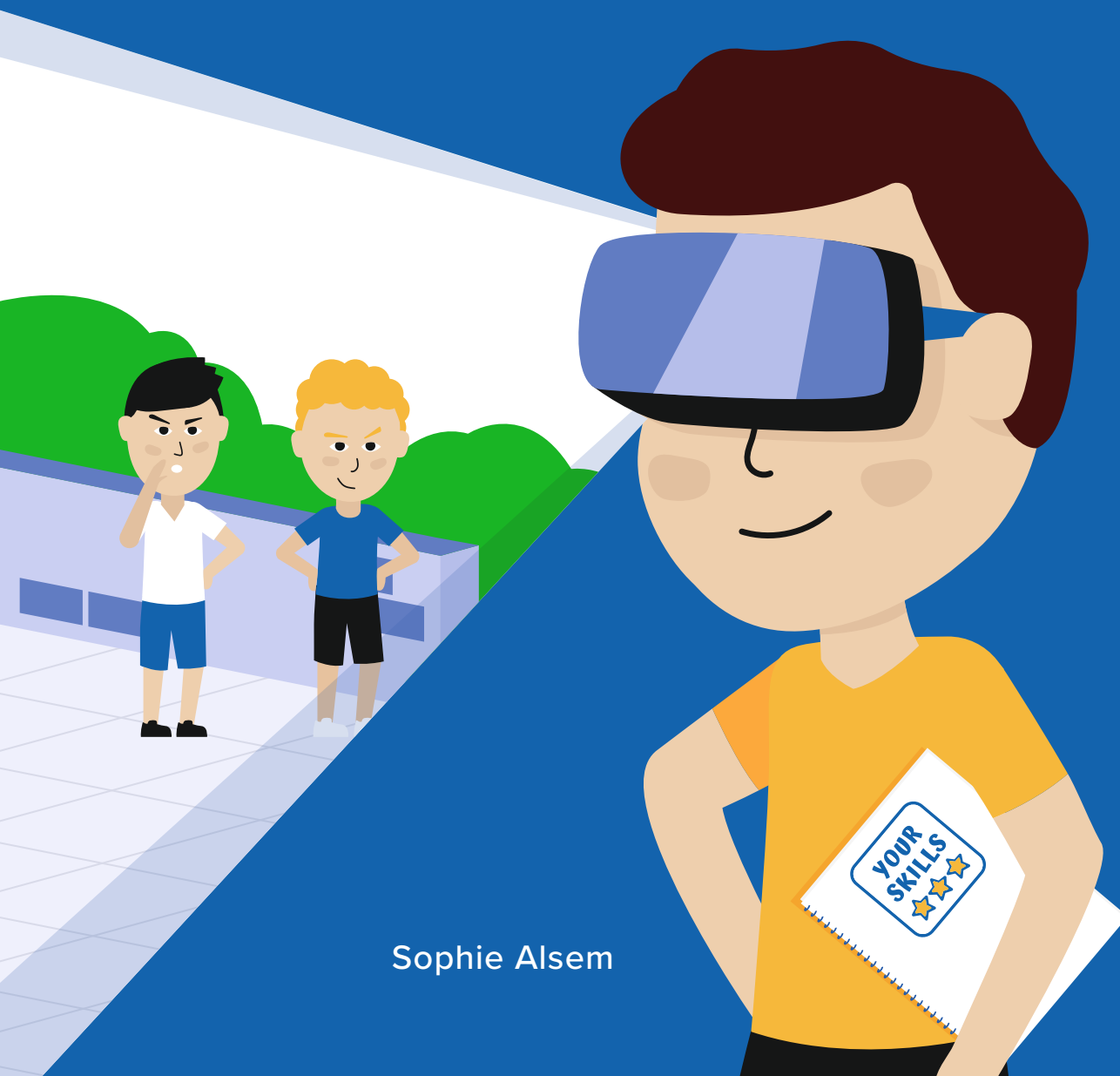# IMPROVE YOUR SKILLS WITH VIRTUAL REALITY

Enhancing and understanding treatment effects
for aggressive behavior problems in children

Sophie Alsem

IMPROVE YOUR SKILLS WITH VIRTUAL REALITY

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VERBETER JE VAARDIGHEDEN MET VIRTUAL REALITY

Versterken en Begrijpen van Behandeleffecten
voor Agressieve Gedragsproblemen bij Kinderen
(met een samenvatting in het Nederlands)

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de
Universiteit Utrecht op gezag van de
rector magnificus, prof.dr. H.R.B.M. Kummeling,
ingevolge het besluit van het college voor promoties
in het openbaar te verdedigen op
vrijdag 17 maart 2023 te 4:15 uur

door
Sophie Catharina Alsem
geboren op 14 juni 1991
te Groningen

CONTENTS

1

General introduction

AGGRESSIVE BEHAVIOR PROBLEMS

Aggressive behavior problems are among the most prevalent problems affecting school-aged children (Costello et al., 2003; Merikangas et al., 2009) and a common reason for referring children to mental health care (Lochman & Matthys, 2017). When left untreated, the prognosis of children with aggressive behavior problems is poor, due to the persistence and stability of these problems over time (Burks et al., 2001; Girard et al., 2019; Jester et al., 2008). Aggressive behavior problems predict adverse outcomes later in life, such as delinquency, substance abuse, poor school adjustment, and disturbances in relationships with peers (Burkey et al., 2018; Evans et al., 2021; Loeber & Farrington, 2000; Romeo et al., 2006), and also have a continuing negative impact on children's social environment (McConaughy & Skiba, 1993; Wilson & Lipsey, 2006). To prevent escalation of aggressive behavior problems into persistent negative outcomes, it is important to treat these problems as they arise in childhood (Lochman & Matthys, 2017). Although, treatments are available to reduce children's aggressive behavior problems, current intervention effects are modest and do not benefit all children (McCart et al., 2006).

This dissertation includes research that may help enhance treatment effects for children with aggressive behavior problems. Our research was guided by two overarching aims. The first aim was to examine whether treatment effects can be enhanced by using interactive virtual reality. The second aim was to increase our understanding of potential treatment mechanisms, focusing on two known treatment targets for aggression: anger regulation and hostile intent attribution.

CURRENT TREATMENTS

Currently, one of the most effective ways to treat aggressive behavior problems in school-aged children is through parent training programs (Kaminski & Claussen, 2017; McCart et al., 2006). These programs can effectively improve parenting skills and subsequently reduce children's aggressive behavior problems (Kaminski et al., 2008). However, parent training programs are not always suitable nor equally effective for all families (Leijten et al., 2012). This may not be surprising, as parenting programs cannot directly focus on deficits in social-cognitive child factors, that often predict and maintain children's aggressive behavior problems (de Castro & van Dijk, 2017). Child-focused cognitive behavioral therapy (CBT) targets social-cognitive and emotional processes more directly than parent training programs and can have significant and lasting benefits for children (Weisz & Kazdin, 2017). However, so far CBT treatment effects on aggressive behavior problems are modest and heterogeneous: not all children benefit equally (McCart et al., 2006).

Research into current CBTs has shown that these are most effective when cognitions are actively challenged and children can practice with solving real-life social problems (de Mooij et al., 2020; Landenberger & Lipsey, 2005). Most CBTs for aggressive behavior problems use roleplays exercices (Menting et al., 2015), where children can practice new cognitions and skills in roleplay exercises with their therapists (in individual CBT) or with other children with aggressive behavior problems (in group CBT). Although roleplays seem flexible and easy to deploy, they may also be limited by children's lack of motivation or abilities in perspective taking and imagination (Hadley et al., 2019; Park et al., 2011). In individual CBT, children may have difficulties to pretend to interact with a peer while interacting with a therapist, and in group CBT, roleplay practices may be limited due to group management issues. Hence, new intervention methods are needed that facilitate realistic and engaging practice with social interactions (Weisz et al., 2019). Intervention improvements are also needed that use strategies to build and sustain youth engagement, for example by using digital innovations (Weisz et al., 2019). This dissertation evaluates such an intervention.

AIM 1:
Enhancing treatment effects using virtual reality

Interactive virtual reality may be a promising new method to enhance effects of current CBT for children with aggressive behavior problems. In interactive virtual reality, children are completely immersed in a virtual environment where they can walk around freely, interact, talk, and play with virtual peers and adults in various situations. This offers a realistic and engaging environment to practice in during treatment (Lindner, 2021), as alternative for currently used roleplays (Garland et al., 2008; Sukhodolsky et al., 2016). Virtual reality has three important benefits to optimize treatment effectiveness: 1) it provides an involving and immersive environment to practice in; 2) it may enhance treatment motivation; and 3) it allows for individually tailored exercises.

First, virtual reality provides an involving and immersive environment to practice in. As interventions are most effective when cognitions and behaviors are challenged in emotionally engaging situations (Suveg et al., 2007), children with aggressive behavior problems should ideally practice in anger provoking situations (Sukhodolsky et al., 2016). Possibly, the emotional impact of roleplay exercises in current CBTs is too small to induce major treatment effects, as roleplays highly depend on children's memory and imagination skills (Park et al., 2011). In a virtual environment, children are fully immersed, allowing them to have real interactions with peers and adults that may evoke substantial levels of anger. Indeed, research

showed that virtual reality can successfully elicit anger in children with aggressive behavior problems (Verhoef, van Dijk, et al., 2021).

Second, virtual reality may enhance children's treatment motivation. Children with aggressive behavior problems often show low motivation, or even resistance, to treatment (Frick, 2012; Lochman et al., 2019). Enhancing treatment motivation seems crucial, as it has been positively related to treatment effectiveness (Lochman, Kassing, et al., 2017). Virtual reality may appeal to children as it matches their involvement in technology nowadays (Bakker et al., 2016; Weisz et al., 2019). Indeed, children's treatment participation can be enhanced by using digital methods (i.e., adding an internet component) in treatments for children with aggression problems (Lochman, Boxmeyer, et al., 2017). Specifically virtual reality is found to be a very appealing method for these children (Verhoef, van Dijk, et al., 2021).

Third, virtual reality allows for individually tailored exercises. Currently, most CBTs for children with aggressive behavior problems are delivered in a group format, allowing children to practice in roleplays with actual peers (Lochman et al., 2019). However, group treatments may yield iatrogenic effects for youth with aggressive behavior problem as children may encourage each other to engage in aggressive behavior ('deviancy training'; Dodge et al., 2006). In addition, there are limited opportunities in a group format to adjust and personalize the exercises to each child's needs and characteristics. Virtual reality provides an unique opportunity to combine individual therapy with ecologically valid practice with virtual peers, controlled by the therapist. Individually tailored interventions for children can indeed be more effective than the traditional 'one size fits all' approach or group treatments (Lochman et al., 2015; Weisz et al., 2011; Wilson & Lipsey, 2007).

This dissertation examined whether treatment effects can be enhanced by using interactive virtual reality in individual CBT. To this end, we developed an interactive virtual reality environment for children to practice in during treatment. To promote the most optimal engaging situations that corresponded with children's daily life, we designed three interactive and realistic virtual environments: a classroom, a schoolyard, and a living room. In these environments, children could practice in anger-provoking situations (e.g., being laughed at by a peer). Therapists could evoke children's anger by manipulating the virtual situation itself (e.g., letting the child lose a game, or switching off the television) or by manipulating the speech and actions of the virtual characters (e.g., let a peer show a middle finger, or walk towards the child). Children could walk around freely (in reality, children walked through a therapy room), talk with virtual children and adults, and play games such as building a tower or playing a computer game. Children held controllers

in both hands, allowing them to grab and throw virtual objects. Research in this dissertation compared CBT with and without this virtual environment.

YourSkills treatment

To be able to integrate interactive virtual reality into all facets of treatment, we developed the new individual CBT 'YourSkills'. We designed two versions of YourSkills with identical content, but with different practice modes: one using virtual reality and one using roleplay. This allowed us to compare a treatment with virtual reality to the identical treatment using roleplay practice. YourSkills is based on evidence-based treatments for children with aggressive behavior problems and consists of one 45-minute introduction session with parents and ten 45-minute sessions with the child. During the sessions, children practice anger recognition, anger regulation, and social problem solving in social interactions. Although YourSkills is primarily focused on the child, it also promotes parent involvement by providing parents with an introduction session and by including them at the end of each child session.

To enable children to practice their regulation skills whilst being emotionally engaged, therapists created challenging social situations for children in virtual reality or roleplays. The YourSkills materials included twenty-six cards with brief descriptions of anger-provoking situations, based on a taxonomy of problematic situations for children with aggressive behavior problems. They include: being disadvantaged, authority conflicts, peer rejection, and peer provocation (Matthys et al., 2001). From this taxonomy, therapists selected those situations that matched each child's individual needs.

To examine the effectiveness of our new treatment with virtual reality, we conducted a randomized controlled trial with three conditions. We compared our newly developed YourSkills with virtual reality to the same treatment with roleplay exercises, and to care-as-usual in clinical practice. We expected the most beneficial treatment effects for the virtual reality group. Additionally, we expected that children practicing in virtual reality would appreciate the treatment more and would be more emotionally engaged and immersed than children practicing in roleplays.

AIM 2:
Understanding treatment mechanisms

Another step towards the optimization of interventions is increasing our understanding of treatment mechanisms (Lochman & Matthys, 2017). Identifying which mechanisms of change need to be targeted, seems crucial to obtain

genuine improvements in treatment effects (Weisz et al., 2019). Although the effectiveness of interventions for aggressive behavior problems is commonly studied (Weisz & Kazdin, 2017), surprisingly few studies have investigated the underlying mechanisms through which these interventions exert their beneficial effects (Kazdin, 2009). By identifying these mechanisms of change we cannot only improve our understanding of the development of aggressive behavior problems in children (Kazdin & Nock, 2003), but also ensure that current interventions include solely relevant components (Kraemer et al., 2002). In addition, some underlying mechanisms may be associated with multiple problems, such as externalizing and internalizing problems, and addressing them may thus facilitate parsimony across interventions (Granic, 2014; Kazdin & Nock, 2003). Research in this dissertation therefore examined two intervention targets common in CBT for children with aggressive behavior problems: anger regulation and hostile intent attribution.

