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Research Paper

# The feasibility of an immersive interactive virtual reality task for children and adolescents.

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A R T I C L E I N F O

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A B S T R A C T

The interest in using immersive Virtual Reality (hereafter referred to as VR) for clinical interventions in (mental) health care settings has been growing for adults, as well as adolescents and children. However, VR systems and evidence-based VR-software have not specifically been built for minors. To develop a potentially effective clinical VR intervention for children and adolescents, it is crucial to assess the motivation for and the feasibility of the VR software and the respective VR system first. This study assessed these aspects with regard to a self-developed interactive VR task that serves as a base for a clinical VR intervention in children and adolescents, using a Meta Quest 2 system. Feasibility was measured by assessing tolerability, usability, satisfaction, presence, and perceived realism. The relations between motivation and the different feasibility aspects were explored, and the associations between age, frequency of digital media use, and sex on the one hand and motivation and the five aspects of feasibility on the other were tested. A pre- and post-test design was implemented, using self-report questionnaires. 85 children aged 8–17 years participated ($M_{age}$ = 10.55 years, $SD_{age}$ = 2.06 years), of which 31 (36%) were girls and 54 (64%) were boys. The VR task was found to be highly motivating and overall feasible for this age group, whereby the motivation and the feasibility did not vary based on age, frequency of digital media use, or sex. The results of this study indicate that this task could be a feasible base for a VR mental health intervention for children and adolescents aged 8–17 years using a Meta Quest 2 system, regardless of their sex or frequency of digital media use.

## 1. Introduction

Over the past decades, immersive Virtual Reality (hereafter referred to as VR) has increasingly been used to improve or develop clinical interventions for adults (Lin et al., 2023; Perra et al., 2023). VR provides the possibility to exert control over visual and acoustic stimuli presented to a user, creating indefinite possibilities of application in the clinical field. One of the reasons that favours VR as a treatment tool is that it has been found to elicit higher treatment motivation as compared to regular treatment (Park et al., 2020; Shen et al., 2020). VR can be highly motivating for adults as well as for younger users (Guedj et al., 2023; Harris & Reid, 2005). Since clinical interventions using VR have achieved promising results in the adult population (Heo & Park, 2022; Lin et al., 2023; Perra et al., 2023), interest in using this tool for minors as well has been growing over the past few years. As a result, VR is increasingly being used in clinical interventions for children and adolescents (Bioulac et al., 2020; Maskey et al., 2019).

### 1.1. The use of VR in children and adolescents

Even though VR evidently has potential for being used in clinical treatment of children and adolescents, neither VR systems nor evidence-based VR software have specifically been built for this population. This raises concerns regarding the feasibility of using VR in youth. Additionally, a recent review has highlighted several concerns related to children interacting with VR environments, specifically when overuse of VR occurs (gaming) and when VR use is unsupervised. The authors did however point out promising findings when VR was used for educational or clinical purposes (Kaimara et al., 2022). Therefore, it is of utmost importance to assess the software's and the VR system's feasibility for children and adolescents. The feasibility assessment will likely vary depending on the nature and the goals of the VR software, but feasibility

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is crucial to create any adequate and potentially effective clinical intervention.

### 1.2. Tolerability

One of the most important aspects of feasibility evolves around tolerability as users need to be able to endure the VR intervention. Tolerability describes the absence of negative physical symptoms induced by being in VR (Maloca et al., 2022; Tychsen & Foeller, 2020). VR can induce negative physical symptoms, also known as visually induced motion sickness or cybersickness, which can include nausea, dizziness, headaches, eye strain, blurred vision, difficulty focusing or concentrating, increased salivation, sweating, burping, stomach awareness and vertigo (Kennedy et al., 2010). The VR software is deemed intolerable if it is conducive to subjectively significant negative physical symptoms. Many clinical VR feasibility studies assess cybersickness or nausea and find the VR software used to be overall tolerable (e.g. Negut et al., 2017; Pollak et al., 2010). Tolerability can vary *per* VR application as there seem to be technical factors contributing to a tolerable experience, such as a fixed horizon in the virtual environment (Hemmerich et al., 2020), exposure time shorter than 10 min (Saredakis et al., 2020), and the fit of the distance between the two VR lenses and the distance between the user's pupils. To create a tolerable and potentially effective VR intervention, these factors must be taken into account, and it must be ensured that the VR glasses fit the target audience.

### 1.3. Usability

A second dimension of feasibility, usability, typically indicates the perceived ease of use and how well the VR software has been understood (Shen et al., 2020; Tennant et al., 2020). Some studies also take the comfort of the headset into account when assessing usability (Ammann-Reiffer et al., 2022; Birnie et al., 2018). This is particularly important when conducting feasibility studies with minors as the VR headsets and controllers were designed for adults. It was found that younger participants with smaller hands mostly hold one controller with both hands and therefore have a different interaction with it than children who hold the controller with one hand (Shen et al., 2020). Depending on the intended use of controllers during an intervention, this could severely impact the desired outcome. Measuring usability is of immense importance when feasibility of a VR software is tested: it is essential that the users understand how it works and that they can adequately navigate through the intervention.

### 1.4. Satisfaction

A third facet of feasibility is satisfaction. This describes the degree to which users are satisfied with the VR experience. Some studies have assessed user satisfaction as part of usability (e.g. Ammann-Reiffer et al., 2022), however, we argue that usability refers to the appropriateness of both the tool and the software for the target group, whereas satisfaction is a subjective measure depicting the contentment with the overall experience. VR experiences can be very satisfying and can therefore be even preferred over traditional interventions for children (Walther-Larsen et al., 2019), which can result in the desire to use it again (Birnie et al., 2018). It is important to achieve high satisfaction with any VR experience as it can lead to higher engagement (Ammann-Reiffer et al., 2022).

### 1.5. Presence

A fourth aspect that contributes to the feasibility of a clinical VR application, is the level of presence. Presence is colloquially defined as the feeling of 'being there'. According to the two-dimensional conceptualization proposed by Weber et al. (2021), presence refers to the degree to which a user feels immersed in VR while at the same time directing their attention to the virtual space. If presence is high in the VR application, VR could indirectly enhance effectiveness, as users find it more enjoyable and show higher engagement compared to a real-life alternative (Brade et al., 2017). It has also been found that feelings of presence are correlated with the intensity of an emotion induced with VR. This can be particularly powerful in the context of clinical exposure treatments where negative emotions such as aggression are treated (Alsem et al., 2021; Jicol et al., 2021). VR users tend to feel more present if they can actively engage with the environment (Jicol et al., 2021).

