	12.75 (13.04)	11.22 (15.22)	13.92 (19.12)	23.61 (25.12)	12.17 (14.80)
During[a]	33.23 (25.80)	27.48 (23.97)	18.59 (20.90)	26.08 (27.21)	37.69 (23.02)
After	19.20 (21.25)	15.70 (20.61)	12.43 (16.23)	12.36 (22.52)	13.48 (19.47)
Palmary Sweat					
Before	12.28 (17.43)	10.68 (18.58)	10.14 (16.59)	14.72 (22.49)	8.97 (16.37)
During[a]	24.48 (27.41)	18.77 (24.69)	18.51 (24.13)	11.17 (18.23)	20.86 (21.13)
After	15.85 (24.66)	13.44 (19.38)	11.44 (17.12)	8.22 (18.13)	12.41 (17.65)

Note. [a]Perceived state anxiety during (practice of) the presentation is asked directly after the presentation. Measurements regarding before and after (practice of) the presentation are included for completeness, but are not further analyzed in the current study.

Table 3
Pairwise comparisons of state anxiety during the presentation from session to session.

	Exposure sessions[a]	Estimate	SE	df	*t*	*p*	*d*
Nervousness	1–2	20.43	3.49	303.01	5.86	<.001	0.99
	2–3	2.20	3.57	303.68	0.62	.81	0.11
Heart rate	1–2	11.65	3.12	301.23	3.74	<.001	0.60
	2–3	3.91	3.16	301.70	1.23	.43	0.20
Palmary sweat	1–2	5.70	2.91	301.00	1.96	.12	0.27
	2–3	1.28	2.98	301.34	0.43	.90	0.06

[a] Comparisons of practice sessions reflecting state anxiety during exposure in session 1 minus session 2, and state anxiety during exposure in session 2 minus session 3.

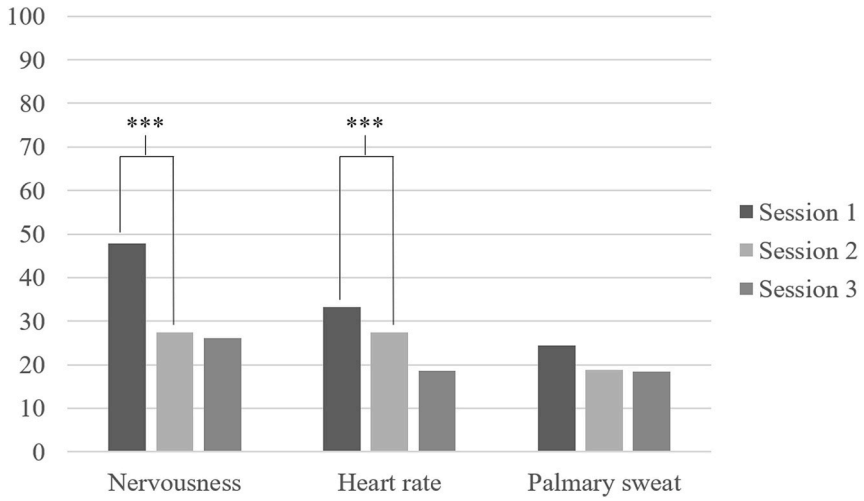

Fig. 2. State anxiety at the second speech phase of the SpeakApp-Kids! training per practice session (mean scores on a scale from 0 to 100). *Note.* ***$p < .001$.

sweat, F (2, 301.69) = 4.87, $p < .01$, differed significantly between the sessions. It appears that the main effect was mainly driven by a significant interaction effect of session and speech phase on nervousness, F (4, 303.01) = 3.12, $p < .05$, and heart rate, F (4, 303.06) = 3.50, $p < .01$, but not on palmary sweat, F (4, 301.03) = 0.36, $p = .84$. When looking at the second speech phase (during speech) only, pairwise comparisons showed a decreasing peak in nervousness and heart rate from the first to the second session (see Table 3, Fig. 2). The peak in palmary sweat did not decrease between sessions.