Anger regulation and hostile intent attribution
Interventions to reduce children's aggressive behavior problems often target anger regulation and hostile intent attribution as possible mechanisms of change (Bookhout et al., 2017; Chorpita & Daleiden, 2009). Both mechanisms are part of the social information processing model (Crick & Dodge, 1994; Lemerise & Arsenio, 2000). This model assumes that children engage in a series of ordered processing steps (e.g., encoding, interpretation, goal selection, response generation) when they respond to social situations. Adequate processing at each step leads to competent behavior in a situation, whereas biased or deficient processing may cause aggressive behavior (Crick & Dodge, 1996). Deviant social information processing has been shown to both precede and maintain children's aggressive behavior problems (de Castro et al., 2015; Dodge et al., 2006).

Empirical research has shown that children with aggressive behavior problems often have difficulties with anger regulation, have a limited repertoire of anger regulation strategies (for reviews see: Roberton et al., 2012; Röll et al., 2012), and display a stronger tendency to interpret ambiguously intended social behavior as stemming from hostile intent (for a review, see: Verhoef et al., 2019). Anger regulation refers to the extrinsic and intrinsic processes that children use to maintain or modify the valence, intensity or duration of their feelings of anger (Cole et al., 2004; Zeman et al., 2006). Anger regulation is a core element in interventions for aggressive behavior problems (Chorpita & Daleiden, 2009; Garland et al., 2008), and targeting anger regulation in treatments is associated with larger reductions in children's aggression (Landenberger & Lipsey, 2005; Sukhodolsky et al., 2016).

Hostile intent attribution is part of the interpretation step in the social information processing model. In this step, a child attributes meaning to intentions of another person's behavior (Crick & Dodge, 1994). Unwarranted attributions that this behavior was conducted with hostile intent can result in aggression. Children with aggressive behavior problems have been found to systematically overinterpret others' intentions as hostile (Verhoef et al., 2019). Unwarranted hostile intention attributions occur most strongly when children are emotionally involved in the social situation (Yaros et al., 2014) or feel frustrated (de Castro et al., 2003). As such, children's hostile intent attribution can also be an effective target for CBT interventions (Lochman et al., 2019; Lochman, Boxmeyer, et al., 2017).

Although there is ample empirical evidence for anger regulation and hostile intent attribution as risk factors for the development of aggressive behavior problems (Röll et al., 2012; Verhoef et al., 2019), it is less clear whether intervention-induced changes in these mechanisms would also subsequently lower children's aggressive behavior. Studying this was the goal of the present dissertation.

Identifying mechanisms of change

When aiming to identify treatment mechanisms, we want to know whether changes in a potential mechanism within a child are related to changes in treatment outcomes in that particular child. Therefore, it is important to examine treatment mechanisms at the within-person individual level (Kazdin, 2011; Laurenceau et al., 2007). Currently however, most research is conducted at the between-person level. As we cannot conclude that evidence from between-person analyses is similar to evidence from within-person analyses (Burke & Loeber, 2016; Kazdin, 2011), research in this dissertation focused on the within-person individual level and examined anger regulation and hostile intent attribution as mechanisms of change for aggression. Two studies were conducted to examine (1) spontaneous covariation over weeks in anger regulation, hostile intent attribution and aggression at the within-person individual level, as well as (2) intervention-induced changes at the individual level, showing whether interventions for aggression problems exert their beneficial effects by changing anger regulation and hostile intent attribution.

Research at the individual level requires high-frequency measurements such as diary report methods (Curran & Bauer, 2011). Using repeated measurements over a pre-defined period (e.g., days or weeks; Lischetzke, 2014) has several important advantages. First, the chances of identifying a treatment mechanism are enhanced (Kazdin, 2007). Wide-ranging trajectories can be observed and provide a picture of how change unfolds over time. This means that conclusions are less dependent on the moment of the measurements (Laurenceau et al., 2007). Second, high-

frequency measurements may better correspond with actual fluctuations in the theorized mechanisms of change. For example, for anger regulation and hostile intent attribution the short-term variability is found to be high, with levels depending on the moment and context (Colasante et al., 2016; de Castro et al., 2003). This means that changes in children's anger regulation and hostile intent attribution are expected to directly affect their subsequent (aggressive) behavior in the situation (de Castro et al., 2015).

Transdiagnostic mechanisms

Anger regulation and hostile intent attribution do not solely contribute to aggressive behavior, but are related to multiple problems in children (Granic, 2014; Kazdin & Nock, 2003). This suggests that these mechanisms might function as transdiagnostic factors, demonstrating that one mechanism in a child accounts for multiple problems for that child. Indeed, cooccurrence rates of aggressive behavior problems with anxiety problems are high in school-aged children. Identifying transdiagnostic factors seems crucial, as they may be important intervention targets to treat cooccurring problems effectively. Possibly, children with cooccurring problems may benefit more from one comprehensive treatment targeting identified transdiagnostic factors than from separate treatments targeting one single problem each (Oland & Shaw, 2005). This dissertation therefore took a transdiagnostic approach to explain comorbid aggression and anxiety problems with hostile intent attribution as transdiagnostic treatment mechanism.

OUTLINE OF THIS DISSERTATION

This dissertation aimed to provide more insight in ways to improve treatment effects for children's aggressive behavior problems. To this end, part one investigated whether treatment effects could be enhanced using virtual reality. Subsequently, part two aimed to increase our understanding of treatment mechanisms, focusing on anger regulation and hostile intent attribution. Table 1 provides an overview of the chapters in this dissertation.

In **Chapter 2**, a pilot study, we examined whether interactive virtual reality is a feasible treatment method for children with aggressive behavior problems. This chapter also investigated children's appreciation of the method and explored whether children's aggression decreased during the treatment. Subsequently, **Chapter 3** describes a multicenter randomized controlled trial, where we examined whether interactive virtual reality enhanced effectiveness of cognitive behavioral therapy (CBT) to reduce children's aggressive behavior problems. We additionally examined whether therapists, children themselves, and their parents experienced

benefits of virtual reality over roleplays as treatment method for children with aggressive behavior problems.

Part two of this dissertation focused on treatment mechanisms for children's aggressive behavior problems. In **Chapter 4**, we examined whether within-person changes in adaptive anger regulation and hostile intent attribution covaried with within-person changes in children's aggression. Building upon this, we investigated in **Chapter 5** whether interventions for aggressive behavior problems exert their beneficial effects by changing anger regulation and hostile intent attribution. We used high-frequency measurements to examine adaptive anger regulation and hostile intent attribution as mechanisms of change in an intervention to reduce children's aggressive behavior problems.

Anger regulation and hostile intent attribution might also contribute to other problems in children, such as anxiety, and might thus be important targets to treat cooccurring problems effectively. In **Chapter 6** we investigated, in two samples, whether children's hostile interpretation of others' intentions was a transdiagnostic factor for cooccurring aggression and anxiety problems in children.

Chapter 7 summarizes the main findings of the included studies, discusses their practical and theoretical implications, and provides directions for future research.

Table 1

Overview of the studies in this dissertation.

Chapter	Type of study	Measurements	Sample	Age	Recruitment setting
2	Pilot	10 weekly measures	6 boys	8-12 years	Clinical centers
3	Randomized controlled trial	Pre- and post-intervention	115 boys[a]	8-13 years	Clinical centers
4	Repeated measures	4 weekly measures	223 children	7-12 years	Primary education
5	Repeated measures	11 weekly measures	76 boys[a]	8-13 years	Clinical centers
6	Cross-sectional	1 measurement	Study 1: 84 boys Study 2: 115 boys[a]	7-13 years 8-13 years	Primary (special) education and clinical centers

[a] These studies include the same sample (for Chapter 5 a subsample was used).

PART

1

Enhancing treatment effects using virtual reality

Using virtual reality to treat aggressive behavior problems in children:
A feasibility study

ABSTRACT

Evidence-based cognitive behavioral therapies (CBT) for children with aggressive behavior problems have only modest effects. Research is needed into new methods to enhance CBT effectiveness. The aims of the present study were to (1) examine whether interactive virtual reality is a feasible treatment method for children with aggressive behavior problems; (2) investigate children's appreciation of the method; (3) explore whether children's aggression decreased during the ten-session treatment. Six boys (8-12 years) participated at two clinical centers in the Netherlands. Newly developed weekly reports were collected on treatment feasibility (therapist-report), treatment appreciation (child-report), and children's aggression (child/parent-report). Results supported treatment feasibility: Therapists delivered on average 98% of the session content, provided more than the recommended practice time in virtual reality, experienced few technical issues, and were satisfied with their treatment delivery. Children highly appreciated the treatment. Parents reported decreases in children's aggression over the treatment period (i.e., between week 1 and week 10), but children did not. The promising findings of this feasibility study, warrant randomized controlled trials to determine whether interactive virtual reality enhances CBT effectiveness for children with aggressive behavior problems.

Keywords
Cognitive behavioral therapy, aggression, virtual reality, children, feasibility, intervention

Author contributions
All authors were involved in conceptualizing the study. SA coordinated the data collection, analyzed the data, and wrote the first draft of the manuscript. All authors provided feedback on the manuscript.

INTRODUCTION

Aggressive behavior problems are among the most prevalent problems affecting children (Lochman & Matthys, 2017). Children with aggressive behavior problems are at heightened risk for adverse outcomes later in life, such as lower educational achievement, delinquency, substance abuse, and mental health issues (Burkey et al., 2018; Loeber & Farrington, 2000). To prevent escalation of aggressive behavior into persistent negative outcomes, it is important to treat aggressive behavior problems as they arise in childhood (Lochman & Matthys, 2017). Cognitive behavioral therapy (CBT) has been shown to reduce aggression in children (Weisz & Kazdin, 2017). However, effects have been modest and heterogeneous (McCart et al., 2006), with stronger effects for CBT interventions in which children practice more with anger exposure and solving real-life social problems (de Mooij et al., 2020; Landenberger & Lipsey, 2005). Therefore, new methods are needed that may enhance ecologically valid exposure and practice (Weisz et al., 2019). Interactive virtual reality is a promising method to enhance effects of current CBT for children with aggressive behavior problems. The present study investigated the feasibility of this treatment method.

Interactive virtual reality seems particularly beneficial to reduce reactive aggression—the most prevalent form of aggression in middle childhood (Vitaro et al., 2002). Reactive aggression can be defined as aggression in response to perceived threat or frustration (Dodge, 1990). To reduce this form of aggression, most CBT interventions target deficits in emotion regulation and social cognitive processing—two mechanisms underlying childhood aggression (Crick & Dodge, 1994; Lochman & Matthys, 2017). As part of CBT, children learn to monitor their anger and use techniques to modulate elevated levels of anger during social interactions (Chorpita & Daleiden, 2009; Sukhodolsky et al., 2016). This is based on the assumption that children's aggression will decrease when they become better at regulating their anger. Therapists typically teach anger regulation in role plays (Garland et al., 2008; Sukhodolsky et al., 2016). In fact, role play practice is integrated in 83% of evidence-based child CBT and parent training interventions for children with externalizing behavior problems (Menting et al., 2015). Interactive virtual reality offers a virtual environment for role play practice. This method seems promising for three reasons: (1) it allows for individually tailored exercises in social interactions; (2) it provides an immersive and emotionally involving environment needed to practice emotion regulation; and (3) it may be a motivating and engaging treatment approach for today's youth.

Individually tailored exercises

Most CBT's for children with aggressive behavior problems are delivered in group format, providing a natural context to practice in role play (Lochman et al., 2019). However, group formats may actually reduce CBT effectiveness. Prior studies have shown iatrogenic effects of group therapy for youth with aggressive behavior problems ('deviancy training'; Dodge et al., 2006). Furthermore, the specific situations, cognitions, and behaviors that children need to practice in therapy will be unique to each individual child. Indeed, research has shown that individual therapy leads to larger decreases in children's aggressive behavior problems than group-format therapy (Lochman et al., 2015; Wilson & Lipsey, 2007). Thus, 'tailoring' treatment to each child's needs and characteristics may increase CBT effectiveness—an advantage also recognized by therapists working with these children (Lochman, Kassing, et al., 2017).

How then, can we provide the paradoxical combination of tailored individual treatment together with ecologically valid practice with actual peers? Interactive virtual reality may provide a solution. In interactive virtual reality, children can interact, talk, and play with virtual peers in different situations, controlled by the therapist. This allows them to practice new cognitions and behavior in tailored 'role plays'—even though they receive individual treatment.

An emotionally involving practice environment

Research suggests that therapy is most effective when cognitions and skills are challenged and practiced in emotionally involving situations (Suveg et al., 2007). Thus, children with aggressive behavior problems should ideally practice in anger provoking situations (e.g., being provoked by peers; Sukhodolsky et al., 2016). Interactive virtual reality offers this possibility. First, interactive virtual reality can simulate anger-provoking situations encountered in daily life. In virtual reality, children are fully immersed in the virtual environment and do not have to rely on their memory or imagination to practice with these situations (Park et al., 2011). Second, virtual reality allows children to practice with dynamic, realistic social challenges, adapted to their abilities (Kandalaft et al., 2013). Therapists can trigger children's anger within ethical boundaries, using a fully controlled virtual environment that can be adapted or stopped at any time. Third, virtual reality allows for repetitive practice in a stimulating environment (Newbutt et al., 2016; Saiano et al., 2015), allowing children to automatize newly learned skills. Indeed, a recent study showed that it is possible to repeatedly elicit children's anger in virtual reality, so that they can practice repeatedly whilst remaining emotionally engaged (Verhoef, van Dijk, et al., 2021).

Motivating and engaging treatment approach

Children with aggressive behavior problems often display low motivation and resistance to treatment (Frick, 2012; Lochman et al., 2019). It is important to enhance children's treatment motivation, which has been related to increases in treatment effectiveness (Lochman, Kassing, et al., 2017). Virtual reality may serve this goal. It may appeal to children, as it resonates with their involvement in digital innovations nowadays (Weisz et al., 2019). Indeed, using technology (i.e., adding an internet component) can increase treatment engagement of children with aggressive behavior problems (Lochman, Boxmeyer, et al., 2017). Similarly, virtual reality has been shown to enhance treatment motivation and attendance in adolescents and adults (Hadley et al., 2019; Park et al., 2011). Last, children with aggressive behavior problems who participated in virtual reality research indicated that they found this method very appealing (Verhoef, van Dijk, et al., 2021).