### 1.6. Perceived realism

The fifth aspect of feasibility is perceived realism. It has been argued that presence and perceived realism are inherently different and should be treated as such. Perceived realism refers to the extent to which the user perceives the VR environment as coherent and believable (Weber et al., 2021). It is necessary to highlight that this is different from *realism*, where the environments' aim is to mimic reality. When designing VR environments, it is important to take the *Uncanny Valley Effect* into account. This effect describes the disturbance of believability through inconsistencies in the degree of realism (Mori et al., 2012). If the application mimics the real world but it is not completely accurate, users can experience a range of negative effects such as eeriness and discomfort. It can also have a negative effect on presence: a study has shown that with increasing realism of avatars the feeling of presence decreased (Vinayagamoorthy et al., 2004). Evidently, environments do not necessarily have to resemble the real world to be perceived as coherent and believable, as long as the displayed imagery and actions correspond with one's expectation of the environment (Bailenson, 2018). Comic-like environments and talking animals can therefore be perceived as realistic if the imagery and the actions are consistent. Furthermore, the principle of veridicality assumes that participants will behave in VR similarly to how they would in the real world if the VR experience is authentic (Parsons, 2016).

### 1.7. User characteristics, motivation and feasibility

The motivation for and the feasibility of VR applications do not only vary based on technical aspects but can also vary across children and adolescents. Differences between age groups could be partly explained by variations in curiosity, cognitive abilities and growth stage, whereby more cognitive abilities and curiosity may facilitate a feasible VR experience. Physical differences, such as smaller heads and hands, could lead to a poor fit of the VR equipment (Fandakova & Gruber, 2021; Ivancovsky et al., 2024). Age could therefore impact the way children and adolescents interact with and navigate through a new VR application. It is necessary to explore whether these findings extend to novel VR interventions and VR systems in order to maximize the treatment benefits.

Another factor that could potentially affect the motivation for and feasibility of VR interventions is the frequency of digital media use. Since VR is a type of digital media, familiarity with and habituation to digital media could not only affect the motivation for VR interventions but also the feasibility thereof. Familiarity with digital media could potentially lead to a faster adaption and therefore easier navigation of VR regardless of the age of the child (Shen et al., 2020). Habituation on the other hand, could lead to a decreased interest in VR. Therefore, it is important to explore the relation between digital media use and motivation for and the feasibility of a VR intervention. Most VR studies have fewer female than male participants, which might imply that people identifying as male might be more interested and motivated to use VR than females (Peck et al., 2020). The participant recruitment however is seldomly described in a way that allows for valid conclusions regarding gender differences in motivation. When looking at the use of other digital media, a general digital gender divide can be observed among adults, which can possibly be applied to VR as well (Perifanou & Economides, 2020). On the other hand, a review focusing on online gaming has found that men and women differed in their motives to play and their games of choice, but that motivation for online gaming was present for both genders (Veltri et al., 2014). Regarding feasibility of VR, there is scarce evidence on sex differences in adults focusing on tolerability or presence (Felnhofer et al., 2012, pp. 103–112; Salimi & Ferguson-Pell, 2021; Saredakis et al., 2020). While some of these studies did report results cautiously favoring men, research on sex differences in feasibility in children is lacking.

### 1.8. Aims

This study aims to assess the motivation for and the feasibility of a short VR task that could serve as a base for a clinical VR intervention for children and adolescents, whereby the relation between motivation and the feasibility constructs is also explored. Firstly, we test whether the motivation for the VR task is high. We also test the task's feasibility, hence whether a) the VR task is tolerable, b) the usability is high, c) the satisfaction is high, d) there is a high sense of presence, and e) there is a high sense of perceived realism. Secondly, we explore the relations between motivation and the feasibility constructs. This study also aims to shed more light on the relation between age, frequency of digital media use, and sex on one hand and motivation and the five aspects of feasibility on the other hand.

## 2. Material and methods

### 2.1. Participants

One hundred children and adolescents (aged 8–17 years) were recruited using convenience sampling to participate in the current study. The majority of the participants (82%) were recruited during a science fair for children. All other participants (18%) were recruited via the social networks of the research assistants involved in this project. The only inclusion criterium was to understand Dutch because the VR task was in Dutch. The aim was to recruit children and adolescents; therefore, the upper age limit was 18 years. The lower age limit was determined by the ability to read and to fill in the questionnaires independently, which is 8 years in the Netherlands (Stichting Leerplan Ontwikkeling, 2021). Due to technical difficulties ($N = 14$) and one child stopping because of strong nausea, data of 15 participants could not be processed. The final sample consisted of 85 children ($M_{age} = 10.55$ years old, $SD_{age} = 2.06$), whereby the age of 7 participants was not registered. Sex was assessed by asking participants whether they are a girl or a boy, whereby 31 (36%) of the participants were girls and 54 (64%) were boys. 20 participants (23%) had never used a VR headset before, whereas 33 participants (39%) have used it once and 32 (38%) had used it more than once.

### 2.2. Procedure

Children and at least one of their parents were informed about the research project. After deciding to participate, the parents as well as children aged 12 years or older were asked to sign a consent form. For children below the age of 12, only the consent of the parent was required. After having signed informed consent, one researcher invited the participant to take a seat on a chair. A second researcher was present to ensure data integrity. A pre- and post-test design was used, with T0 conducted before the VR task and T1 directly after. All questionnaires used child-appropriate language and were programmed in the software Qualtrics. They were filled out on a tablet under supervision of the researcher. After filling out the questionnaires at T0, the researcher set the interpupillary distance in consultation with the participant, explained the VR system and the VR task. The experiment was conducted in an open environment with non-participating individuals present. Therefore, the participants wore over-ear headphones for the duration of the VR task. After having completed the VR task, participants were asked to fill out the T1 questionnaires. All participants received a small gift. The procedures performed followed applicable laws and the institutional guidelines. The Ethics Committee of the Institute of Education and Child Studies of Leiden University approved this study (ECPW-2022-347).

### 2.3. VR task

For this study the Meta Quest 2 system consisting of a VR headset and controllers was used. A recent study examining feasibility among 8- to 16-year-olds has found that the Meta Quest 2 system has good feasibility overall (Alrashidi et al., 2023). The VR task was developed in Unity 3D 2021. It was single player, and the story line was preprogramed, whereby the participant's actions prompted the story to unfold. The story was set in a cozy atmosphere with 6 avatars sitting around a bonfire (excluding the user). We chose this environment specifically because of its potential for future clinical interventions as it resembles a group therapy setting. The task consisted of drawing on a virtual canvas together with another virtual character and finally throwing the canvas in the bonfire (see Fig. 1). It could only be completed when reacting to specific cues.

After starting the VR experience, the participants found themselves in a cartoony environment sitting on a tree trunk around a bonfire. Visual, haptic and auditory stimuli were used to direct the participants' attention to cues. For example, the participant would see the handle of a drawer blink (visual cue), they would feel their controllers vibrate (haptic cue) or would hear the voice of a virtual character (auditory cue). Before they started the VR task, participants were informed that they would draw in VR and throw away the drawing in the end to prevent disappointment and frustration.