3.3. State anxiety during the actual presentation (hypothesis 2)

Irrespective of speech phases, the SpeakApp-Kids! condition and control condition did not differ on state anxiety during the actual presentation (nervousness, heart rate, and palmary sweat: all Fs < 1; all ps > .10). However, pairwise comparisons following the significant interaction effect of condition and speech phase (nervousness: F (2, 125.24) = 12.04, $p < .001$; heart rate, F (2, 126) = 7.66, $p < .001$; palmary sweat: F (2, 126) = 6.43, $p < .01$) showed that, at the second speech phase, state anxiety was higher for the control condition than for the SpeakApp-Kids! condition (see Table 2, Table 4, Fig. 3).

Table 4
Pairwise comparisons of state anxiety during the actual presentation for the SpeakApp-Kids! condition and control (at home) condition.

	Estimate	SE	df	*t*	*p*	*d*
Nervousness	12.72	6.10	141.64	2.09	<.05	0.48
Heart rate	15.84	5.84	125.98	2.62	<.05	0.60
Palmary sweat	11.35	5.05	104.35	2.25	<.05	0.52

Note. Comparisons of groups reflecting state anxiety during exposure for the control condition minus state anxiety during exposure for the SpeakApp-Kids! condition.

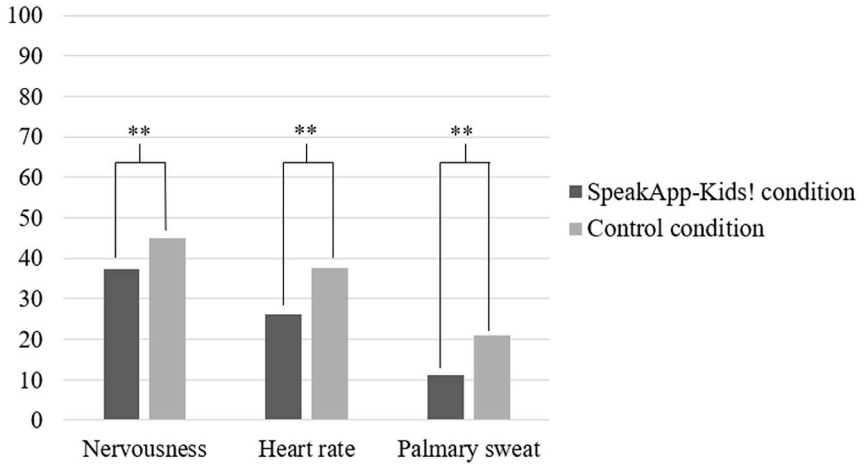

Fig. 3. State anxiety during the actual presentation (mean scores on a scale from 0 to 100). *Note.* $^{**}p < .05$.

3.4. General public speaking anxiety (hypothesis 3)

Regarding the development of general public speaking anxiety from before the first practice session (baseline) until one week after the actual presentation, a decrease for both conditions was observed (see Table 1). There was a main effect of condition, $F\,(1, 87) = 5.42$, $p < .05$, showing a greater decrease of general public speaking anxiety for the SpeakApp-Kids! condition ($M = -16.07$, $SD = 30.91$) than for the control condition ($M = -3.90$, $SD = 17.80$), Estimate $= -12.18$, SE $= 5.23$, $t\,(87) = -2.33$, $p < .05$.

3.5. General public speaking anxiety in association with social anxiety

Since public speaking anxiety is a specific form of social anxiety, as both are based on fear of negative evaluation, we aimed at exploring that association, by correlating scores on general public speaking anxiety at baseline and social anxiety at baseline. A Pearson correlation revealed a significant positive association between general public speaking anxiety and social anxiety, $r\,(87) = 0.45$, $t = 4.66$, $p < .001$, indicating that children who reported higher levels of general public speaking anxiety also reported higher levels of social anxiety (see Table 1).

3.6. Speech preparation

Although it was attempted to objectivize children's speech preparation behavior, such as the number of hours and the ways that they had practiced at home, this deemed unreliable data. For example, some children in the virtual reality condition stated to not have practiced (for) their presentation at all, while others indicated to have practiced a rather unlikely high number of hours per week or in total. This led to the decision to omit these data, thwarting the opportunity to control for group differences.