The present study

Given the potential advantages of using virtual reality, we decided to develop an individual CBT with interactive virtual reality for children with aggressive behavior problems. To our knowledge, this is implementation of virtual reality in therapy for children with aggressive behavior problems. Hence, we decided to conduct a small-scale feasibility study. The aim of this study was to describe the content, appreciation, and feasibility of this treatment approach. We developed the CBT 'YourSkills' and designed a virtual reality-based version of this treatment, in which children practice emotion regulation and social information processing in interactive virtual reality to decrease their aggressive behavior. We examined the feasibility of YourSkills with virtual reality using therapist reports, investigated children's appreciation of the treatment, and explored whether children's aggressive behavior problems decreased during treatment according to both parents and children.

METHOD

Participants

Six boys referred for aggressive behavior problems were recruited at two clinical centers in the Netherlands. These centers provide mental health care for children with a broad range of mental health problems, including aggressive behavior problems. All children met the inclusion criteria for YourSkills: age 8-12 years, aggressive behavior problems (according to the clinic's records), intelligence level above 80, no severe autism spectrum disorder, and no epilepsy or severe visual or auditory limitations. We chose to only include children from 8-12 years as these

children are old enough to profit from CBT (McCart et al., 2006) and still in Dutch elementary school. Only boys were included because we initially developed YourSkills specifically for this group, considering that girls' development, forms, and outcomes of aggression are found to be different from boys (Underwood, 2002). Therapists invited parents of children who met the inclusion criteria to participate in this feasibility study. Parents provided active consent for participation in this study. The study was approved by the Medical Ethics Committee of the Utrecht University Medical Center (NL67139.041.18).

Procedure

This feasibility study followed children participating in ten weekly treatment sessions of YourSkills with interactive virtual reality. Therapists rated a short questionnaire after each session, assessing treatment feasibility. After the treatment, therapists indicated their satisfaction with treatment delivery and answered an open-ended question about their general evaluation of YourSkills. Children and parents filled out a short questionnaire during each treatment session, assessing children's appreciation of the treatment (child-report) and aggressive behavior (child- and parent-report) from pre-treatment (week 1) to post-treatment (week 10).

Treatment

YourSkills with interactive virtual reality is a manualized CBT, developed through iterative discussions between experienced health care psychologists and researchers. YourSkills is based on evidence-based treatments for children with aggressive behavior problems, including Coping Power (Lochman et al., 2008) and Self-Control (van Manen, 2001). We chose to develop a new treatment manual, rather than adding virtual reality to an existing treatment. This way, we could integrate interactive virtual reality into all facets of our treatment (rather than merely replacing role play exercises with virtual reality).

YourSkills consists of one 45-minute introduction session with parents and ten 45-minute sessions with the child (Table 1). The aim of YourSkills is to reduce children's aggressive behavior problems by enhancing emotion regulation and social information processing skills. Children practice anger recognition, anger regulation, and social problem solving in virtual social interactions. In each session, therapists first explain a new skill, then model the skill using role play, and then use virtual reality to let children practice the skill in anger-provoking social situations. YourSkills includes a reward system to motivate children to practice the newly learned skills. Children receive tokens for each time they practiced, both during the session and at home.

All treatment sessions have the same structure, providing a predictable course of the sessions for children. First, therapists show children the session's agenda and ask them to rate a brief outcome rating scale (see Measures). Next, therapists briefly discuss last week's "at home training" (i.e., homework assignments, such as practicing relaxation at least three times). Most of the session time is then spent on practicing the session's new skill in virtual reality. Children practice the same skill several times in different situations or with increasing difficulty level. After practicing, children rate a brief session rating scale to assess their appreciation of the treatment (see Measures). During the last ten minutes of each session, therapists invite parents, summarize the session, and discuss next week's homework assignment.

Although YourSkills is primarily focused on the child, it also promotes parent involvement. Parents have an important role in child CBT: they are the ones to bring their child to the sessions, provide information about their child's behavior, and recognize and reward their child's efforts at home (Sukhodolsky et al., 2016). For this reason, YourSkills starts with an introduction session for parents (Table 1), and involves parents at the end of each session. Additionally, therapists send parents an e-mail summarizing each session directly after each session.

In this study, YourSkills was delivered by four licensed therapists with a background in child psychology and CBT. Therapists received a two-day course in YourSkills, supervised by the first and second author and a certified psychologist. Therapists learned to work with the treatment manual and virtual reality equipment during the course, and could receive consultation by phone during the treatment period.

Virtual reality
The YourSkills virtual reality environment consists of a classroom, a schoolyard, and a living room, built by the technological company CleVR (see Figure 1). Children enter an immersive digital environment, where they have full mobility: they can walk around in the digital world, move objects, play games, and interact with virtual others. Children wore an Acer Windows Mixed Reality headset, a noise cancelling headphone, and they held controllers in both hands, allowing them to grab and throw virtual objects. In the first session, therapists explained to children that the virtual environment allowed them to walk around freely (within a 3×3 meter area), talk with virtual children and adults, and play games such as building a tower or playing a game on the television. Virtual peers were boys and girls from the same age range, who had average height and dark hair. Virtual adults were male and female characters with diverse physiques. Children were asked to select the characters that most resembled their parents, siblings, or teachers.

Table 1

Content of the YourSkills treatment sessions.

Session	Content*
Introduction session with parents	• Parents learn about the content of the therapy • Therapist emphasizes the importance of parent and teacher involvement (e.g. assisting in home work, reinforcing practiced skills at home) • Parents formulate relevant anger provoking situations for their child
1. Know yourself	• Child and therapist get to know each other, and discuss the child's strengths • Therapist introduces emotions and explains how angry feelings link to specific situations • Child becomes acquainted with interacting in virtual reality • Child learns how the reward system and at-home training work
2. Check your feelings	• Therapist explains how anger builds up, which is visualized using an anger stairs (similar to thermometer or stoplight methods) • Child practices with recognizing angry feelings in virtual reality, focusing on bodily sensations and cognitions
3. Take a break	• Child learns how to take a time-out (i.e., behavioral distraction) and practices this skill in virtual reality
4. Feel relaxed	• Child learns how to use relaxation exercises (i.e., behavioral relaxation) and practices this skill in virtual reality
5. Think strong	• Child learns how to use helping thoughts (i.e., cognitive reappraisal) and practices this skill in virtual reality
6. Think again	• Child learns how to change negative interpretations (i.e., attribution retraining, perspective taking) and practices this skill in virtual reality
7. Make a smart move	• Child learns that being agreeable can be the best solution (i.e., problem solving) and practices this skill in virtual reality
8. Stand together	• Child learns how to ask an adult for help (i.e., problem solving) and practices this skill in virtual reality
9. Pro training	• Child rehearses the learned skills in virtual reality • Child and parents agree on a 'secret signal' as a reminder for the child
10. Expert training	• Child rehearses the learned skills in virtual reality • Child and therapist make a relapse prevention plan • Parents, child and therapist end the treatment with a certificate

* Additionally, all sessions start with an outcome rating scale and a discussion of last week's homework, and end with a session rating scale and a discussion of next week's homework with parents

Therapists used the virtual environment to create challenging social situations for children to practice with. The YourSkills virtual reality software consists of twenty-six anger-provoking starting situations that therapists could tailor to children's individual needs. These situations were based on a taxonomy of problematic

situations for children with aggressive behavior problems. They include: being disadvantaged, authority conflicts, peer rejection, and peer provocation (Matthys et al., 2001). All situations were designed to trigger moderate levels of anger, aiming to help children practice their regulation skills whilst being emotionally engaged. Therapists fully controlled the virtual environment and could immediately adapt or stop the situation if needed.

Each session, therapists prepared children by explaining that they would use the virtual reality environment to try to evoke their angry feelings. Therapists could evoke children's anger by manipulating the virtual situation itself (e.g., letting the child lose a game, switching off the television) or by manipulating the speech and actions of the virtual characters. Therapists used a microphone with voice transformer to emulate a different voice for each virtual character. They used a tablet to control the characters' bodily movements (e.g., walking away), gestures (e.g., raising a middle finger), and facial expressions (i.e., an expression scale from happy to angry). The dynamic nature of virtual reality allows the therapist to tailor exercises to the specific needs and goals of the child, for example by making provocative behavior of virtual peers more or less subtle, or by responding to children's behavior in ways that would trigger their anger in daily life.

Figure 1
Virtual reality classroom, living room and schoolyard environments.

Measures

Feasibility

Therapists rated four aspects of treatment feasibility after each session. First, they indicated whether they had completed each session element (e.g., discuss homework, explain skill) by rating '*done*' or '*not done.*' To estimate feasibility, we calculated the percentage of completed elements out of all ten elements in each session. Second, therapists reported any technical issues with the virtual reality equipment. Third, they estimated the time children practiced in virtual reality (recommended time was ten minutes). Fourth, they reported how many times children practiced a skill in virtual reality (recommended number was at least two times). After the last session, therapists completed three items on their satisfaction with treatment delivery across all sessions (i.e., *For this child I successfully delivered the 10 sessions of the treatment,*' '*For this child I am satisfied with how I delivered the treatment,*' and '*For this child I am confident that I successfully delivered the treatment*') on a scale from 1 ('*not at all*') to 5 ('*totally*'). Ratings were averaged across the three items. Last, after all treatment sessions, therapists were asked the open ended question '*How did you experience working with YourSkills with interactive virtual reality?*' We used their answers to add relevant descriptions of therapists' experiences to the data.

Children's appreciation

Children rated two items on their treatment appreciation at the end of each session (i.e., '*I liked what we did today*' and '*I am looking forward to the next time*') on scale from 1 ('*not at all*') to 5 ('*totally*'). Ratings were averaged between the two items.

Aggressive behavior

We assessed children's aggressive behavior in the past week during each treatment session. To assess weekly change in children's aggression during the treatment, a measure was needed that can be used for such frequently repeated measurements (Lischetzke, 2014). Therefore, we chose to use a new weekly report measure (Alsem, Keulen, et al., 2022). Parents and children rated three items (i.e., '*This week I/my child fought with someone,*' '*This week I/my child kicked or beat someone,*' and '*This week I/my child called someone names*') on a scale from 1 ('*never*) to 5 ('*very often*'). Ratings were averaged across items. The child report version of this measure was investigated in another study (n = 223, M_{age} = 10.18, SD = 1.21; (Alsem, Keulen, et al., 2022). Results showed adequate internal consistency (i.e., Cronbach's α's ranged from .64 to .69 over four weeks) and supported the convergent and concurrent validity.

Analyses

We used descriptive statistics to investigate treatment feasibility and children's appreciation. To explore whether children's aggression decreased over the treatment period, we inspected means and standard deviations of aggression in week 1 and week 10 for child- and parent-report. We also evaluated graphs of within-person change in aggression by plotting all 10 ratings over the treatment period. As our small-sample study was not designed to examine significant changes over time at the group level, no statistical tests were conducted.

We had missing data on parent-reported aggression for two children, because one parent did not speak Dutch and the other parent forgot to provide ratings for more than half of the weeks. For missing data of aggression being used in the graphs, we used last observation carried forward (LOCF). This approach seemed appropriate as no participants dropped out of the study and the percentage of missing data was low (2%).

RESULTS

Feasibility

Therapists indicated that working with the interactive virtual reality was feasible. Despite working with new equipment, they managed to carry out almost all session elements (M = 98%; range = 95-100% across therapists and sessions). In the open evaluation question, therapists indicated that in the first sessions they needed extra preparation time (15 min) to set up the virtual reality equipment. However, after a few sessions, they were able to set it up quickly and easily.

Therapists experienced few technical problems. They effectively used the virtual reality equipment in 59 of the 60 sessions (98.3%). Only in one session did a therapist encounter a technical problem (i.e., the VR headset stopped tracking) that could not be solved before starting the session, upon which she decided to use role plays instead. In eight other sessions, therapists encountered a small technical problem while setting up the equipment, such as hearing no sound through the headset or not seeing the controllers in the virtual reality. They resolved these small problems themselves.

Therapists indicated that children practiced more in virtual reality than the recommended 10 minutes (M = 11.7 minutes, SD = 1.35). Within this practice time, children practiced their new skill more often than the recommended two times (M = 3.4, SD = 1.08). The last two sessions were meant for skill rehearsal. In these

sessions, children practiced even longer (i.e., M = 13.0 minutes, SD = 2.74 in session 9; M = 14.2, SD = 2.04 in session 10).

Therapists were satisfied with how they delivered the treatment (M = 4.06, SD = 0.49, on a 5-point scale). In response to the open evaluation question, therapists indicated that they had an overall positive experience using the virtual reality. They experienced that skill rehearsal in virtual reality is important to reinforce children's learned skills. In addition, they indicated that children participated very actively in the virtual environment and quickly knew how to use the virtual reality equipment.

Children's appreciation
Children liked the treatment very much. Across the ten sessions, children's average appreciation score was 4.68 (SD = 0.33) on a 5-point scale. Looking at the treatment sessions separately, we found that children were positive about all ten sessions (i.e., mean appreciation scores ranged from 4.44 to 4.83 across sessions).

Changes in aggressive behavior
As predicted, parent-reported aggression decreased between week 1 (M = 3.25, SD = 0.88) and week 10 (M = 2.08, SD = 0.57). This is an average decrease of 1.17 (SD = 0.58), equaling 2.02 standard deviations improvement. However, when looking at child-reported aggression, almost no change was seen between week 1 (M = 2.06, SD = 0.53) and week 10 (M = 1.78, SD = 0.60), possibly because children's aggression ratings were already modest at pre-test (i.e., M = 2.06 on a scale of 1 to 5).