To increase feasibility, several factors were considered. First, to minimize the development of negative physical symptoms, the user-movement matched the virtual content: the participants remained seated in both worlds (Saredakis et al., 2020). Furthermore, a fixed virtual horizon was installed (Hemmerich et al., 2020). To prevent discomfort of the headset and negative physical symptoms such as eye strain or light headedness, the VR task would take 10 min to complete at most (Saredakis et al., 2020). To increase the feeling of presence and perceived realism, the avatars and the environment were consistently comic-like to prevent the Uncanny Valley effect (Mori et al., 2012; Vinayagamoorthy et al., 2004). Studies have shown that VR users tend to feel more present if they have agency (e.g. Jicol et al., 2021), therefore the task required the participants to interact with the environment, for example by drawing. Participants could use their hands (controllers) to grab charcoal and draw on the canvas. Depending on how quickly the participants grasped what was being asked from them, but also on how

**Fig. 1.** Impression of the VR environment.

much time they spent drawing, the duration of the VR task was between four and 11 min ($M = 5.5$min, $SD = 1.6$min) in the virtual environment.

### 2.4. Measurements

Fig. 2 presents an overview of the constructs and associated variables that were used in this study. The universal phrasing of the translated as well as the self-developed questionnaires was tested with children from the targeted age range to ensure comprehension. Except for the constructs Tolerability and Frequency of digital media use, all questionnaires were self-developed.

*Motivation.* Motivation was assessed retrospectively with one item as part of a self-developed VR experience survey (“*I was looking forward to do the VR task*” – freely translated from Dutch). This item is based on a study on intrinsic motivation and hedonic information systems (Wang & Scheepers, 2012), and is scored on a 5-point Likert-scale ranging from *Not at all* to *Very much.*

*Tolerability.* To assess tolerability, we administered the Child Simulator Sickness Questionnaire (CSSQ; Hoeft et al., 2003), a child-friendly adaptation of the Simulator Sickness Questionnaire (SSQ; Kennedy et al., 1993) which has been widely used to assess negative physical symptoms in adults. The CSSQ has 7 items that are scored on a 3-point Likert scale ranging from *Not at all*, to *A little bit*, to *A lot.* Since we used this tool to assess tolerability rather than simulator sickness, we inversed the scale so that higher values correspond to higher tolerability. Most studies assess tolerability only *after* the VR task as initially proposed by the authors of SSQ, assuming that users do not experience any negative physical symptoms at baseline. This assumption of a zero-symptoms-baseline has been found to be misleading as some symptoms might already be present before VR, meaning that not all negative symptoms were induced by VR (Brown et al., 2022). Therefore, we measured tolerability before (T0) as well as after the VR task (T1).

Our data inspection revealed very skewed distributions for the T0- as well as the T1-scores, with all items having at least 87% of the participants scoring the maximum score 14. Therefore, we did not presuppose the original 3-subscale structure of the CSSQ, but a) explored the T0- and T1-scores per item on a descriptive level and b) summed all T0- as well as all T1-items as indicators of the total magnitude of tolerability before and after the VR task. The differential score of the T0 and T1 sum scores was used as an indication of the decrease of tolerability.

*Usability, satisfaction, presence, and perceived realism.* These constructs were measured with a self-constructed survey, consisting of items that are scored on a 5-point Likert-scale ranging from *Not at all* to *Very much.* Three items were used to assess *usability*: measuring understanding, perceived ease of use, and comfort of the headset. These items are based on research indicating that the headsets could potentially be uncomfortable (Lowry et al., 2013; Maloca et al., 2022). The internal reliability for the usability scale was acceptable, Cronbach’s alpha = 0.60. *Satisfaction* was assessed with one item (“*I enjoyed doing the VR task.*”) which is based on research about intrinsic motivation and hedonic information systems (Wang & Scheepers, 2012). *Presence* and *perceived realism* were both assessed with one item each by asking the participant a) whether they felt like they were really there and b) thought that the virtual world seemed real, respectively (Busselle & Bilandzic, 2008; Weber et al., 2021).

*Frequency of digital media use.* The frequency of digital media use was measured with one item from a questionnaire based on *Iene Miene Media* )(Mediawijsheid and Nikken, 2022). For this study, we used the item that measures the frequency of digital media use across different types media such as television, tablet, mobile phone, gaming devices

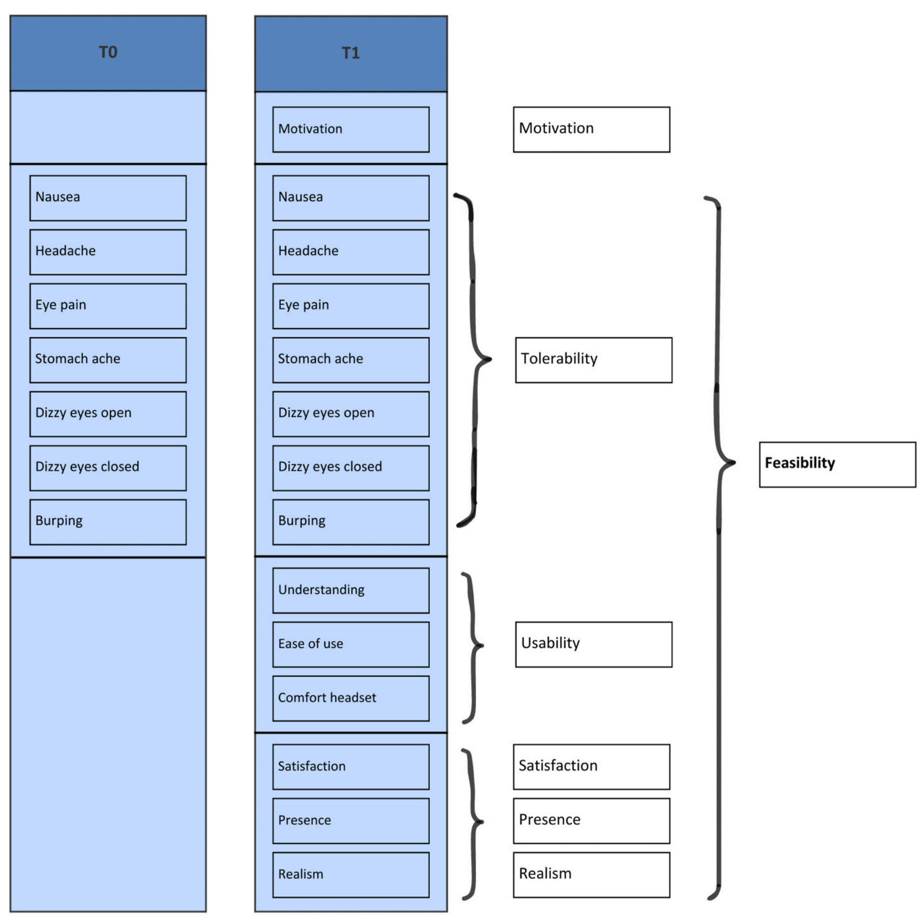


**Fig. 2.** Overview of constructs and associated variables that are used in the feasibility evaluation.

(PlayStation, Xbox, et cetera), laptop, and e-reader. This frequency was assessed by asking how often the participant used these devices *per* day. Participants were asked to indicate their digital media use on a 5-point Likert scale ranging from *Not every day, Once per day, 2–3 times per day, 4–5 times per day,* to *More than 5 times per day*. The higher the frequency, the higher the digital media use.