4. Conclusions and discussion

Within the context of primary education, this study aimed (1) to explore the impact of repeated speech practice in front of a virtual audience on self-reported public speaking anxiety symptoms during practicing, and (2) to verify the extent to which this impact translates to a presentation in the actual classroom. As hypothesized, we found a reduction in children's state anxiety during speech practice from the first to the second practice session, while the third session did not have any additional benefit. Also, as expected, children who received the SpeakApp-Kids! training reported lower state anxiety during the actual presentation in the classroom than children in the control condition. Finally, we found a reduction in general public speaking anxiety from the first practice session until a week after the actual presentation for both conditions, however, this reduction was larger for children in the SpeakApp-Kids! condition than for children in the control condition.

The reduction of children's state anxiety during the training from the first to the second training session seems corroborated in the third session and can be explained by the fact that, on average, state anxiety was already relatively low at the start of our study (on average, 25 on VASs ranging from 0 to 100). Similarly, Harris, Kemmerling, and North (2002) found that non-clinical undergraduates'

state anxiety was relatively low at the start of their study (on average, 30 on a subjective units of discomfort scale ranging from 0 to 100). As a result, they found no difference in state anxiety at the end of the second and fourth (last) exposure to a virtual audience. However, other studies generally only report pretest and posttest assessments of experienced state anxiety (e.g., Kang, 2016; Morina, IJntema, Meyerbröker, & Emmelkamp, 2015), lacking information on state anxiety changes between training sessions. Thus, our study replicates findings from adult studies (e.g., Boetje & Van Ginkel, 2020; Frisby et al., 2020; Kothgassner & Felnhofer, 2020; Lindner et al., 2021) in a sample of children, while, in addition, showing that three brief repeated speech trainings in front of a virtual audience reduce state anxiety. In fact, two practice sessions containing two speech practice trials each, are seemingly enough to reduce state anxiety in children.

State anxiety in the SpeakApp-Kids! condition during the actual presentation in the classroom was lower as compared to that of the control condition, but generally higher than during the SpeakApp-Kids! training. A possible explanation is that the real audience during the actual presentation still was more anxiety-evoking than the virtual audience in the SpeakApp-Kids! even though we verified that the virtual audience evoked substantial anxiety, as compared to a standard situation (i.e., watching television). This, in turn, could be explained by a teacher who was present in the real audience, but not in the virtual audience. In fact, speakers tend to exhibit more state anxiety when exposed to audiences of greater expertise (Hillmert, Christenfeld, & Kulik, 2002), such as a teacher. Similarly, a previous study found that undergraduates reported higher levels of subjective state anxiety in front of a real audience, even after repeated exposure to a virtual audience (Kang, 2016). Thus, our study replicates findings from adult studies (e.g., Finn et al., 2009; Harris et al., 2002; Kang, 2016; Kothgassner & Felnhofer, 2020; Lindner et al., 2021) in a sample of children, while, in addition, providing information about the benefit of two brief repeated speech trainings in front of a virtual audience on the reduction of children's state anxiety during an actual presentation in the classroom.

We also demonstrated a stronger decrease in general public speaking anxiety from baseline until one week after the actual presentation for children who received the SpeakApp-Kids! training as compared to children who did not receive this training. However, we also found that children in the SpeakApp-Kids! condition reported elevated levels of general public speaking anxiety at baseline as compared to the control condition. These elevated levels could be explained by uncontrollable differences in teaching styles between teachers, such as, for example, being generally stricter in terms of expectations regarding public speaking. Another explanation is that children in the SpeakApp-Kids! condition anticipated that a presentation was coming up, since they received instruction from the teacher *before* general public speaking anxiety was assessed, whereas children in the control condition received this instruction at a later point in time, and filling in the questionnaires without any concrete event in mind. In fact, foreknowledge about the nature of a task, such as a presentation, increases anticipation of the task even though the measure is supposed to measure a trait rather than a state (Lipton et al., 2020). This could have made children more aware of their (lacking) public speaking skills and (fearful) experiences regarding public speaking. Yet, our results indicate a significantly stronger decrease of anxiety from baseline to post measurement, irrespective of the baseline-measures. This is in line with St-Jacques, Bouchard, and Bélanger (2010), who studied the effect of four virtual-reality based (in virtuo) exposure sessions on children's arachnophobia, as compared to actual (in vivo) exposure sessions. Their findings indicated that, at the end of therapy, children from the in virtuo and in vivo group were comparably efficient in facing a live tarantula, even though children in the in virtuo group were more severely phobic from the outset. Thus, our results, in line with others (e.g., St-Jacques et al., 2010) underline the effectiveness of VR-training in reducing anxiety, irrespective of the degree of initial anxiety.