Next, we created graphs to plot within-person change in aggression over the ten weeks, both for parent and child ratings (Figure 2). These graphs show a similar pattern of decreasing aggression levels according to parents and stable modest levels of aggression according to children. For child-reported aggression small increases were observed for Child 2 and 6. We calculated reliable change indices (RCI) to further interpret these findings, although it should be noted these RCIs are based on statistics of only six children (Appendix A). For Child 6, the RCI suggests no reliable change. For Child 2, the RCI suggests moderate deterioration, which is in contrast with the RCI for parent report, suggesting recovery. Thus, there was no clear indication of increases of aggressive behavior across multiple sources of information for any participant.

Figure 2

Aggressive behavior reported by parents and children over the weeks.
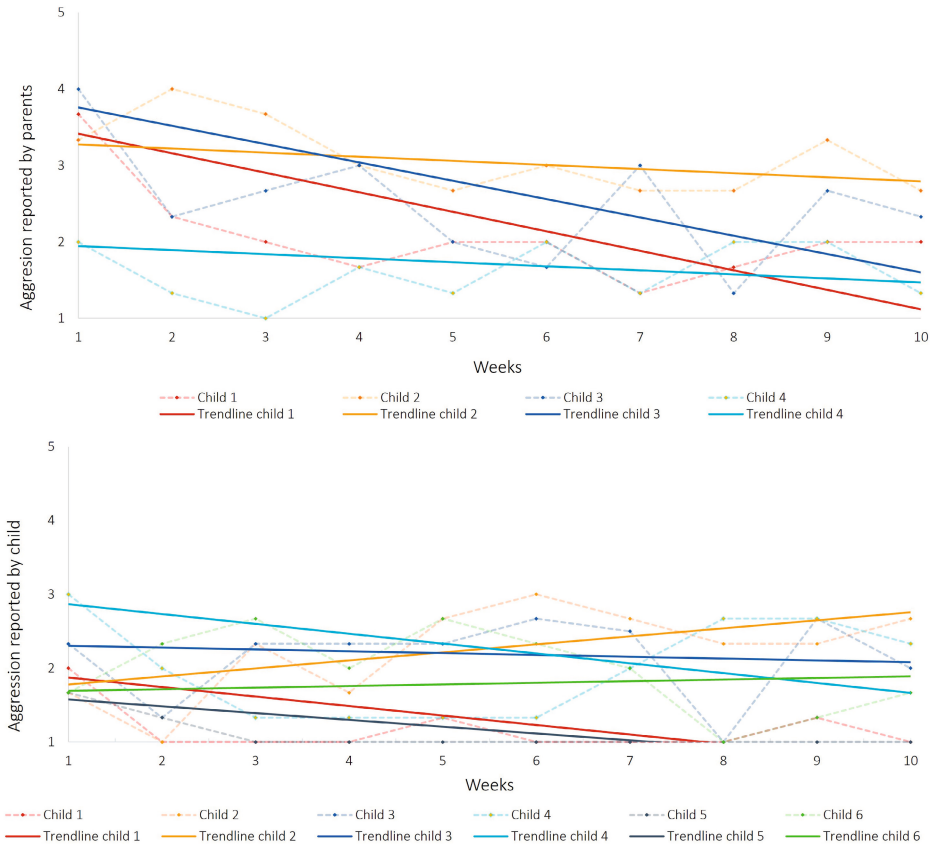
Note. Dotted lines reflect reported scores and solid lines reflect linear trendlines.

DISCUSSION

The aim of the present study was to evaluate the feasibility of a newly developed cognitive behavioral therapy (CBT) with interactive virtual reality in a sample of six boys with aggressive behavior problems. Results were promising: therapists indicated that providing the treatment was feasible. They were able to complete almost all session elements, deliver the recommended amount of practice time in virtual reality, and they experienced few technical issues. Therapists were generally satisfied with their delivery of the treatment. Children highly appreciated the treatment, which was also recognized by therapists, who indicated that children actively participated in the virtual environment. Given that the main aim of our study was to examine feasibility rather than effectiveness, we only explored possible

change in aggression. Parents reported decreases in children's aggressive behavior, however children reported low levels of aggression at pre-test that did not decrease. Although this was a feasibility study with a small sample, it does give a preliminary indication that using virtual reality to treat boys from 8 to 12 years with aggressive behavior problems is feasible and may potentially reduce aggressive behavior.

Interactive virtual reality may be a promising tool to enhance CBT for children with aggressive behavior problems. It allows children to repeatedly practice social interactions in an individually tailored way, without the risks inherent in group treatment (Dodge et al., 2006). Moreover, it provides an emotionally involving practice environment, where children can frequently rehearse regulation skills in realistic anger-provoking social situations. Future virtual reality treatments could also include recordings of children's successful behavior in the virtual reality situations and use this to stimulate social confirmation by showing the recordings to parents. Last but not least, our study showed that interactive virtual reality treatment is an appealing method for children with aggressive behavior problems, which may prevent motivation problems and resistance to therapy, as often encountered in this population (Frick, 2012; Lochman et al., 2019).

Strengths and limitations

A strength of this study was that we examined children in routine care at clinical institutions. Children were referred to these institutions for their aggressive behavior problems, but none of the participants or their parents actively sought this new form of treatment. All children completed the treatment and reported high levels of appreciation, and all therapists were satisfied with how they were able to deliver the treatment. This indicates that using interactive virtual reality is feasible and acceptable for children in routine care.

This study also had its limitations. First, the small sample size warrants cautious interpretation of the results. The present findings should be seen as indicative of the potential of virtual reality in CBT for children with aggressive behavior problems, rather than as conclusive evidence. Second, because the study lacked a control condition and included a very small sample, it is uncertain whether changes in aggressive behavior were an actual effect of the treatment. Hence, we could only explore within-person changes to provide a preliminary indication of whether it would be promising to conduct a large efficacy trial.

Given the feasibility and high appreciation of the treatment, and the preliminary findings for aggressive behavior, a next logical step would be to test the positive indications from this study rigorously in a randomized controlled trial. Such a

controlled trial could also be used to determine whether virtual reality actually *enhances* CBT—that is, whether CBT with interactive virtual reality is more effective than the same CBT without virtual reality. The added value of interactive virtual reality may thus be established in order to determine whether its effects outweigh the financial costs of implementing this tool. Such future research is important, especially since the use of virtual reality seems theoretically promising and is increasingly called for by practitioners (Lindner et al., 2019).

Conclusions

In conclusion, we developed a new CBT with interactive virtual reality for boys with aggressive behavior problems using an emotionally engaging and individually tailored practice environment. The present study showed that this interactive virtual reality treatment is feasible and appealing to children and therapists, and has the potential to reduce aggressive behavior. These findings suggest enough promise to conduct randomized controlled trials needed to determine whether CBT with interactive virtual reality reduces aggressive behavior more strongly and for more children than regular CBT would.

2

APPENDIX A

The RCI indicates whether an individual change score is significantly larger than would be expected by chance (Jacobson & Truax, 1991). We calculated RCIs based on children's difference scores between week 1 and week 10, the standard error, and scale reliability in week 1. To obtain insight in the clinical significance of the RCIs, we interpreted them according to the guidelines of Wise (2004). The RCIs should be interpreted with caution because they are based on standard deviations and reliability statistics of only six children.

Table 2
Reliable change indices with clinical significance terms for aggression from pre-treatment (week 1) to post-treatment (week 10).

Child	Parent-reported aggression		Child-reported aggression	
1	5.04	Recovered	1.64	Remitted
2	2.01	Recovered	-1.64	Moderately deteriorated
3	5.04	Recovered	0.55	No change
4	2.01	Recovered	1.10	Improved
5	-	-	1.10	Improved
6	-	-	0.00	No change

Note. For two parents no reliable change index was computed due to missing scores in week 10.

3

Treating children's aggressive behavior problems using cognitive behavioral therapy with virtual reality:
A multicenter randomized controlled trial

ABSTRACT

This multicenter randomized controlled trial investigated whether interactive virtual reality enhanced effectiveness of cognitive behavioral treatments (CBT) to reduce children's aggressive behavior problems. We randomized 115 boys with aggressive behavior problems (M_{age} = 10.58, SD = 1.44; 95.7% born in Netherlands) into three groups: CBT with virtual reality, CBT with roleplays, or care-as-usual. Bayesian analyses showed that CBT with virtual reality more likely reduced aggressive behavior compared to care-as-usual for six of seven outcomes (ds .19–.95), and compared to CBT with roleplays for four outcomes (ds .14–.68). Moreover, compared to roleplays, virtual reality more likely enhanced children's emotional engagement, practice immersion, and treatment appreciation. Thus, virtual reality may be a promising tool to enhance CBT effectiveness for children with aggressive behavior problems.

Keywords
Virtual reality, cognitive behavioral therapy, aggressive behavior problems, children, randomized controlled trial

Author contributions
SA, AD, EV, and BC were involved in conceptualizing the study. SA coordinated the data collection, analyzed the data, and wrote the first draft of the manuscript. All authors provided feedback on the manuscript.

INTRODUCTION

Aggressive behavior problems are the most common form of malfunctioning in school-aged children (Costello et al., 2003). These problems predict adverse outcomes for children later in life (Burkey et al., 2018; Loeber & Farrington, 2000) and have a continuing negative impact on children's environment (McConaughy & Skiba, 1993; Wilson & Lipsey, 2006). Many intervention programs therefore target aggressive behavior problems as they arise in childhood (Lochman & Matthys, 2017). Cognitive behavioral therapy (CBT) can reduce aggressive behavior in children (Weisz & Kazdin, 2017), but intervention effects tend to be modest and heterogeneous (McCart et al., 2006). Effects can be stronger when interventions focus more on exposure to anger and on solving real-life social problems (de Mooij et al., 2020; Landenberger & Lipsey, 2005). Hence, intervention methods that promote ecologically valid practice may enhance effectiveness (Weisz et al., 2019). Interactive virtual reality may be a promising tool to attain this goal. In interactive virtual reality, children can walk around freely, talk to virtual peers, and play games, offering a realistic and engaging environment to practice new skills during therapy (Lindner, 2021). Our feasibility study showed that using virtual reality in CBT was feasible and acceptable for children in routine care, and had the potential to reduce aggressive behavior (Alsem et al., 2021). The aim of the current randomized controlled trial is to investigate whether virtual reality actually *enhances* effectiveness compared to CBT without virtual reality and care-as-usual.

Virtual reality may have three important benefits for CBT with children. First, practicing in virtual reality can enhance children's emotional engagement and immersion. This is important because CBT practice has been found to be most effective when cognitions and skills are practiced in emotionally engaging situations (Suveg et al., 2007). Children should thus ideally practice whilst experiencing feelings of anger (Sukhodolsky et al., 2016). Virtual reality can simulate anger-provoking situations that children encounter in daily life and has been shown to successfully elicit children's anger (Geraets et al., 2021; Verhoef, van Dijk, et al., 2021). It may be more immersive and engaging than roleplay exercises currently used in CBT, as children do not have to rely on their memory or imagination (Park et al., 2011). Supporting this idea, research found that a virtual reality assessment of aggressive behavior better predicted children's real-life aggressive behavior than an imagery-based assessment using hypothetical stories (Verhoef, Verhulp, et al., 2021).

Second, virtual reality can enhance children's treatment appreciation and their perception of the treatment's efficacy. Children with aggressive behavior problems

are often not motivated, or even resistant, to treatment (Frick, 2012; Lochman et al., 2019). It is important to enhance these children's treatment appreciation, which has been related to increases in treatment effectiveness (Lochman, Kassing, et al., 2017). As many children grow up surrounded by digital devices, using technology in interventions may have particular appeal and utility to them (Bakker et al., 2016; Weisz et al., 2019). Indeed, using technology (e.g., adding an internet component) in a treatment for children with aggression problems effectively increased children's treatment participation and perceived efficacy (Lochman, Boxmeyer, et al., 2017). Accordingly, our feasibility study showed that children with aggressive behavior problems highly appreciated CBT with virtual reality (Alsem et al., 2021).

Third, virtual reality allows for individually tailored exercises in CBT. Most current CBTs for children with aggressive behavior problems are provided in groups (Lochman et al., 2019). Although group treatments provide a natural context to practice in roleplays with actual peers, they limit opportunities to adjust the exercises to each child's specific needs. Moreover, individual therapy can lead to larger decreases in children's aggression than group therapy (Lochman et al., 2015; Wilson & Lipsey, 2007), whereas group therapy may yield iatrogenic effects (i.e., 'deviancy training'; Dodge et al., 2006). Virtual reality provides an opportunity to combine individual therapy with ecologically valid practice with virtual peers. Focusing the exercises on the situations, cognitions, and behaviors of an individual child can not only enhance children's treatment appreciation and adherence, but also the effectiveness of the intervention (Hollis et al., 2017; Lochman, Kassing, et al., 2017).

Although virtual reality has the potential to enhance effectiveness compared to current CBT treatments using roleplays, no study so far has investigated this (Hadley et al., 2019). Studies with a multi-armed design are needed to investigate the added benefits of virtual reality compared to identical intervention without virtual reality and care as usual (Lindner, 2021). We took this into account by comparing CBT with interactive virtual reality not only to care-as-usual, but also to the same CBT using similarly structured roleplay exercises. We conducted our study within routine care, as the use of virtual reality in therapy is increasingly called for by clinicians (Lindner et al., 2019).

We developed the new individual CBT 'YourSkills' based on evidence-based treatments for children with aggressive behavior problems. YourSkills targets deficits in emotion regulation and social information processing—two mechanisms underlying childhood aggression (Crick & Dodge, 1994; Lochman & Matthys, 2017). Similar to most CBTs for aggression, children learn to monitor their anger and practice techniques to modulate elevated levels of anger during social interactions

and solve social problems (Chorpita & Daleiden, 2009; Sukhodolsky et al., 2016). We designed two versions of YourSkills with identical content, but with different practice modes: one using virtual reality and one using roleplay. As clinicians often have to decide under uncertainty which treatment is most likely to be effective, we used Bayes Factors to indicate how likely it was that the virtual reality led to larger decreases in aggressive behavior compared to the comparison groups.