### 2.5. Analyses

We inspected motivation and the feasibility of the VR-session: The T0-, T1- as well as the differential scores of tolerability were inspected and a one-sided Wilcoxon signed rank test comparing the sum scores of the CSSQ T0 and T1 was administered to assess the change in tolerability from pre to post. To assess whether the VR task was useable, satisfactory, created a sense of presence, and was perceived as realistic, the descriptives of the remaining four feasibility constructs were inspected. We then calculated the mutual correlations of motivation and the feasibility constructs and investigated the relations between age, frequency of digital media use, and sex on the one hand, and motivation and the feasibility variables on the other hand. We calculated correlations and performed independent *t*-tests, whereby non-parametric variants were used for ordinal variables or severely skewed distributions. Because several significance tests were done, the significance of the *p*-values was sequentially adjusted with Holm's sequential correction for multiple testing (Holm, 1979). We refrained from doing so when inspecting the tolerability of the VR task because the null hypothesis was expected to be true. Therefore, we conducted an inferiority test to assess if the possible difference found was lower than the smallest effect size of interest (Lakens et al., 2022). For this 14-point scale, we considered an effect to be of interest when the mean tolerability score would decrease with 0.5, or when the median would decrease with one point (this means that 50% of the children would decrease with one point). Smaller effects were not considered to be of interest. Cohen's *d* of 0.20, 0.50 and 0.80 were interpreted as small, medium and large effects, and Eta squared of 0.01, 0.06 and 0.14 were interpreted as small, medium, and large effects (Cohen, 1988). Spearman's Rho between 0.20 and 0.39, 0.40 to 0.59, and 0.60 to 0.79 were interpreted as weak, moderate and strong correlations respectively (Siegel, 1956).

## 3. Results

Table 1 presents the descriptives of motivation, the feasibility constructs, age, and frequency of digital media use. The correlations between these variables can be found in Table 2.

*Motivation.* Motivation for the VR-task was rated high, with an average score of 4.47 on a five-point scale ($SD = 1.01$, $Mdn = 5$).

*Tolerability.* All tolerability items at both T0 and T1 were skewed to the left indicating low symptoms before and after the VR task. The sum scores of tolerability for the 85 children who completed the assessment were also negatively skewed. At both T0 and T1 the reported tolerability was high: the median was 14 (the maximum score), and most participants (ranging from 87% to 98% across the 7 items) reported no symptoms at all for both T0 and T1 (maximum score). The mean of the T0-score was 13.53 on a scale from 0 to 14, and the mean of the T1-score 13.25. The mean difference score between T0 and T1 was −0.28. This difference was statistically significant ($z = -2.75$, $p = 0.006$, $\eta^2 = 0.09$). An inferiority test however showed that the effect found was statistically inferior to our smallest effect size of interest ($z = -6.02$, $p < 0.001$).

Out of all children who completed T1, 69% ($N = 59$) indicated no change in tolerability and 6 of them (7%) even indicated an increase. In total, 20 children (23%) did indicate to experience decreased tolerability, notably with most of these children ($N = 13$; 15%) mentioning the smallest decrease possible: one symptom to the extent of *a little bit*. One participant (male, 8-years-old) did not complete the VR task due to developing strong nausea throughout the task. The participant scoring the lowest at T1 indicated in the voluntary comment section that they enjoyed the task very much. Summarizing, tolerability was overall high at both T0 and T1.

*Usability, satisfaction, presence, and perceived realism.* The report of *usability* after the VR task was very positive with an average score of 4.16 on a five-point scale ($SD = 0.69$, $Mdn = 4.33$). *Satisfaction* ($M = 4.53$, $SD = 0.89$, $Mdn = 5$) and *presence* ($M = 4.02$, $SD = 1.14$, $Mdn = 4$) were also rated high. *Perceived realism* scored the lowest, however, since the scale value 3 corresponds to *neutral,* the average score was still above neutral ($M = 3.22$, $SD = 1.22$, $Mdn = 3$).

*Mutual correlations.* Motivation was positively and moderately correlated with usability, satisfaction and presence ($\rho(83) = 0.39$, $p < 0.001$, $\rho(83) = 0.37$, $p < 0.001$, and $\rho(83) = 0.40$, $p < 0.001$ respectively), but not with tolerability or perceived realism. The statistically significant *p*-values remained significant after correction for multiple testing.

*Age, frequency of digital media use, and sex.* The correlations between age, and motivation and the feasibility aspects were all non-significant with ρ ranging from −0.15 to 0.18. Frequency of digital media use was not significantly correlated with motivation or the feasibility constructs either (ρ ranging from −0.01 and 0.10). Boys and girls did not differ in motivation levels ($U = 782.50$, $p = 0.41$, $\eta^2 = 0.01$), and a two-tailed *t*-test did not reveal a significant difference in terms of tolerability between boys and girls either ($t(83) = 1.31$, $p = 0.20$, $d = 0.28$). There were no significant sex differences detected for *usability, satisfaction, presence,* and *perceived realism,* with $\eta^2$ ranging from 0.00 to 0.02.