In summary, the usage of VR-training in children is promising when attempting to reduce early public speaking anxiety symptoms. This study shows that two brief repeated speech trainings in front of a virtual audience are seemingly enough to reduce children's state anxiety and general public speaking anxiety in four weeks, even within a non-clinical sample. These repeated confrontations with a realistic virtual audience, representing a class of children, are suggested to elicit the negative emotion regarding feared unsatisfactory evaluations from an audience, thereby changing maladaptive cognitions (such as decreased subjective nervousness and the experience that no negative evaluation occurs or that occasional negative evaluation is not as bad as one feared), and attenuating physiological fear responding (such as decreased subjective heart rate; Abramowitz et al., 2019; Craske et al., 2014).

4.1. Limitations and future research

A number of limitations should be mentioned when interpreting our findings. First, we were not able to randomly allocate children to the SpeakApp-Kids! condition or the control condition due to school organization. Instead, we could only allocate entire classes of children to one of the two conditions. That, however, implied that classes in the SpeakApp-Kids! condition and control condition had different tasks for their actual presentations, namely either a book presentation (SpeakApp-Kids! condition) or a presentation about a news item (control condition). Teachers considered the two tasks as similar in terms of expectations regarding public speaking skills but it is possible that talking about one's favorite book may be easier and less anxiety evoking than talking about a (self-selected) news item. Therefore, our findings may be confounded by not randomizing across classes with different teachers and presentation instructions. A randomized controlled trial (RCT) would have been ideal, but is less common in school contexts, due to the teaching curriculum and concessions to daily routines. In fact, research in educational contexts oftentimes relies on between group comparisons and is dependent on compromising experimental control in order to make the research feasible (Chalkidou et al., 2012; D'Agostino &

Kwan, 1995). In addition, according to the dean of the school, parents would not have allowed the participation of their children if their child had been allocated to the control group and supposedly miss the opportunity of receiving a higher grade because of the anxiety-reducing effects of the training, while other children do get the opportunity. In addition, children allowed to participate but not being picked up for the training would know that they are in the control condition or eagerly wait to be picked up, and would be disappointed if they are not. General differences between classes are rather normal and direct grade competition is uncommon. Yet, to obtain more representative data, for future research it is advised to randomize children to a training or control condition to, for example, reduce the effect of differences between teachers on children's public speaking anxiety symptoms.