We conducted a randomized controlled trial with three conditions, comparing YourSkills virtual reality to YourSkills roleplay and care-as-usual. The first aim of our study was to examine treatment effects on children's aggressive behavior problems. We hypothesized that aggression decreases were larger for (1a) the two YourSkills groups versus the care-as-usual group, (1b) the YourSkills virtual reality versus the YourSkills roleplay group, and (1c) the YourSkills virtual reality versus the care-as-usual group. The second aim of our study was to investigate the potential experienced benefits of virtual reality above roleplays as treatment method for children with aggressive behavior problems. We hypothesized that children participating in YourSkills virtual reality would score higher than children participating in YourSkills roleplays on (2a) emotional engagement, (2b) practice immersion, (2c) treatment appreciation, and (2d) perceived efficacy.

METHOD

Design
This study was a multicenter randomized controlled trial with three groups: YourSkills virtual reality, YourSkills roleplay, and care-as-usual. Children were recruited at fifteen clinical centers in the Netherlands providing mental health care for children with problems that are so severe that daily functioning is impaired and treatment is necessary. Recruitment began in September 2019, and all post-intervention assessments were completed by July 2021. Children were randomized at the individual level using computer-generated general random numbers. Specifically, we conducted randomization per clinical center.

Participants
Therapists working in the clinical centers were asked to approach parents of boys whose casefiles met our study's inclusion criteria: age 8-13 years, aggressive behavior problems, estimated intelligence level above 80, no severe autism spectrum disorder, and no epilepsy or severe visual or auditory limitations. Only boys were included, as aggression by girls in middle childhood may differ from aggression by boys in its development, forms, processes, and outcomes (Berkout

et al., 2011; Fontaine et al., 2009; Underwood, 2002), and it has been argued that especially boys' aggression results from the mechanisms that were specifically targeted in YourSkills: anger regulation and hostile intent attribution (Berkout et al., 2011). Moreover, even if the same mechanisms for the same kinds of aggression were targeted, the intervention with girls would likely require different virtual reality stimuli (e.g., different girls avatars, group interactions), which would be more feasible after a first 'proof of principal' with only boys in the present study. Children with severe autism spectrum disorder and low intelligence level were excluded, because cognitive behavioral therapy exercises require perspective taking and imagination skills, as well as cognitive skills to reflect on thoughts and behavior (Sukhodolsky et al., 2016). We chose to exclude children with epilepsy and severe visual or auditory limitations as practicing in virtual reality would not be possible for them.

Consent was obtained for 127 children. Twelve children were excluded prior to intervention (for reasons, see Figure 1). Thus, 115 boys in the age range 8 to 13 years (M = 10.58, SD = 1.44) were included in the study. In addition to aggressive behavior problems at baseline (see Table 2), estimates of diagnostic classifications, based on the criteria of the Diagnostic and Statistical Manual of Mental Disorders (DSM), were obtained by asking parents to report about their children's casefiles: 38 children (33.0%) were not diagnosed with a disorder, 59 children (51.3%) were diagnosed with one disorder, 16 children (13.9%) with two disorders, and two children (1.7%) with three disorders. Diagnoses included attention-deficit hyperactivity disorder (n = 59), oppositional deficit disorder (n = 16), autism spectrum disorder (n = 14), anxiety disorder (n = 2), attachment disorder (n = 2), and depressive disorder (n = 1). Children's intelligence level was on average 97.80 (SD = 12.18). Most children and parents were born in the Netherlands and most parents attained middle levels of education (see Table 1). After randomization, 40 children were assigned to the YourSkills virtual reality group, 41 to the YourSkills roleplay group, and 34 to the care-as-usual group.

Written informed consent was obtained from parents and 12-and 13-year old children. Participation was voluntary and children and parents were assured of confidential use of their data. Children received a small gift (e.g., a multicolor pen) after filling out the post-assessment. We also asked parents' consent to approach children's teachers to complete questionnaires (94.8% consent). This study was approved by the Ethics Committee of the University Medical Center Utrecht and was registered in the Dutch Trial Register (NTR; https://trialregister.nl/trial/7959). We registered 'treatment motivation' as primary outcome measure but broadened

this concept into 'potential benefits of virtual reality' by also examining children's emotional engagement and practice immersion.

Procedure

After randomization, therapy sessions were planned by the therapists, who then invited researchers to conduct the pre-assessment 30 minutes before the first therapy session. Researchers were invited again at the last therapy session to conduct the post-assessment directly after this session ended. When children in the care-as-usual group did not receive therapy at the clinical centers during the study, researchers planned home visits to conduct the pre- and post-assessments after randomization and twelve weeks later (i.e., the estimated average time of the YourSkills intervention). Children who discontinued the treatment ($n = 9$) were invited to remain in the study so that we could conduct intention-to-treat analyses and overcome problems with missing data (4 children and 3 parents filled out the post-assessment; White et al., 2011).

All assessments with children were conducted face-to-face. Children were individually interviewed in 20-30 minutes by the first author or a trained research assistant. At the same time, parents were also asked to fill out questionnaires in an online system. When both parents were present during the assessment, we asked them to each fill out the questionnaires. For data analyses, we matched pre- and post-assessments of the same parent: mothers (45.2%) or fathers (27.0%).

If both parents filled out both assessments (5.2%), we chose mother reports to align with the largest group filling out both assessments. In some cases, we had to combine mother- and father-report (20.9%) or had only pre-assessment data available (6.9%). We also asked teachers to fill out the pre- and post-assessment via an online questionnaire, in the same weeks as children and parents (82.6% provided both assessments; 9.6% only the pre-assessment; 1.7% only the post-assessment).

YourSkills treatment

YourSkills is a manualized CBT, based on evidence-based treatments for children with aggressive behavior problems, including Coping Power (Lochman et al., 2008) and Self-Control (van Manen, 2001). We developed a new treatment manual, rather than adding virtual reality to an existing treatment. This way, we could integrate interactive virtual reality into all facets of the treatment and compare it to the identical treatment using roleplay practice.

Figure 1

Participant flow diagram.
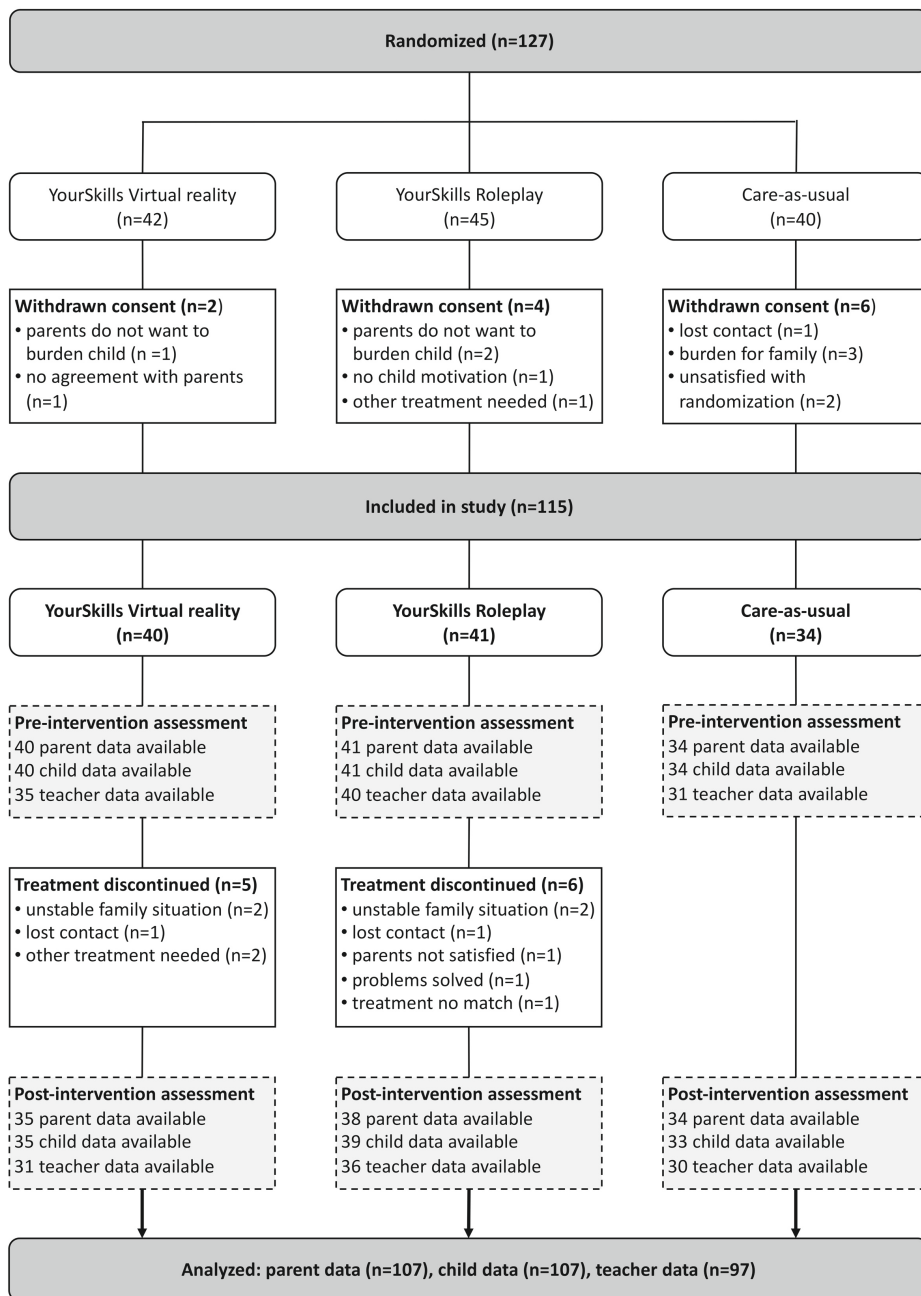
The aim of YourSkills is to reduce children's aggressive behavior problems by enhancing emotion regulation and social information processing skills. Children practice anger recognition, anger regulation, and social problem solving in social interactions. YourSkills consists of one 45-minute introduction session with parents and ten 45-minute sessions with the child (for an overview of the sessions, see Alsem et al., 2021). All treatment sessions have the same structure, making the session course predictable for children. Although YourSkills is primarily focused on the child, it also promotes parent involvement by providing them with an introduction session and including them at the end of each session (for more information, see Alsem et al., 2021).

To let children practice their regulation skills whilst being emotionally engaged, therapists create challenging social situations for children in virtual reality or roleplays. In each session, therapists first explain a new skill, then model the skill using roleplay, and then use virtual reality or roleplays to let children practice the skill in anger-provoking social situations. The YourSkills materials include twenty-six cards with anger-provoking situations, based on a taxonomy of problematic situations for children with aggressive behavior problems. They include: being disadvantaged, authority conflicts, peer rejection, and peer provocation (Matthys et al., 2001). Therapists select those situations that match children's individual needs.

In this study, YourSkills was delivered by 31 licensed therapists (90.3% female) working at the participating clinical centers. All therapists had experience providing treatment to children and adolescents, ranging from 2.0 to 25.1 years ($M = 7.79$, $SD = 5.75$). Therapists' experience with treatments specifically for children ages 8 to 13 years with aggressive behavior problems ranged from 0.5 to 12.5 years ($M = 5.72$, $SD = 4.07$), with only one therapist having less than one year of experience. Most therapists had completed a post-master course in cognitive behavioral therapy (87.1%). Therapists were trained in both versions of YourSkills in a two-day course, supervised by the first and second author and a certified CBT therapist. They learned to work with the treatment manual, how to conduct roleplay exercises, and use the virtual reality equipment. These therapists used the same treatment manual for both versions of YourSkills, and only distinguished in practice mode during the exercises by using either virtual reality or roleplays depending on the condition their client was assigned to. Thus, therapist characteristics were equal across conditions. As the only difference between the two treatment versions was the practice mode, contamination of one version to the other was not likely. During the treatment period, therapists could receive consultation over the phone from the first or second author. The focus of the consultation was

on help with practical issues, rather than supervision. Few therapists used the opportunity for consultation, and most questions concerned exclusion criteria for study participation or technical questions about the virtual reality equipment (e.g., the laptop is not starting).

Therapists managed to carry out almost all session elements of YourSkills (virtual reality: M = 98.6%; roleplay: M = 97.1%; for a session description, see Alsem et al., 2021). Therapists indicated that children practiced more than the recommended 10 minutes per session (virtual reality: M = 11.8 minutes, SD = 2.2; roleplay: M = 11.4, SD = 2.1). Within this practice time, children practiced their new skill more often than the recommended two times (virtual reality: M = 3.0, SD = 0.7; roleplay: M = 3.3, SD = 1.0). Therapists were satisfied with how they delivered the treatment (virtual reality: M = 4.2 on a 5-point scale, SD = 0.6; roleplay: M = 4.3, SD = 0.6).

YourSkills virtual reality
The YourSkills virtual reality software includes practice scenarios that correspond with the YourSkills cards describing anger-provoking situations. The virtual reality environment consists of a classroom, a schoolyard, and a living room (for an impression, see Alsem et al., 2021). Children wore an Oculus Rift S headset, a noise cancelling headphone, and they held controllers in both hands, allowing them to grab and throw virtual objects. In the first session, therapists explained to children that the virtual environment allowed them to walk around freely (within a 3×3 meter area), talk with virtual children and adults, and play games such as building a tower or playing a game on the television. Therapists could evoke children's anger by manipulating the virtual situation itself (e.g., letting the child lose a game, or switching off the television) or by manipulating the speech and actions of the virtual characters. Therapists used a microphone with voice transformer to emulate a different voice for each virtual character. They used a tablet to control the characters' bodily movements (e.g., walking away), gestures (e.g., raising a middle finger), and facial expressions (i.e., an expression scale from happy to angry).

YourSkills roleplay
The YourSkills roleplay version was identical to the virtual reality version, except that children did not practice in virtual reality but in roleplays. Therapists used the cards describing anger-provoking situations to roleplay challenging social situations, and played the role of a child's parent, teacher or peer. Therapists were encouraged to use physical objects and make use of the room to stimulate active engagement of children during the roleplays.