## 4. Discussion

This study aimed to assess motivation for and the feasibility of a short VR task that could serve as a base for a clinical VR intervention for children and adolescents, using a Meta Quest 2 system. As compared to other feasibility and pilot studies of new VR interventions for minors, this study additionally investigated motivation to use VR, used a higher number of feasibility aspects, and explored individual factors that could

**Table 1**
Descriptives of motivation, the feasibility constructs, age, and frequency of digital media use.

| | *N* | Minimum | Maximum | *M* | *SD* | Skewness | | Kurtosis | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Statistic | *SD* | Statistic | *SD* |
| Motivation | 85 | 1 | 5 | 4.47 | 1.01 | −2.35 | 0.26 | 5.22 | 0.52 |
| T0 | 85 | 11 | 14 | 13.53 | 0.77 | −1.73 | 0.26 | 2.66 | 0.52 |
| T1 | 85 | 8 | 14 | 13.25 | 1.19 | −2.04 | 0.26 | 4.60 | 0.52 |
| Tolerability | 85 | −5 | 3 | −0.28 | 0.97 | −1.64 | 0.26 | 8.00 | 0.52 |
| Usability | 85 | 1 | 5 | 4.16 | 0.69 | −1.68 | 0.26 | 5.41 | 0.52 |
| Satisfaction | 85 | 1 | 5 | 4.53 | 0.89 | −2.49 | 0.26 | 6.83 | 0.52 |
| Presence | 85 | 1 | 5 | 4.02 | 1.14 | −1.12 | 0.26 | 0.49 | 0.52 |
| Perceived realism | 85 | 1 | 5 | 3.22 | 1.22 | −0.16 | 0.26 | −0.86 | 0.52 |
| Age | 78 | 8 | 17 | 10.59 | 2.03 | 0.56 | 0.27 | −0.21 | 0.54 |
| Frequency of digital media use | 85 | 1 | 5 | 3.45 | 1.23 | −0.31 | 0.26 | −0.74 | 0.52 |

*Note. T0* and *T1* refer to the respective sum scores of tolerability.

**Table 2**
Spearman Rho correlation table of motivation, the feasibility constructs, age, and frequency of digital media use.

| | Motivation | Tolerability | Usability | Satisfaction | Presence | Realism | Age |
|---|---|---|---|---|---|---|---|
| Tolerability | 0.07 | | | | | | |
| Usability | 0.39** | 0.29** | | | | | |
| Satisfaction | 0.37** | 0.28** | 0.35** | | | | |
| Presence | 0.40** | 0.08 | 0.32** | 0.47** | | | |
| Perceived realism | 0.19 | 0.10 | 0.35** | 0.21 | 0.44** | | |
| Age | −0.07 | 0.12 | 0.16 | −0.15 | −0.05 | 0.08 | |
| Frequency of digital media use | 0.04 | 0.05 | 0.01 | −0.01 | 0.10 | 0.05 | 0.47** |

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

be of importance with regards to the target population for the clinical intervention (see e.g. Ammann-Reiffer et al., 2022; Flujas-Contreras et al., 2020). Our study showed that children and adolescents were highly motivated to execute the VR task. This finding is in line with previous works conveying the excitement about using immersive VR systems (Maloca et al., 2022; Seesjärvi et al., 2023). The use of VR could pose an opportunity for populations with low treatment motivation, such as children and adolescents with severe psychiatric problems (Rizzo et al., 2018; Roedelof et al., 2013), since treatment motivation has been linked to therapeutic alliance which in turn is associated with treatment success (Fjermestad et al., 2018; Karver et al., 2018). Moreover, motivation was found to be positively correlated with usability, satisfaction, and presence, indicating that the more motivated the participants were, the more useable it was, the more satisfied they were, and the more present they felt in the VR environment. However, the design of the study does not allow for discussion of causality or direction of the effect. The motivation score could also be indicative of the motivation to use the task again: since it was assessed retrospectively, it is possible that experiencing the module as very useable, highly satisfactory, and feeling highly present, has positively impacted the report of motivation. It is important to discriminate between initial motivation to use VR and motivation to use it again, as it is possible that the motivation for the VR intervention decreases over the course of the treatment. Regardless of the causality or directionality of the effect we found, this finding points to the benefits of using this task as a base for a clinical VR intervention.

Furthermore, we found that our VR task was tolerable for the vast majority of the participants. Overall, the tolerability was reported to be very high, with a mean score almost equaling the maximum score and a median being the maximum score. It is noteworthy that most of the participants who reported a decrease in tolerability, reported the smallest decrease possible. Others even reported an increase in tolerability, and only one participant discontinued the VR task due to strong nausea. The participant scoring the lowest on tolerability at T1 indicated in the open remarks section that they thought that *"the task was amazing, and they would love to do it every day"* (freely translated from Dutch). Even though their reported symptoms were high, they were not perceived as severe. The decrease in tolerability could be explained by a potential poor fit of the VR headset or lagging of the VR task as both lead to distorted images and induce strong feelings of nausea (Holla & Berg, 2022). Therefore, it is crucial to ensure that the headset fits properly, and that the software of future clinical VR interventions is not lagging. Another explanation could simply be that the symptoms were non-specific. This is supported by the fact that some participants reported an increase in tolerability after the VR task. Hence, using this task as a base for the clinical VR intervention increases the likelihood of the software being perceived as tolerable as well when using a Meta Quest 2 system. It can be concluded that this task meets one of the most important feasibility requirements, tolerability, as our results revealed only a marginal decrease in tolerability.

Usability, satisfaction and presence were rated highly positively as well. This indicates that the task was useable, that participants enjoyed the task and that they felt present in the VR environment. Like tolerability, usability can be viewed as a prerequisite for a feasible VR intervention as users must understand what is being asked of them and must be able to navigate the intervention for it to be enjoyable and evoke feelings of presence. These results imply that this VR task meets these three feasibility criteria and could therefore be used as a base for a clinical VR intervention using a Meta Quest 2 system.

We found that perceived realism was rated as 'neutral', indicating that the participants perceived the environment as neither realistic nor unrealistic. It is plausible that the phrasing of the item assessing perceived realism was not capturing the construct adequately ("*The virtual world seemed just like real")*: perceived realism describes the extent to which a VR environment is perceived as coherent and believable, which does not exclude *realistic* but is not tied to realism either. It is possible that the participants did not quite understand what was being asked, which is supported by the average neutral score (Sturgis et al., 2014). It could also simply mean that the participants felt indifferent about perceived realism.

Finally, taking all feasibility constructs into account, we conclude that this VR task is feasible for this population when viewed with a Meta Quest 2 system. In case this task is used with an older VR system or a VR system from a different company, the feasibility constructs should be reassessed. Newer Meta Quest systems are presumably improved; therefore, we expect that the feasibility assessment would yield similar or better results. Tolerability, however, must always be monitored as it is not entirely understood yet why VR evokes negative physical symptoms for certain individuals (Saredakis et al., 2020).

Neither age nor frequency of digital media use was found to be related to motivation. We did not find differences in motivation between girls and boys, either. Possibly, sex differences in affinity to technology manifest only at a later developmental stage when individuals grow more aware of gender roles, typically occurring during adolescence, a trend which has previously been observed (Erikson, 1980; Fedorowicz et al., 2010). The average participant of this study was pre-adolescent, which might explain our findings. However, considering the general increase in frequency of digital media use in children (Reid Chassiakos et al., 2016), it is more plausible that the sex and age differences have lessened. These findings indicate that our study population was highly motivated or engaged, regardless of the frequency of their digital media use, age, and sex, meaning that an immersive clinical VR intervention based on this task could be motivating for a wide range of young people.