A second limitation is that it remains unclear what the actual cause was of the decrease of state anxiety during the SpeakApp-Kids! training and the actual presentation. We assume that the repeated speech trainings in front of the virtual audience led to these decreases. However, other mediating and moderating factors could also have influenced these decreases, such as receiving attention from the researcher during the SpeakApp-Kids! training or merely the additional time of speech practice, as both the SpeakApp-Kids! condition and control condition were allowed to practice their presentation at home, as they would normally do. In fact, simply practicing a presentation is suggested to already contribute to the reduction of anticipatory state anxiety (Finn et al., 2009; Menzel & Carrell, 1994). Our attempt to control for these factors by assessing pupils' individual practice behavior failed. It seemed that indicating weekly practice time or means of speech preparation may have been too abstract for that age group. Even though it remains unclear how children behaved at home regarding their speech practice, the added value of the SpeakApp-Kids! is based on how children usually prepare themselves for a presentation, keeping the realistic school situation as much as possible untouched. In terms of clinical randomized controlled studies, the control (at home) condition is comparable to a 'waitlist control' or 'treatment as usual' condition. Another factor that could have explained the decrease of state anxiety is multiple exposure to the same passive audiences that could have lowered the sense of realism when the presenter becomes aware of the repetition during the second and third session. Yet, the time interval between every practice session was one week, and no child mentioned the passiveness of the audiences nor the fact that they were identical, leading us to assume that this interval is sufficient to prevent recognition from the recordings. For future research, a dismantling study is advised, in which, e.g., children in a control condition also practice their presentation repeatedly, in a controlled setting. This could be, for instance, in front of a virtual empty classroom, thereby mimicking the classroom setting but not the suggested anxiety-evoking stimulus (i.e., the audience), and controlling speech practice time. In addition, it may be that a more responsive audience would be a valuable addition contributing to minimized repetition, more realism, increased state anxiety levels and means of positive feedback. In lab-based research, responses of virtual audiences can be altered 'online' by software that recognizes the speaker's behavior, allowing a virtual audience of computer-generated people respond in any desirable/preprogrammed way (e.g., Palmas et al., 2019). With 360° videos and stand-alone systems this is much more difficult: all potential/desired audience responses would need to be pre-recorded with a trained audience and the software would need to recognize presenters' behavior and trigger alternative audience-behavior recordings accordingly. We carefully weighed the trade-off between realistic but passive audiences and computer generated potentially more responsive audiences in favor of the first. Future research and (affordable) advancing technology may give us the opportunity to use the best of both worlds.

Another limitation is that state anxiety was measured by means of self-report through questionnaires rather than, e.g., physiological measures, and by assessing anxiety directly *after* (practice of) the presentation rather than during. Our choices regarding the set-up resulted from several considerations. Although physiological measures allow continuous assessment of stress- and anxiety indices, 'wiring' children right before their speech to measure their physiological responses could have artificially increased their tension and fears during the actual presentation with an unjustifiable potential to decrease performance and even grades in both groups. Despite that, it has been shown that physiological measures *do* reliably measure increases in physiological responding to (feared) VR scenarios irrespective of individual differences, but are by far *less reliable* in tracing decreases after exposure therapy (Diemer et al., 2014; Kahlon et al., 2019; Lindner et al., 2019). This seems to indicate that subjective experiences of anxiety may be more relevant in determining the effect of a therapeutic intervention or training than objective indices such as heartrate. The decision to assess self-reported anxiety right after instead of during the presentation (practice), again, resulted from weighing two aspects: disrupting the flow of the presentation and reducing 'presence' in the virtual reality scene by interrupting their speech and asking about children's anxiety at that very moment, versus asking directly afterwards and assuming that children are accurate in remembering and reporting their level of state anxiety they experienced during the speech. The retrospection concerned a time-lapse of no more than 10 min, which, in our eyes, is justifiable. Nevertheless, for future research it is recommended to find the most reliable index of state anxiety and disentangle the correlations between subjective (retrospective) and physiological measures, during and after the task in question.

Finally, the training situation and/or the SpeakApp-Kids! seems to create an anticipation effect: children in the SpeakApp-Kids! condition reported higher levels of state anxiety before the actual presentation, probably because the practice sessions continuously reminded them that their actual presentation was coming up. Despite this anticipation effect, the results suggest that the training prevents a peaking of state anxiety during the actual presentation, an attenuation which the control condition did not experience. For future research, we suggest to examine this anticipation effect in a larger sample in more detail, to get insight into its underlying mechanisms.

Keeping the aforementioned limitations in mind, this study can be seen a proof-of-concept for the prototype of the SpeakApp-Kids!. It shows that two brief practice sessions with virtual audiences reduce children's state anxiety and general public speaking anxiety.

Therefore, virtual reality is a promising technology to reduce symptoms of public speaking anxiety. The potential effect for long-term prevention has yet to be researched. Our results encourage further development of the SpeakApp-Kids! providing children with the opportunity to repeatedly rehearse their presentation in the virtual equivalent of an actual public speaking situation in the classroom that could, in the future, be further developed to contain audiences of different age groups, cultural backgrounds, and so forth. Also, responsive audiences could be added as new feature in future versions, although this may be particularly useful in a true treatment context. As such, it could be investigated whether responsive 'designed' audiences provoke more anxiety or have better therapeutic effects than non-responsive 'real audiences'. The effects of rehearsal with the SpeakApp-Kids! on public speaking anxiety symptoms are not only important to consider this app as an educational tool to practice, but have great potential to prevent public speaking anxiety from developing into a full-blown anxiety later in life.