Table 1

Background characteristics of participants included in the study.

	Total (*n* = 115)	YourSkills virtual reality (*n* = 40)	YourSkills roleplay (*n* = 41)	Care-as-usual (*n* = 34)
Age (years)	10.58 (1.44)	10.78 (1.49)	10.48 (1.56)	10.47 (1.21)
Intelligence level	97.80 (12.18)	95.03 (11.19)	98.85 (12.41)	99.62 (12.76)
Child born in the Netherlands	95.7%	95.0%	95.1%	97.1%
Parents born				
Both in the Netherlands	71.3%	72.5%	73.2%	67.6%
One in the Netherlands	14.8%	17.5%	12.2%	14.7%
Both elsewhere	13.9%	10.0%	14.6%	17.6%
Parental educational level				
Low education (ISCED 0-2)	18.3%	20.0%	19.5%	14.7%
Middle education (ISCED 3-4)	43.5%	47.5%	39.0%	44.1%
High education (ISCED 5-6)	38.2%	32.5%	41.5%	41.2%
Weeks pre- to post-assessment				
Parent- and child-reports	16.85 (7.98)	17.60 (7.33)	18.32 (10.41)	14.44 (4.36)
Teacher-reports	17.79 (9.26)	18.30 (8.15)	19.17 (11.36)	15.55 (7.07)
COVID-19 lockdown				
Finished before lockdown	9.6%	12.5%	2.4%	14.7%
In lockdown during study	18.3%	17.5%	19.5%	17.6%
Started after lockdown	72.2%	70.0%	78.0%	67.6%

Note. ISCED = International Standard Classification of Education (UNESCO, 2012).

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Care-as-usual

Children in the care-as-usual group received the usual care provided by the clinical institutions. Trained therapists for this study were not allowed to provide care-as-usual to this group, to assure that they did not make use of YourSkills' treatment elements. We expected a variety of care (Kazdin, 2015), including individual therapy, group therapy, and parent training. At post-assessment, we asked parents to fill out whether and what therapy they or their children received for children's aggressive behavior problems.

Treatment participation in routine care

As children were recruited in routine care, children in all intervention groups were allowed to receive other services when needed. Few children in the YourSkills groups participated in additional treatments: Some children also received medication (virtual reality: $n = 6$; roleplay: $n = 4$) and some parents also participated in parent training for the aggressive behavior problems of their child (virtual reality: $n = 4$; roleplay: $n = 2$).

During the study period, 50% of the 34 families in the care-as-usual group participated in treatments specifically aimed at decreasing children's aggressive behavior problems. The other families indicated that they did not participate in a treatment specifically aimed at these problems. Of the 17 children participating in routine care, 14 participated in some form of individual therapy covering on average 8.8 sessions ($SD = 5.3$). Of these 14 children, three also received medication and one family participated in parent training. Of the other 3 children, one child participated in five group sessions, and one child participated in two group sessions, received medication, and his parents participated in a training. In one family only parents participated in parent training.

Measures

We here present the measures assessed to answer this studies' research questions. We assessed additional measures for other purposes, which are not reported here.

Children's aggressive behavior

To obtain a comprehensive picture of changes in children's aggression, we used a multi-informant (parent-, child-, and teacher-reports), multi-instrument approach. Including multiple informants is highly informative as aggressive behavior is context-dependent and the correspondence between informants is relatively low (De Los Reyes et al., 2015). We used three instruments, providing different information on children's aggressive behavior. First, we assessed aggressive

behavior in the past month using a widely used instrument (i.e., the ASEBA forms: CBCL and TRF; Achenbach & Rescorla, 2001). This instrument has normative data for parent- and teacher-report, allowing us to investigate changes from clinical to normative levels of aggressive behavior. Second, we assessed the frequency of aggression in the past month with the validated IRPA questionnaire (Polman et al., 2009). This instrument is not only suitable for parent- and teacher-report but also for child-report and may be more sensitive to small changes in behavior as it uses a 5-point scale (instead of the 3-point scale in the ASEBA forms). Third, we included a new weekly report measure assessing children's aggression in the past week (Alsem, Keulen, et al., 2022), allowing us to capture short-term changes in aggression, directly after the intervention ended.

CBCL and TRF aggressive behavior

Parents and teachers filled out the aggressive behavior scale of the Child Behavior Checklist (CBCL) and the Teacher Report Form (TRF), respectively (Achenbach & Rescorla, 2001). They rated children's aggressive behavior in the past month on a 3-point scale (0 = not true, 1 = somewhat true, 2 = very true or often true). The CBCL scale consists of 18 items (e.g., 'Argues a lot') and the TRF scale of 20 items (e.g., 'Physically attacks people'). We used norms for Dutch children to calculate T-scores to examine (sub)clinical levels of aggression, and calculated sum scores for all other analyses. In our sample, the internal consistency was adequate for both parents and teachers at pre- and post-assessment (αs .86–.95).

IRPA aggression frequency

Parents, teachers, and children filled out the Instrument for Reactive and Proactive Aggression (IRPA; Polman et al., 2009). They rated the frequency of aggression in the past month on 7 items (e.g., 'How often did your child/the child/you hit someone in the past month?') on a scale from 1 (never) to 5 (daily). Ratings were averaged across items, with adequate internal consistency for all informants at pre- and post-assessment (αs .74–.86).

Weekly report measure

Parents and children filled out a weekly report measure (Alsem, Keulen, et al., 2022). They rated three items (e.g., 'This week my child/I fought with someone') on a scale from 1 (never) to 5 (very often). Ratings were averaged across items. The child-report version showed adequate internal consistency, convergent, and concurrent validity in a previous study (Alsem, Keulen, et al., 2022). The internal consistency in the current study was adequate for both parents and children at pre- and post-assessment (αs .75–.79).

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Measures assessing the potential benefits of virtual reality
To investigate the potential benefits of virtual reality as treatment method for children with aggressive behavior problems, children and parents rated items about their experience with YourSkills at post-assessment. Therapists filled out items about the two versions of YourSkills after the study ended (we counterbalanced the order of items on virtual reality versus roleplay).

Emotional engagement
Children and therapists rated children's emotional engagement whilst practicing in the virtual reality or roleplays on three items (e.g., 'Some things in the virtual reality/roleplays really pissed me/the children off a bit,' 'I/the children never felt anger in the virtual reality,' and 'Sometimes I/the children felt like getting angry in the virtual reality') on a scale from 1 (totally disagree) to 5 (totally agree). Ratings were averaged across items, with adequate internal consistency for both children and therapists (αs .77–.91).

Practice immersion
Children and therapists rated four items on practice immersion during virtual reality or roleplays (i.e., 'I/the children was/were completely immersed in virtual reality/the roleplays,' 'The virtual reality felt real (for the kids),' 'I felt/the children were feeling like the virtual reality really happened to me/them,' and 'During the virtual reality it felt like I/the children was/were actually experiencing it') on a scale from 1 (totally disagree) to 5 (totally agree). Ratings were averaged across items, with adequate internal consistency for children and therapists (αs .84–.88).

Treatment appreciation
Children, parents, and therapists rated four items about children's treatment appreciation (e.g., 'I/my child/the children liked to participate in YourSkills') on a scale from 1 (totally disagree) to 5 (totally agree). Ratings were averaged across items. The internal consistencies were adequate for parents and children (α .80–.89) and the therapist roleplay scale (α = .90) but not for the therapist virtual reality scale (α = .59). To gain an overall impression of children's appreciation of YourSkills, we also asked children give a grade from 1 to 10 to the treatment as a whole and to practicing in the virtual reality/roleplays.

Perceived efficacy
Children, parents, and therapists rated four items on their perceived efficacy of the treatment (e.g., 'I/my child/the children learned a lot in YourSkills') on a scale from 1 (totally disagree) to 5 (totally agree). Ratings were averaged across items. The

internal consistencies were adequate for children (α = .83) and parents (α = .76) and the therapist roleplay scale (α = .75), but not the therapist virtual reality scale (α = .54).

Intelligence

When information on intelligence was available from children's casefile (administered within the past two years; 59.1% of the cases), we did not assess intelligence again. Otherwise, we administered the subtests 'Block Design' and 'Vocabulary' of the Wechsler Intelligence Scale for Children (WISC-III; Kort et al., 2005) to estimate an IQ score (Silverstein, 1970). Such estimated IQ scores are strongly associated with IQ scores based on the total WISC (Hrabok et al., 2014).

Analyses

We conducted our analyses using Bayesian statistics, a method that is becoming more common in social and behavioral sciences (van de Schoot et al., 2014). An advantage of Bayesian statistics is that it quantifies the amount of support for the study hypotheses instead of yielding a dichotomous decision on whether the null hypothesis is rejected or not (van de Schoot et al., 2014). This provides clinicians with an indication of which treatment is most likely to be effective. Another reason to use Bayesian analyses was to overcome problems with our large number of outcome measures. Specifically, a major advantage of Bayesian analyses is that there are no risks for type I or type II errors when conducting multiple analyses (Hoijtink et al., 2019). Moreover, our sample size was smaller than the intended sample size, due to COVID-19 related inclusion problems. As we did not specify the analytic approach forehand, we chose to use Bayesian statistics to minimize problems with our smaller sample size.

Bayesian analyses yield Bayes factors (*BF*), which quantify to what extent the data support one hypothesis compared to another. A Bayes factor of 1 indicates equal support for both hypotheses; a Bayes factor of > 1 indicates support in favor of the planned hypothesis over the null hypothesis, with higher Bayes factors providing more support. For instance, if we would find *BF* = 10 for the hypothesis that YourSkills virtual reality leads to larger decreases in aggression than care-as-usual, this would indicate that it is 10 times more likely that YourSkills indeed outperformed care-as-usual than not. We conducted our statistical analyses in JASP version 0.15.0.0 with the Bain package (Hoijtink et al., 2019; Marsman & Wagenmakers, 2017).

Before we statistically tested our hypotheses, we explored clinically relevant changes in aggression. We used the available norms of the CBCL and TRF to calculate T-scores and classify children in the normal range (T-score ≤ 64, ≤ 93rd

percentile), subclinical range (T-score 65-69, 94-97th percentile), or clinical range (T-score > 69, > 97th percentile). We defined clinically relevant improvement as a shift from one range to another from pre- to post-assessment. Next, we preliminarily explored if there was an overall decrease in aggression across groups. We conducted Bayesian paired sample *t*-tests to test our prediction that post-intervention levels of aggression were lower than pre-intervention levels against the contrasting prediction that pre- and post-intervention aggression levels were equal. As our analysis included two parameters (i.e., mean difference and mean difference variance), we set the fraction on two (Hoijtink et al., 2019).

To investigate our first research question, we tested whether decreases in aggression were larger for (1a) the two YourSkills groups versus the care-as-usual group, (1b) the YourSkills virtual reality versus the YourSkills roleplay group, and (1c) the YourSkills virtual reality versus the care-as-usual group. We first calculated mean difference scores by subtracting the pre-intervention from the post-intervention scores. We then conducted Bayesian ANOVA's, to test the hypothesis that the mean difference scores differed between the groups in expected directions against the complementary hypothesis (e.g., for hypothesis 1c: that the mean differences on aggression were *not* larger in the YourSkills virtual reality versus care-as-usual group). In addition, we calculated Cohen's *d* effect sizes based on the means and standard deviations (Cohen, 1988).

To investigate our second research question, examining the potential benefits of virtual reality versus roleplays, we used Bayesian one-way ANOVAs to analyze whether children practicing in virtual reality showed higher levels of (2a) treatment appreciation, 2b) emotional engagement, (2c) practice immersion, and (2d) perceived efficacy. Again, each hypothesis was tested against its complement. We also calculated Cohen's *d* effect sizes (Cohen, 1988).

To check for missing data patterns, we conducted Little's test, which produced a normed χ^2 (i.e., χ^2/df) of 1.16, indicating that data were missing completely at random (Bollen, 1989). Therefore, we used default settings in JASP (i.e., listwise deletion). This means that participants who did not fill out post-assessment were excluded from the analyses. We tried to avoid exclusion by asking participants to remain in the study after drop-out, to be able to conduct intention-to analyses and overcome problems with missing data due to dropout (White et al., 2011). In the intention-to-treat principle, all randomized participants are included in the analyses in the groups to which they were randomized, even if they stopped treatment early. This method is preferred in randomized trials as these analyses give unbiased, conservative estimates of treatment effects, and allow for the greatest generalizability (Gupta, 2011). In total, we analyzed data of 107 children and parents (7.0% missing) and 97 teachers (15.7% missing; see Figure 1).

Table 2

Pre-intervention assessment and post-intervention assessment means (*M*) and standard deviations (*SD*) of the outcome variables for the YourSkills virtual reality group, YourSkills roleplay group, and the care-as-usual group.

| | YourSkills Virtual reality | | | | YourSkills Roleplay | | | | Care-as-usual | | | |
| | Pre-test | | Post-test | | Pre-test | | Post-test | | Pre-test | | Post-test | |
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Aggression frequency parents (IRPA)	1.91	0.59	1.70	0.43	2.12	0.64	1.84	0.63	1.93	0.66	1.91	0.58
Aggression frequency teacher (IRPA)	2.03	0.70	1.77	0.63	2.04	0.88	1.93	0.83	1.99	0.71	1.92	0.72
Aggression frequency child (IRPA)	1.82	0.56	1.67	0.48	2.00	0.69	2.04	0.71	1.97	0.74	1.82	0.63
Weekly aggression parents	2.58	0.74	1.78	0.54	2.57	0.90	2.29	0.78	2.48	0.86	2.38	0.80
Weekly aggression child	1.99	0.94	1.62	0.57	2.14	1.15	1.77	0.67	2.10	1.01	2.28	1.10
Aggressive behavior parents (CBCL)	15.91	6.30	11.83	4.71	17.63	6.80	13.90	6.80	16.94	7.27	13.82	5.71
Aggressive behavior teacher (TRF)	17.37	10.35	13.77	10.24	17.17	10.44	14.61	10.67	16.38	10.89	14.45	10.45

Note. IRPA = Instrument for Reactive and Proactive Aggression, CBCL = Child Behavior Checklist, TRF = Teacher Report Form

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RESULTS

Preliminary analyses
Pre-intervention group differences

To check whether randomization was successful, we examined between-group differences at pre-assessment. Results showed that it was more likely that there were *no* group differences in background characteristics (Table 1) than that there *were* group differences, with *BF*s favoring no differences ranging from 3.04 to 128.49. Next, we compared pre-intervention levels of aggression (Table 2), and found that it was more likely that groups did *not* differ than that they *did* differ at baseline, according to all aggression measures by all informants, with *BF*s ranging from 5.42 to 11.44. We also checked whether the three groups were differentially affected by the COVID-19-related lockdown (i.e., Dutch clinical institutions were closed from March 22th to May 11th 2019; Table 1). First, we inspected the number of children affected by the lockdown, and found that no differences were more likely, *BF* = 36.62. Second, we inspected the time between pre- and post-assessment. Results showed no differences were more likely, but only for the time between teacher-reports (*BF* = 3.22) and not for parent- and child-reports (*BF* = 1.21). Time between pre- and post-assessment for these reports was on average 14 weeks in the care-as-usual group, and 18 weeks in the two YourSkills groups.