The feasibility of the VR task did not differ across different ages. Even though the Meta Quest 2 system was not specifically designed for younger children, there is no indication that the tool is poorly fitting or too challenging and thereby impacting the feasibility of it. Therefore, the VR task using the Meta Quest 2 system is deemed equally feasible for children and adolescents aged 8–17 years old. However, since children's interpupillary distance tends to be smaller than adult's (Dodgson, 2004), it is especially important that the fit of the VR headset is thoroughly assessed to prevent poor fitting (Holla & Berg, 2022). Boys and girls experienced the VR task as equally feasible as well, similarly to the findings regarding motivation: potential sex differences might no longer be reflected in children's behaviour due to overall increased digital media use.

The feasibility of the VR task did not vary depending on the frequency of digital media use either. Potential effects of familiarity and habituation might have already taken place as compared to older generations: In today's age digital media use typically increases with time, starting much earlier than in previous decades (Reid Chassiakos et al., 2016). This is advantageous for clinical VR interventions as they can be experienced as more familiar and hence more accessible. Finally, it can be concluded that the feasibility of this VR task did not differ across different age groups, frequency of digital media use, or sex. This implies that the task is a solid base for a clinical VR intervention which could be administered to a wide range of clients. If the final intervention's content changes and is viewed with a different VR system - that is to say, from a different producer or an older model - feasibility should be reassessed to ensure its suitability for the target group.

This study has several strengths and limitations. As compared to other feasibility studies and pilot studies, this study included a relatively large sample to assess the feasibility of a task that serves as a base for a digital mental health intervention (e.g. Ammann-Reiffer et al., 2022; Flujas-Contreras et al., 2020). Furthermore, this study evaluated a higher number of frequently assessed factors associated with feasibility, and hence a more comprehensive picture of feasibility could be presented. The assessment itself, however, had its limitations. For lack of validated and age-appropriate questionnaires to measure the feasibility concepts in general and especially for this target group, we have administered the CSSQ to assess tolerability and a non-validated self--developed questionnaire to assess the other feasibility constructs. Because of the severely skewed distributions of our data, we could not apply the original structure of the CSSQ. Nonetheless, even with this measurement taken, our data corroborates the rejection of the zero-baseline assumption, leading to a more accurate assessment of tolerability.

### *4.1. Conclusion*

The results of this study imply that this VR task using a Meta Quest 2 system is motivating and feasible for children and adolescents aged 8–17 years old, regardless of their sex or frequency of digital media use. Using this task as a base for a VR mental health intervention could be a promising starting point for the feasibility of the intervention. However, feasibility should be monitored if changes are made to the application that could decrease feasibility, or if a different VR system is used. Our results corroborate previous findings, highlighting the potential of immersive VR potential in the clinical field.

## CRediT authorship contribution statement

**Nina Krupljanin:** Writing – original draft, Visualization, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Lenneke R.A. Alink:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Anja van der Voort:** Writing – review & editing, Supervision, Methodology, Formal analysis. **Maarten R. Struijk Wilbrink:** Writing – review & editing, Software, Investigation. **Catharina E. Bergwerff:** Writing – review & editing, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization.

## Selection and participation

The study's participants were children and adolescents from the Netherlands. Prior to signing informed consent, the legal guardians as well as the children and adolescents were informed about the study's purpose, the procedure, and the data collection. They were informed that the participation is completely voluntary, and that they can stop during the study as well as withdraw their consent at a later point in time without naming a reason. Written informed consent was obtained prior to participation and data collection. Data collection started after obtaining approval of the data stewards (Institute of Education and Child Studies, University of Leiden) as well as the privacy officer (Social Sciences, University of Leiden), complying with all the regulations and recommendations for research with this target group and its data. The data collection took place during a science fair and in standardized settings conforming to the experimental set-up during the science fair.

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## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Data availability

The data package including the questionnaires as well as the anonymized data set is available via this link https://doi.org/10.34894/GB7KFP.

## References

Alrashidi, M., Wadey, C. A., Tomlinson, R. J., Buckingham, G., & Williams, C. A. (2023). The efficacy of virtual reality interventions compared with conventional physiotherapy in improving the upper limb motor function of children with cerebral palsy: A systematic review of randomised controlled trials. *Disability & Rehabilitation: An International, Multidisciplinary Journal, 45*(11), 1773–1783. https://doi.org/10.1080/09638288.2022.2071484. psyh.

Alsem, S. C., van Dijk, A., Verhulp, E. E., & De Castro, B. O. (2021). Using virtual reality to treat aggressive behavior problems in children: A feasibility study. *Clinical Child Psychology and Psychiatry, 26*(4), 1062–1075. https://doi.org/10.1177/13591045211026160

Ammann-Reiffer, C., Kläy, A., & Keller, U. (2022). Virtual reality as a therapy tool for Walking activities in pediatric neurorehabilitation: Usability and user experience evaluation. *JMIR Serious Games, 10*(3), Article e38509. https://doi.org/10.2196/38509

Bailenson, J. (2018). *Experience on demand: What virtual reality is, how it works, and what it can do*. WW Norton & Company. WW Norton & Company.

Bioulac, S., Micoulaud-Franchi, J. A., Maire, J., Bouvard, M. P., Rizzo, A. A., Sagaspe, P., & Philip, P. (2020). Virtual remediation versus methylphenidate to improve distractibility in children with adhd: A controlled randomized clinical trial study. *Journal of Attention Disorders, 24*(2), 326–335. https://doi.org/10.1177/1087054718759751

Birnie, K. A., Kulandaivelu, Y., Jibb, L., Hroch, P., Positano, K., Robertson, S., Campbell, F., Abla, O., & Stinson, J. (2018). Usability testing of an interactive virtual reality distraction intervention to reduce procedural pain in children and adolescents with cancer. *Journal of Pediatric Oncology Nursing, 35*(6), 406–416. https://doi.org/10.1177/1043454218782138

Brade, J., Lorenz, M., Busch, M., Hammer, N., Tscheligi, M., & Klimant, P. (2017). Being there again – presence in real and virtual environments and its relation to usability and user experience using a mobile navigation task. *International Journal of Human-Computer Studies, 101*, 76–87. https://doi.org/10.1016/j.ijhcs.2017.01.004

Brown, P., Spronck, P., & Powell, W. (2022). The simulator sickness questionnaire, and the erroneous zero baseline assumption. *Frontiers in Virtual Reality, 3*, Article 945800. https://doi.org/10.3389/frvir.2022.945800

Busselle, R., & Bilandzic, H. (2008). Fictionality and perceived realism in experiencing stories: A model of narrative comprehension and engagement. *Communication Theory, 18*(2), 255–280. https://doi.org/10.1111/j.1468-2885.2008.00322.x

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Dodgson, N. A. (2004). Variation and extrema of human interpupillary distance. *Stereoscopic Displays and virtual reality systems XI, 5291(stereoscopic displays and virtual reality systems XI)*.