Credit author statement

Robin Sülter: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization, Project administration. **Paul Ketelaar**: Conceptualization, Methodology, Validation, Resources, Writing – review & editing, Supervision. **Wolf-Gero Lange**: Conceptualization, Methodology, Validation, Writing – review & editing, Supervision.

Declaration of competing interest

None.

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Appendix A. Instruction of the book presentation (SpeakApp-Kids! condition) and the news presentation (control condition)

Book presentation

The rules and guidelines of the book presentation and news presentation, as determined by the teachers, were comparable. As preparation of the book presentation, children were told to read a book of their choice, and to answer a variety of questions about the book (see below). The book presentation consisted of three parts. In the first part, children were instructed to provide information about the following: 'What is the title of the book?'; 'Who is the author?'; 'Who is the illustrator?'; 'What other books did the author write?'; 'Background information about the author'; 'What is the book genre?'; Who are the main characters?'; 'Book summary'. In the second part, children were instructed to read aloud a book section of their own choice. In the third part, children had to ask their classmates two multiple-choice questions and one open-ended question about their book presentation. Children were allowed to look at the same PowerPoint slide that was used in the SpeakApp-Kids! training, but not to use any additional "cheat sheets". In total, the book presentation should last 15 min.

News presentation

Regarding the news presentation, children were told to prepare themselves by searching for four or five news photos that each depicted a news situation in the Netherlands, Europe or the world, and reading the accompanying news article. Additionally, they had to write a summary of the news article and prepare at least two discussion questions for their classmates. They were allowed to prepare a PowerPoint slide with some key words. During the news presentation, children had to show each of the selected photos, after which their classmates had to guess what has happened. Next, children had to give a summary of the news article, and to start and lead a discussion with their classmates about the news article. In total, the news presentation should last 20 min.

Appendix B. Visual analogue scales for assessing state anxiety

1. **Hoe zenuwachtig ben je nu?**

Helemaal niet zenuwachtig

Heel erg zenuwachtig

2. **Hoe snel bonst je hart nu?**

Gewoon

Heel erg snel

3. **Hoe zweterig zijn je handen nu?**

Helemaal niet zweterig

Heel erg zweterig

Appendix C. Visual analogue scales for assessing state anxiety in a standard situation (i.e., watching television)

1. **Hoe zenuwachtig ben je als je televisie kijkt?**

Helemaal niet zenuwachtig	Heel erg zenuwachtig

2. **Hoe snel bonst je hart als je televisie kijkt?**

Gewoon	Heel erg snel

3. **Hoe zweterig zijn je handen als je televisie kijkt?**

Helemaal niet zweterig	Heel erg zweterig

Appendix D. Revised version of the Personal Report of Public Speaking Apprehension (PRPSA) for assessing general public speaking anxiety