Figure 3

Average T-scores for each group at pre- and post-assessment for both parent-reported aggression (CBCL; left) and teacher-reported aggression (TRF; right).
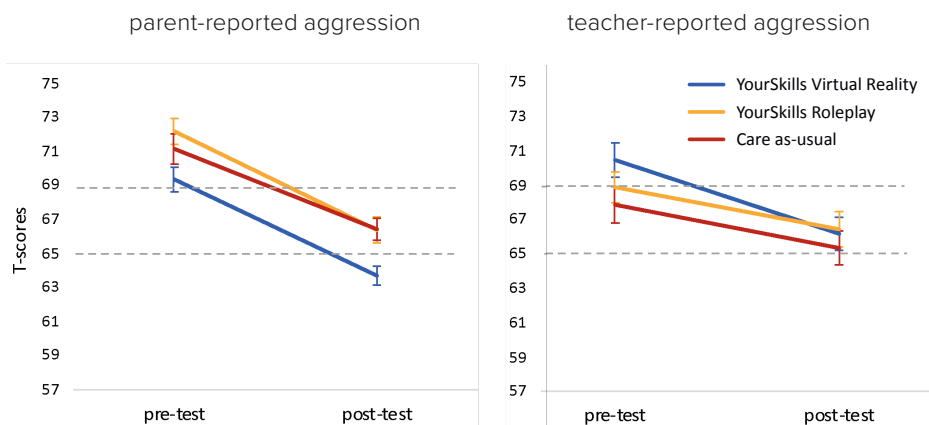
Note. Error bars show standard errors. Dashed lines represent the subclinical (lower line) and clinical (upper line) T-score cut-offs.

Descriptive clinical decreases in aggression (CBCL and TRF)

Figure 3 presents the average aggression T-scores at pre- and post-assessment for parent- and teacher-report. All three groups decreased in parent-reported aggression: from the clinical to the normal range for the YourSkills virtual reality group, and from the clinical to the subclinical range for the other two groups. Teacher-reported aggression also decreased in all three groups, but only the YourSkills virtual reality group started in the clinical range and decreased to the subclinical range, whilst the other two groups started and remained in the subclinical range.

We then explored percentages of children who did not change, improved or deteriorated (i.e., shifted from one range to another; Figure 4). For parent-reported aggression, most children improved in the YourSkills virtual reality group (48.6%), followed by the YourSkills roleplay group (39.5%), and care-as-usual group (26.5%). Many children remained in the same range, but the least in the YourSkills virtual reality group (42.9%), followed by the YourSkills roleplay group (50.0%) and the care-as-usual group (64.7%). Some children deteriorated (i.e., 8.6 to 10.5% across groups). For teacher-reported aggression, a slightly different pattern was found. Most children remained in the same range in all three groups (61.1 to 66.7%), whilst in the YourSkills roleplay group more children improved (30.6%) than in the virtual reality and care-as-usual groups (23.3% and 17.2%, respectively). Deterioration was highest in the care-as-usual group (17.2%).

Figure 4

Percentages of children who improved, did not change, or deteriorated in each group for both parent-reported aggression (CBCL; left) and teacher-reported aggression (TRF; right).
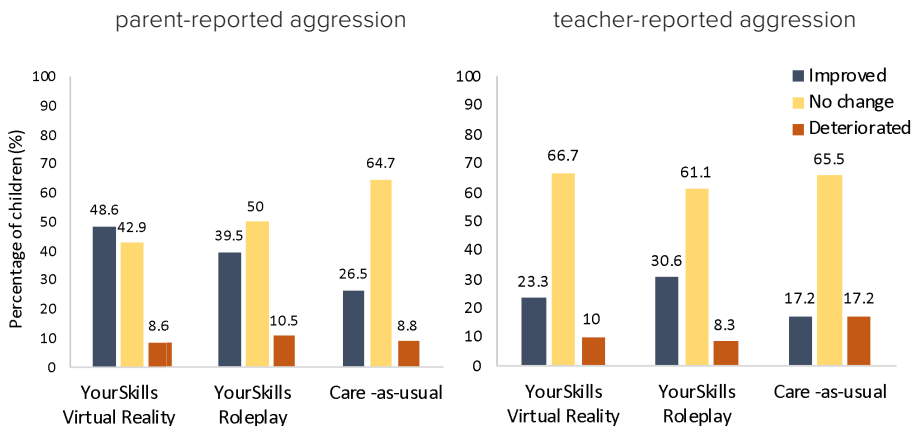
Overall decreases in aggression

We used Bayesian paired sample *t*-tests to explore decreases in aggression from pre- to post-assessment across the three intervention groups. We found that decreases in aggression were more likely than no change for six out of seven aggression measures (Table 3). This was over 36 times more likely for all three parent-reported aggression measures and teacher-reported aggressive behavior (TRF) but only about two times more likely for teacher-reported aggression frequency (IRPA) and child-reported weekly aggression. We found no support for decreases in child-reported aggression frequency (*BF* < 1).

Research question 1: Group differences in aggression decreases

To investigate group differences in aggression decreases from pre- to post-assessment (Figure 5), we conducted Bayesian ANOVAs.

YourSkills (both versions) versus care-as-usual

Six out of seven aggression measures suggested superior effectiveness of YourSkills compared to care-as-usual (Table 3). It was at least 187 times more likely that YourSkills outperformed care-as-usual than not according to parent- and child-reported weekly aggression (*d*s = 0.55), 27 times more likely according to parent-reported aggression frequency (IRPA; *d* = 0.39), but only 3 times more likely according to teacher-reported aggression frequency (IRPA) and parent- and teacher-reported aggressive behavior (CBCL/TRF; *d*s 0.14–0.16). For child-reported aggression frequency (IRPA), it was more likely that the YourSkills groups did *not* improve more than the care-as-usual group (*BF* < 1).

Virtual reality versus roleplay

Results for four out of seven aggression measures favored virtual reality over roleplays (Table 3). It was 528 times more likely that virtual reality outperformed roleplay than not according to parent-reported weekly aggression (*d* = 0.68), but only 2 to 8 times more likely according to teacher-reports of aggression (IRPA and TRF) and child-reported aggression frequency (IRPA; *d*s 0.14–0.30). We found no support for larger aggression decreases in virtual reality relative to roleplay on the other parent-reported aggression measures (IRPA and CBCL) and weekly child-reported aggression (*BF*s < 1.53, *d*s < 0.06).
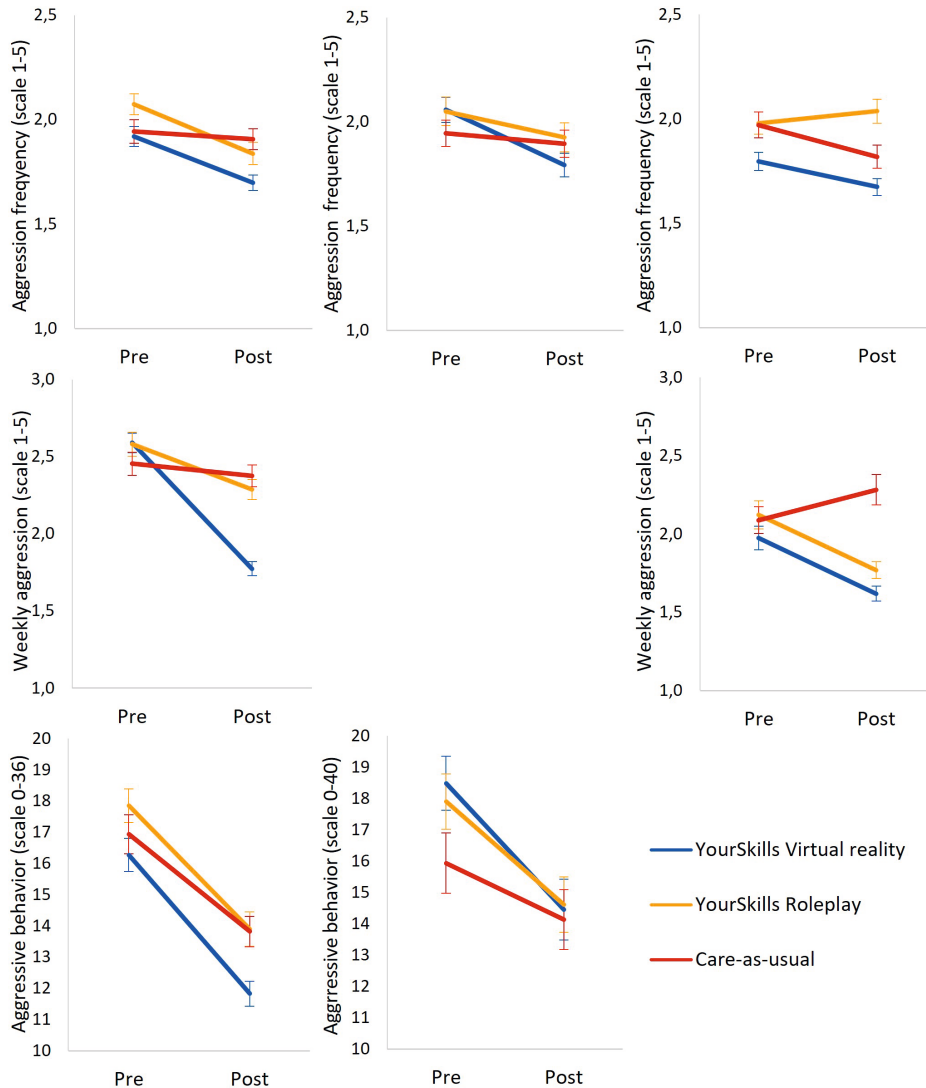
Table 3

Bayes factors (*BF*) and Cohen's d effect sizes (*d*) for decreases in aggression and group comparisons on mean differences between pre-intervention and post-intervention assessments.

	Decrease aggression across groups	YourSkills (both versions) vs care-as-usual		Virtual reality vs roleplay		Virtual reality vs care-as-usual	
	BF	*BF*	*d* [95% CI]	*BF*	*d* [95% CI]	*BF*	*d* [95% CI]
Aggression frequency parents (IRPA)	36.56	27.64	0.39 [-0.04, 0.81]	0.47	-0.12 [-0.58, 0.35]	9.95	0.31 [-0.17, 0.80]
Aggression frequency teacher (IRPA)	2.78	3.34	0.16 [-0.27, 0.60]	4.38	0.20 [-0.29, 0.68]	6.28	0.33 [-0.19, 0.84]
Aggression frequency child (IRPA)	0.66	0.29	-0.16 [-0.57, 0.25]	8.38	0.30 [-0.16, 0.76]	0.95	<-0.01 [-0.48, 0.47]
Weekly aggression parents	68280.95	187.31	0.55 [0.12, 0.97]	528.82	0.68 [0.19, 1.15]	$108.77e^{2}$	0.95 [0.43, 1.45]
Weekly aggression child	1.99	223.20	0.55 [0.13, 0.96]	1.03	<0.01 [-0.45, 0.46]	84.38	0.58 [0.09, 1.06]
Aggressive behavior parents (CBCL)	$173.60e^{7}$	3.01	0.14 [-0.27, 0.55]	1.53	0.06 [-0.40, 0.52]	3.21	0.19 [-0.29, 0.66]
Aggressive behavior teacher (TRF)	322.92	3.14	0.16 [-0.28, 0.59]	2.64	0.14 [-0.35, 0.62]	4.50	0.24 [-0.27, 0.75]

Note. A Bayes factor of >1 indicates support of our hypothesis (i.e., decreased aggression). CI = Confidence Interval, IRPA = Instrument for Reactive and Proactive Aggression, CBCL = Child Behavior Checklist, TRF = Teacher Report Form. e is used for readability and indicates exponential notation, with the corresponding number indicating how many times the *BF* must be multiplied by ten to generate the original number.

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Figure 5

Pre- to post-intervention aggression reports of parents, children, and teachers for the YourSkills virtual reality group, YourSkills roleplay group and the care-as-usual group.

Note. Error bars show standard errors

Virtual reality versus care-as-usual

Results for six out of seven aggression measures favored virtual reality over care-as-usual (Table 3). It was 84 times more likely that virtual reality outperformed care-as-usual than not, according to child- and parent-reported weekly aggression (ds 0.59–0.95), and 3 to 10 times more likely according to other parent- and teacher-reports of aggression (IRPA and CBCL/TRF; ds 0.19–0.33). For child-reported aggression frequency (IRPA), we found no support for larger aggression decreases in virtual reality versus care-as-usual ($BF < 1$).

Research question 2: Additive value of virtual reality

We conducted Bayesian ANOVAs to analyze whether children in the virtual reality group experienced higher levels of emotional engagement, practice immersion, treatment appreciation, and perceived efficacy than children in the roleplay group.