Erikson, E. H. (1980). *Identity and the life cycle*. W W Norton & Co.

Fandakova, Y., & Gruber, M. J. (2021). States of curiosity and interest enhance memory differently in adolescents and in children. *Developmental Science, 24*(1), Article e13005. https://doi.org/10.1111/desc.13005

Fedorowicz, J., Vilvovsky, S. G., & Golibersuch, A. J. (2010). Gender differences in teenagers' elective use of computer technology. *Communications of the Association for Information Systems, 27*. https://doi.org/10.17705/1CAIS.02703

Felnhofer, A., Kothgassner, O. D., Beutl, L., Hlavacs, H., & Kryspin-Exner, I. (2012). Is virtual reality made for men only? Exploring gender differences in the sense of presence. *Proceedings of the international society on presence research*.

Fjermestad, K. W., Lerner, M. D., McLeod, B. D., Wergeland, G. J. H., Haugland, B. S. M., Havik, O. E., Öst, L.-G., & Silverman, W. K. (2018). Motivation and treatment credibility predict alliance in cognitive behavioral treatment for youth with anxiety disorders in community clinics. *Journal of Clinical Psychology, 74*(6), 793–805. https://doi.org/10.1002/jclp.22551

Flujas-Contreras, J. M., Ruiz-Castañeda, D., & Gómez, I. (2020). Promoting emotional well-being in hospitalized children and adolescents with virtual reality: Usability and acceptability of a randomized controlled trial. *CIN: Computers, Informatics, Nursing, 38*(2), 99–107. https://doi.org/10.1097/CIN.0000000000000586

Guedj, C., Tyrand, R., Badier, E., Planchamp, L., Stringer, M., Zimmermann, M. O., Férat, V., Ha-Vinh Leuchter, R., & Grouiller, F. (2023). Self-regulation of attention in children in a virtual classroom environment: A feasibility study. *Bioengineering, 10* (12), 1352. https://doi.org/10.3390/bioengineering10121352

Harris, K., & Reid, D. (2005). The influence of virtual reality play on children'S motivation. *Canadian Journal of Occupational Therapy, 72*(1), 21–29. https://doi.org/10.1177/000841740507200107

Hemmerich, W., Keshavarz, B., & Hecht, H. (2020). Visually induced motion sickness on the horizon. *Frontiers in Virtual Reality, 1*, Article 582095. https://doi.org/10.3389/frvir.2020.582095

Heo, S., & Park, J.-H. (2022). Effects of virtual reality-based graded exposure therapy on ptsd symptoms: A systematic review and meta-analysis. *International Journal of Environmental Research and Public Health, 19*(23), Article 15911. https://doi.org/10.3390/ijerph192315911

Hoeft, R. M., Vogel, J., & Bowers, C. A. (2003). Kids get sick too: A proposed child simulator sickness questionnaire. *Th ANNUAL MEETING, 5*.

Holla, M., & Berg, M. V. D. (2022). Virtual reality techniques for trauma education. *Injury, 53*, S64–S68. https://doi.org/10.1016/j.injury.2022.08.067

Holm, S. (1979). A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics, 6*(2), 65–70.

Ivancovsky, T., Baror, S., & Bar, M. (2024). A shared novelty-seeking basis for creativity and curiosity. *Behavioral and Brain Sciences, 47*, e89. https://doi.org/10.1017/S0140525X23002807

Jicol, C., Wan, C. H., Doling, B., Illingworth, C. H., Yoon, J., Headey, C., Lutteroth, C., Proulx, M. J., Petrini, K., & O'Neill, E. (2021). Effects of emotion and agency on presence in virtual reality. *Proceedings of the 2021 CHI conference on human factors in computing systems*. https://doi.org/10.1145/3411764.3445588

Kaimara, P., Oikonomou, A., & Deliyannis, I. (2022). Could virtual reality applications pose real risks to children and adolescents? A systematic review of ethical issues and concerns. *Virtual Reality, 26*(2), 697–735. https://doi.org/10.1007/s10055-021-00563-w

Karver, M. S., De Nadai, A. S., Monahan, M., & Shirk, S. R. (2018). Meta-analysis of the prospective relation between alliance and outcome in child and adolescent psychotherapy. *Psychotherapy, 55*(4), 341–355. https://doi.org/10.1037/pst0000176

Kennedy, R. S., Drexler, J., & Kennedy, R. C. (2010). Research in visually induced motion sickness. *Applied Ergonomics, 41*(4), 494–503. https://doi.org/10.1016/j.apergo.2009.11.006

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. *The International Journal of Aviation Psychology, 3*(3), 203–220. https://doi.org/10.1207/s15327108ijap0303_3

Lakens, D., Scheel, A., & Isager, D. (2022). Equivalence testing for psychological research: A tutorial. https://doi.org/10.17605/OSF.IO/QAMC6.

Lin, C., Ren, Y., & Lu, A. (2023). The effectiveness of virtual reality games in improving cognition, mobility, and emotion in elderly post-stroke patients: A systematic review and meta-analysis. *Neurosurgical Review, 46*(1), 167. https://doi.org/10.1007/s10143-023-02061-w

Lowry, P., Gaskin, J., Twyman, N., Hammer, B., & Roberts, T. (2013). Taking "fun and games" seriously: Proposing the hedonic-motivation system adoption model (HMSAM). *Journal of the Association for Information Systems, 14*(11), 617–671. https://doi.org/10.17705/1jais.00347

Maloca, P. M., Williams, E. A., Mushtaq, F., Rueppel, A., Müller, P. L., Lange, C., Carvalho, E. R., Inglin, N., Reich, M., Egan, C., Hasler, P. W., Tufail, A., Scholl, H. P. N., & Cattin, P. C. (2022). Feasibility and tolerability of ophthalmic virtual reality as a medical communication tool in children and young people. *Acta Ophthalmologica, 100*(2). https://doi.org/10.1111/aos.14900

Maskey, M., Rodgers, J., Grahame, V., Glod, M., Honey, E., Kinnear, J., Labus, M., Milne, J., Minos, D., McConachie, H., & Parr, J. R. (2019). A randomised controlled feasibility trial of immersive virtual reality treatment with cognitive behaviour therapy for specific phobias in young people with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 49*(5), 1912–1927. https://doi.org/10.1007/s10803-018-3861-x

Mediawijsheid, N., & Nikken, P. (2022). *Iene miene media*.