1. Als ik een kring of presentatie voorbereid, voel ik me nerveus.
2. Ik voel me nerveus als ik weet dat ik een kring of presentatie op school moet houden.
3. Ik ben in de war als ik een kring of presentatie houd.
4. Vlak na een kring of presentatie vond ik het leuk om te doen.
5. Ik word bang als ik bedenk dat ik binnenkort een kring of presentatie moet houden.
6. Ik ben niet bang om een kring of presentatie te houden.
7. Ook al ben ik nerveus vlak voor een kring of presentatie, ik voel me snel weer op mijn gemak als ik ben begonnen met de kring of presentatie.
8. Ik verheug me op het houden van een kring of presentatie.
9. Als de juf of meester zegt dat we een kring of presentatie moeten houden, dan word ik nerveus.
10. Mijn handen trillen als ik een kring of presentatie houd.
11. Ik voel me op mijn gemak als ik een kring of presentatie houd.
12. Ik vind het leuk om een kring of presentatie voor te bereiden.
13. Ik ben de hele tijd bang om te vergeten wat ik had voorbereid om te zeggen.
14. Ik word angstig als iemand me iets vraagt over mijn onderwerp wat ik niet weet.
15. Ik heb vertrouwen in mezelf als ik een kring of presentatie moet houden.
16. Ik kan goed nadenken als ik een kring of presentatie houd.
17. Ik heb geen angst om een kring of presentatie te houden.
18. Ik zweet vlak voordat ik een kring of presentatie houd.
19. Mijn hart bonst heel snel aan het begin van een kring of presentatie.
20. Ik ben erg angstig als ik in de klas zit vlak voordat ik mijn kring of presentatie moet houden.
21. Sommige delen van mijn lijf voelen erg gespannen als ik een kring of presentatie houd.
22. Het maakt me erg nerveus en angstig als ik weet dat ik nog maar weinig tijd over heb tijdens een kring of presentatie.
23. Ik weet van mezelf dat ik goed kan omgaan met spanning en stress tijdens een kring of presentatie.
24. Ik adem sneller vlak voordat ik een kring of presentatie moet houden.
25. Ongeveer een uur totdat mijn kring of presentatie begint, voel ik me op mijn gemak.
26. Ik doe het slechter tijdens kringen of presentaties, omdat ik angstig ben.
27. Ik voel me angstig als ik de datum weet waarop ik een kring of presentatie moet houden.
28. Als ik een fout maak tijdens een kring of presentatie, dan vind ik het moeilijk om het de rest van de kring of presentatie goed te doen.
29. Ik kom ‘s avonds moeilijk in slaap als ik de volgende dag een kring of presentatie moet houden.
30. Mijn hart bonst heel snel tijdens een kring of presentatie.
31. Ik voel me angstig als ik wacht om mijn kring of presentatie te houden.
32. Tijdens een kring of presentatie word ik zo nerveus dat ik informatie vergeet die ik echt wel weet.
33. Mijn benen trillen als ik een kring of presentatie houd.

Appendix E. Social Anxiety Scale for Children - Revised (SASC-R) for assessing social anxiety

1. Ik maak me zorgen om iets te doen wat ik nog nooit heb gedaan waar andere kinderen bij zijn.
2. Ik vind lezen leuk [filler].
3. Ik maak me zorgen dat ik word geplaagd.
4. Ik ben verlegen bij kinderen die ik niet ken.
5. Ik denk dat andere kinderen achter mijn rug om over mij praten.
6. Ik praat alleen met kinderen die ik heel goed ken.
7. Ik vind sporten leuk [filler].
8. Ik maak me zorgen over wat andere kinderen over mij denken.
9. Ik ben bang dat andere kinderen mij niet aardig zullen vinden.
10. Ik word nerveus als ik met kinderen praat die ik niet heel goed ken.
11. Ik vind het leuk om met andere kinderen te spelen [filler].
12. Ik maak me zorgen over wat andere kinderen over mij zeggen.
13. Ik word nerveus als ik met kinderen praat die ik niet ken.
14. Ik maak me zorgen dat andere kinderen mij niet aardig vinden.
15. Ik ben stil in een groep met kinderen.
16. Ik vind het leuk om alleen te spelen [filler].
17. Ik denk dat andere kinderen me uitlachen.
18. Stel dat ik ruzie krijg met een ander kind, dan maak ik me zorgen dat hij of zij mij niet aardig zal vinden.
19. Ik ben bang om anderen bij mij thuis te vragen, omdat ze misschien ‘nee’ zeggen.
20. Ik voel me nerveus als ik bij bepaalde kinderen in de buurt ben.
21. Ik voel me verlegen, zelfs als ik bij kinderen ben die ik heel goed ken.
22. Ik vind het moeilijk om aan andere kinderen te vragen of ze met me willen spelen.

Appendix F. SpeakApp-Kids!

Virtual empty classroom as embedded in the prototype of the SpeakApp-Kids!

Virtual audience as embedded in the prototype of the SpeakApp-Kids!

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