Mori, M., MacDorman, K., & Kageki, N. (2012). The Uncanny Valley [from the field]. *IEEE Robotics and Automation Magazine, 19*(2), 98–100. https://doi.org/10.1109/MRA.2012.2192811

Negut, A., Jurma, A., & David, D. (2017). Virtual-reality-based attention assessment of ADHD: ClinicaVR: Classroom-CPT versus a traditional continuous performance test. *Child Neuropsychology, 23*(6), 692–712. https://doi.org/10.1080/09297049.2016.1186617

Park, J.-S., Jung, Y.-J., & Lee, G. (2020). Virtual reality-based cognitive–motor rehabilitation in older adults with mild cognitive impairment: A randomized controlled study on motivation and cognitive function. *Healthcare, 8*(3), 335. https://doi.org/10.3390/healthcare8030335

Parsons, S. (2016). Authenticity in virtual reality for assessment and intervention in autism: A conceptual review. *Educational Research Review, 19*, 138–157. https://doi.org/10.1016/j.edurev.2016.08.001

Peck, T. C., Sockol, L. E., & Hancock, S. M. (2020). Mind the gap: The underrepresentation of female participants and authors in virtual reality research. *IEEE Transactions on Visualization and Computer Graphics, 26*(5), 1945–1954. https://doi.org/10.1109/TVCG.2020.2973498

Perifanou, M. A., & Economides, A. A. (2020). Gender digital divide in europe. *International Journal of Business, Humanities and Technology, 10*(4). https://doi.org/10.30845/ijbht.v10n4p2

Perra, A., Riccardo, C. L., De Lorenzo, V., De Marco, E., Di Natale, L., Kurotschka, P. K., Preti, A., & Carta, M. G. (2023). Fully immersive virtual reality-based cognitive remediation for adults with psychosocial disabilities: A systematic scoping review of methods intervention gaps and meta-analysis of published effectiveness studies. *International Journal of Environmental Research and Public Health, 20*(2), 1527. https://doi.org/10.3390/ijerph20021527

Pollak, Y., Shomaly, H. B., Weiss, P. L., Rizzo, A. A., & Gross-Tsur, V. (2010). Methylphenidate effect in children with ADHD can be measured by an ecologically valid continuous performance test embedded in virtual reality. *CNS Spectrums, 15*(2), 125–130.

Reid Chassiakos, Y., Linda, Radesky, J., Christakis, D., Moreno, M. A., Cross, C., Hill, D., Ameenuddin, N., Hutchinson, J., Levine, A., Boyd, R., Mendelson, R., & Swanson, W. S. (2016). Children and adolescents and digital media. *Pediatrics, 138* (5), Article e20162593. https://doi.org/10.1542/peds.2016-2593

Rizzo, A. S., Koenig, S. T., & Talbot, T. B. (2018). Clinical virtual reality: Emerging opportunities for psychiatry. *Focus (American Psychiatric Publishing), 16*(3), 266–278. https://doi.org/10.1176/appi.focus.20180011

Roedelof, A. J. M., Bongers, I. L., & Van Nieuwenhuizen, C. (2013). Treatment engagement in adolescents with severe psychiatric problems: A latent class analysis. *European Child & Adolescent Psychiatry, 22*(8), 491–500. https://doi.org/10.1007/s00787-013-0385-y

Salimi, Z., & Ferguson-Pell, M. W. (2021). Motion sickness and sense of presence in a virtual reality environment developed for manual wheelchair users, with three different approaches. *PLoS One, 16*(8), Article e0255898. https://doi.org/10.1371/journal.pone.0255898

Saredakis, D., Szpak, A., Birckhead, B., Keage, H. A. D., Rizzo, A., & Loetscher, T. (2020). Factors associated with virtual reality sickness in head-mounted displays: A systematic review and meta-analysis. *Frontiers in Human Neuroscience, 14*, 96. https://doi.org/10.3389/fnhum.2020.00096

Seesjärvi, E., Laine, M., Kasteenpohja, K., & Salmi, J. (2023). Assessing goal-directed behavior in virtual reality with the neuropsychological task EPELI: Children prefer head-mounted display but flat screen provides a viable performance measure for remote testing. *Frontiers in Virtual Reality, 4*, Article 1138240. https://doi.org/10.3389/frvir.2023.1138240

Shen, J., Xiang, H., Luna, J., Grishchenko, A., Patterson, J., Strouse, R. V., Roland, M., Lundine, J. P., Koterba, C. H., Lever, K., Groner, J. I., Huang, Y., & Lin, E.-J. D. (2020). Virtual reality–based executive function rehabilitation system for children with traumatic brain injury: Design and usability study. *JMIR Serious Games, 8*(3), Article e16947. https://doi.org/10.2196/16947

Siegel, S. (1956). *Nonparametric statistics for the behavioral sciences*. McGraw-Hill.

Stichting Leerplan Ontwikkeling. (2021). Bij kerndoel 4. https://www.slo.nl/thema/meer/tule/nederlands/kerndoel-4-0/.

Sturgis, P., Roberts, C., & Smith, P. (2014). Middle alternatives revisited: How the neither/nor response acts as a way of saying "I don't know". *Sociological Methods & Research, 43*(1), 15–38. https://doi.org/10.1177/0049124112452527

Tennant, M., McGillivray, J., Youssef, G. J., McCarthy, M. C., & Clark, T.-J. (2020). Feasibility, acceptability, and clinical implementation of an immersive virtual reality intervention to address psychological well-being in children and adolescents with cancer. *Journal of Pediatric Oncology Nursing, 37*(4), 265–277. https://doi.org/10.1177/1043454220917859

Tychsen, L., & Foeller, P. (2020). Effects of immersive virtual reality headset viewing on young children: Visuomotor function, postural stability, and motion sickness. *American Journal of Ophthalmology, 209*, 151–159. https://doi.org/10.1016/j.ajo.2019.07.020

Veltri, N., Krasnova, H., Baumann, A., & Kalayamthanam, N. (2014). *Gender differences in online gaming: A literature review*.

Vinayagamoorthy, V., Brogni, A., Gillies, M., Slater, M., & Steed, A. (2004). An investigation of presence response across variations in visual realism. In *In the 7th annual international presence workshop* (pp. 148–155).

Walther-Larsen, S., Petersen, T., Friis, S. M., Aagaard, G., Drivenes, B., & Opstrup, P. (2019). Immersive virtual reality for pediatric procedural pain: A randomized clinical trial. *Hospital Pediatrics, 9*(7), 501–507. https://doi.org/10.1542/hpeds.2018-0249

Wang, Z., & Scheepers, H. (2012). Understanding the intrinsic motivations of user acceptance of hedonic information systems: Towards a unified research model. *Communications of the Association for Information Systems, 30*. https://doi.org/10.17705/1CAIS.03017

Weber, S., Weibel, D., & Mast, F. W. (2021). How to get there when you are there already? Defining presence in virtual reality and the importance of perceived realism. *Frontiers in Psychology, 12*, Article 628298. https://doi.org/10.3389/fpsyg.2021.628298