Emotional engagement and practice immersion

Results showed that it was very likely that children were more emotionally engaged during practice in virtual reality versus roleplays, as suggested by both child and therapist-report (BFs > 60.20, ds 0.58–0.60; Table 4). For practice immersion, results indicated that it was very likely that children practicing in virtual reality felt more immersed than children practicing in roleplays, according to both child- and therapist-reports (BFs > 48.57, ds 0.48–1.05).

Treatment appreciation and perceived efficacy

Results showed that it was likely that children in the virtual reality group appreciated the treatment more than children in the roleplay group, according to themselves ($BF = 13.93$, $d = 0.35$), their therapists ($BF > 100,000$, $d = 1.23$) and their parents ($BF = 79.23$, $d = 0.54$; Table 4). Further, results showed that it was only somewhat more likely that children participating in the virtual reality version rated the treatment overall with a higher grade than children in the roleplay version ($BF = 2.71$, $d = 0.14$), but much more likely that children rated virtual reality as practicing method with a higher grade than roleplays ($BF = 1631.37$, $d = 0.75$). For perceived efficacy, reports showed that it was much more likely that therapists perceived virtual reality as more effective than roleplays ($BF = 568.47$, $d = 0.62$; Table 4), and only somewhat more likely that children and parents had this perception (BFs 2.40–2.65; ds 0.13–0.14).

Table 4

Means (*M*), standard deviations (*SD*), Bayes factors (*BF*) and Cohen's d effect sizes (*d*) of emotional engagement, practice immersion, treatment appreciation, and perceived efficacy.

		YourSkills Virtual reality		YourSkills Roleplay		Virtual reality vs Roleplay	
		M	*SD*	*M*	*SD*	*BF*	*d* [95% CI]
Engagement	Child	2.77	1.15	2.13	1.08	153.43	0.58 [0.11, 1.04]
	Therapist	3.71	1.16	3.06	0.96	60.20	0.60 [0.01, 1.18]
Immersion	Child	3.35	1.05	2.81	1.18	48.57	0.48 [0.01, 0.94]
	Therapist	3.54	0.93	2.58	0.89	71293.20	1.05 [0.43, 1.65]
Appreciation	Child	4.24	0.96	3.87	1.15	13.93	0.35 [-0.11, 0.81]
	Therapist	4.56	0.45	3.69	0.91	176419.75	1.23 [0.59, 1.83]
	Parent	4.35	0.86	3.86	0.97	79.23	0.54 [0.05, 1.01]
Efficacy	Child	4.36	0.65	3.79	0.73	2.65	0.14 [-0.32, 0.60]
	Therapist	4.24	0.59	3.83	0.74	568.47	0.62 [0.02, 1.19]
	Parent	4.22	0.90	4.11	0.79	2.40	0.13 [-0.34, 0.60]
Rating	YourSkills	8.40	1.75	8.10	2.34	2.71	0.14 [-0.32, 0.60]
	Method	8.66	1.51	6.90	2.88	1631.37	0.75 [0.27, 1.22]

Note. CI = Confidence Interval

DISCUSSION

The present multicenter randomized controlled trial examined whether interactive virtual reality enhanced the effectiveness of CBT for boys with aggressive behavior problems compared to CBT with roleplays and care-as-usual. The results indicated that CBT with virtual reality was more likely to reduce aggressive behavior than care-as-usual for six out of seven outcomes. Effects were medium-to-large for measures assessing weekly aggression (*d*s .59 − .95) and small-to-medium for measures assessing aggression in the past month (*d*s .19 − .33). The same pattern of results was found when we compared both CBT groups (i.e., virtual reality and roleplays) to care-as-usual, suggesting that our newly developed CBT protocol outperformed care-as-usual. When we directly compared virtual reality versus roleplays, results favored virtual reality on four of seven aggression measures, with small-to-medium effect sizes (*d*s .14 − .68). Virtual reality clearly outperformed roleplays on other aspects: it was very likely that children were more emotionally engaged and immersed during virtual reality practice than in roleplays. Also, children most likely appreciated virtual reality more and perceived this method as more effective than roleplays.

Our findings provide the first indication that interactive virtual reality can enhance effects of CBT for children with aggressive behavior problems. Effect sizes for virtual reality versus care-as-usual were substantial (ds .19 − .95) and similar or larger than in meta-analytic research comparing CBT to control groups (d = .23; McCart et al., 2006). In line with these effects, 48.6% of parents in the CBT virtual reality group reported clinically relevant improvements in children's aggression, and parent-rated average aggression scores decreased from clinical levels to the normal range. Moreover, virtual reality likely enhanced children's treatment appreciation and involvement. This is highly relevant, as children with aggressive behavior problems are often not motivated for treatment (Frick, 2012; Lochman et al., 2019), whereas enhancing treatment appreciation has been related to increases in treatment effectiveness (Lochman, Kassing, et al., 2017).

Interactive virtual reality had some benefits over CBT with roleplays. Children practicing in virtual reality were more emotionally engaged and immersed, and we found some indications that virtual reality outperformed roleplays in effectiveness. These findings align with the dual-mode social information processing model for children with aggressive behavior problems (Verhoef et al., 2022). This model proposes that children process social information in either the automatic mode (i.e., fast, emotion-driven aggression) or the reflective mode (i.e., slow, deliberately selected aggression). Based on this model, interventions may be most effective when children's social information processing patterns are targeted in the mode that is also active when they engage in aggressive behavior in daily life. Virtual reality may trigger the automatic mode more so than roleplays, as children practice in realistic environments and do not have to rely on their memory or imagination (Park et al., 2011), triggering the reflective mode.

Although our results provide first indications that both virtual reality and our newly developed CBT protocol outperformed care-as-usual, we did find marked differences between outcome measures. Effects on measures assessing aggression in the past *month* (i.e., CBCL/TRF and IRPA) were generally smaller than effects on measures assessing aggression in the past *week* (i.e., weekly aggression measure). We propose three explanations for this discrepancy. First, we used measures that were validated to assess children's aggression in the past month. However, at post-assessment, this month included the last few weeks of the treatment period. In these weeks children still needed to learn new skills and generalize these to daily life, and so the monthly measures may have underestimated treatment effects. Second, the weekly measures might have been more sensitive to short-term changes in behavior as these items were specifically developed to capture this (Alsem, Keulen, et al., 2022). Third, questions concerning a longer time period

may be more strongly affected by the 'halo effect': a generalized impression of a child as 'aggressive' (Abikoff et al., 1993). The weekly measures may have been less susceptible to negative views that parents and teachers may have developed about children with behavior problems (DeVries et al., 2017).

Effects of CBT with virtual reality also differed between informants. Child-reported effects on aggression were generally smaller than effects reported by parents and teachers. One explanation is that children may have underreported their aggressive behavior problems at pre-assessment (e.g., due to external attributions of their own behavior; De Los Reyes & Kazdin, 2005). Children may then have become more aware of their problems during the treatment (i.e., response shift bias; Rioux & Little, 2020), which is in line with our finding that we found little support for decreases in child-reported aggression across all treatment groups. Alternatively, parents and teachers may have overreported effects of the treatment. They were not blind to allocation status, and may have expected the novel virtual reality treatment to be more effective. However, this alternative explanation seems less likely, as intervention effects on parent reported measures have generally been found to be similar in magnitude to actual observed effects (Menting et al., 2013).

Strengths of this study include the randomized design with two comparison groups that allowed us to compare virtual reality with care-as-usual and examine the additive value of virtual reality compared to roleplays. We included multiple clinical centers, and recruited children in routine care. We used a multi-informant approach, which is highly informative as aggressive behavior is context-dependent and the correspondence between informants is relatively low (De Los Reyes et al., 2015). Last, we used Bayesian statistics, presenting the enhanced effectiveness of virtual reality in terms of likelihood, which is relevant for clinicians who have to decide under uncertainty which treatment is most likely to be effective.

Our study also had its limitations. First, we were not able to achieve our preregistered sample size, which was inevitable given the COVID-19 situation. We used Bayesian statistics, which are still influenced by smaller sample sizes (i.e., lower Bayes factors reflect less certainty), but allowed us to quantify the amount of support for our hypotheses instead of yielding a dichotomous decision based on an arbitrary cut-off (e.g., $p < .05$; Cohen, 1988) that may have been unduly influenced by a lack of power (van de Schoot et al., 2014). Second, only half of the families in the care-as-usual group participated in treatment for aggressive behavior problems during the study (although they could receive treatment for other problems). This group should thus be seen as a partly passive control group, and effects might have been smaller when care-as-usual treatment participation had been higher. On the other hand, our control group does reflect treatment

received by children in routine care in clinical centers in the Netherlands. Third, due to ethical and practical regulations in the clinical centers, pre-assessments were conducted after randomization. Parents, children and teachers were not blind to allocation during the pre-assessment, which might in theory have influenced their reports of children's aggressive behavior problems, as well drop-out rates. Specifically, our randomization procedure could not prevent us from ending up with unequal sample sizes over conditions. The care-as-usual group was smallest, due to the highest number of parents who withdrawn consent after randomization ($n = 6$). This was inevitable, given the ethical requirement that consent can be withdrawn at all times and without reasons. Future research may aim for baseline assessments prior to randomization, if ethically and practically attainable.
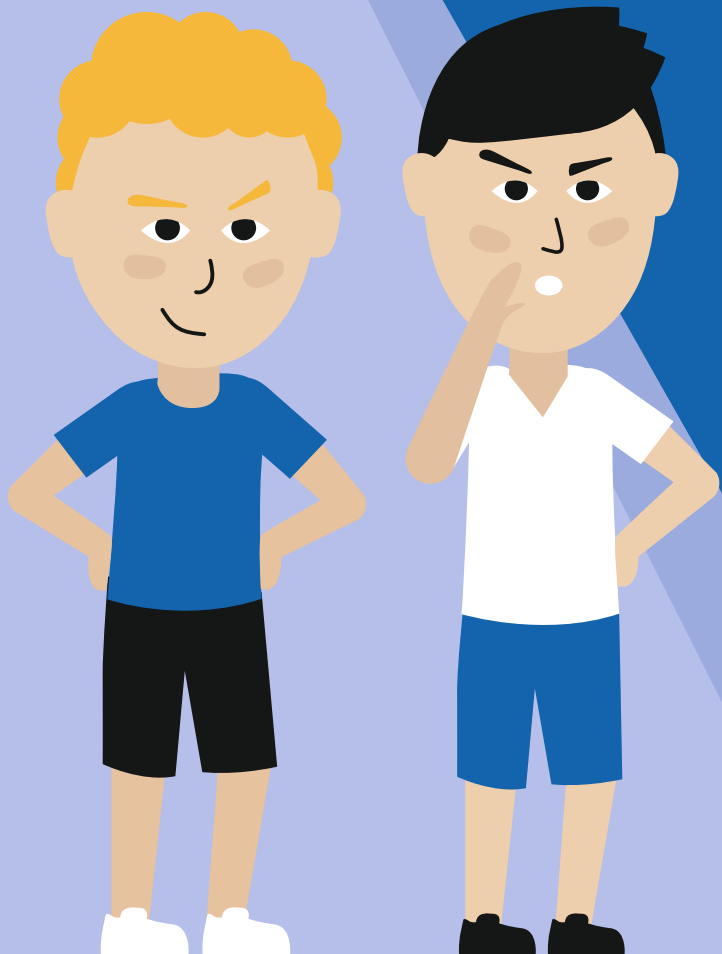
Our findings open up promising directions for future research. First, our study provides promising first indications that CBT with interactive virtual reality may be more effective than care-as-usual for children with aggressive behavior problems; however, this is a first study and replication is needed. Second, building on the promising immediate post-intervention effects of CBT with virtual reality, it would be interesting to examine longer term effectiveness, as training effects can become more apparent when children have had more time to generalize learned skills to daily life (Lochman et al., 2015; McCart et al., 2006). Third, we included only boys in our study and findings can thus not be generalized to girls. Future research could examine whether girls with aggressive behavior problems benefit equally from adding virtual reality to interventions, or that adaptions need to be made in virtual reality scenarios. Fourth, it may be interesting to examine the mechanisms of change that may drive the decreases in aggression within children (Chorpita et al., 2005). For example, researchers could test if enhanced levels of emotional engagement and immersion in virtual reality predict larger decreases in aggression. Also, it may be relevant to test emotion regulation and social information processing as treatment mechanisms, especially as virtual reality may be a more effective tool to practice these skills. Fifth, investigating the cost-effectiveness of CBT with virtual reality may be a relevant next step, as this new technology comes along with extra costs for equipment, licenses to use the virtual reality, and training professionals (Lindner, 2021). This could be worth the investment if converging evidence shows that CBT with virtual reality is more effective than current treatments and may result in shorter treatments, less drop out, and lower costs for society on the long term (Geraets et al., 2021). Sixth, future research could examine therapist effects and for example investigate the influence of therapeutic alliance or years of experience on treatment outcomes (Karver et al., 2018).

In conclusion, we have found that it is likely that CBT with interactive virtual reality leads to larger decreases in children's aggressive behavior compared to care-as-usual. Compared to CBT with roleplays, results moderately favored virtual reality on four out of seven aggression measures, and clearly supported that virtual reality is likely to enhance children's emotional engagement and practice immersion, as well as treatment appreciation and perceived efficacy. Thus, interactive virtual reality seems a promising tool to enhance children's motivation during treatment and increase the effectiveness of CBT for children with aggressive behavior problems.

PART

2

Understanding treatment mechanisms

4

Capturing mechanisms of change:

Weekly covariation in anger regulation, hostile intent attribution, and children's aggression

ABSTRACT

Interventions for children's aggression typically target assumed underlying mechanisms, such as anger regulation and hostile intent attribution. The expectation here is that targeting these mechanisms will result in *within-person* changes in aggression. However, evidence for these mechanisms is mostly based on *between-person* analyses. We therefore examined whether within-person changes in adaptive anger regulation and hostile intent attribution covaried with within-person changes in children's aggression. Children (N = 223; age 7 to 12; 46% boys) filled out four weekly report measures to assess adaptive anger regulation, hostile intent attribution, and aggression. The psychometric properties of these novel measures were adequate. Results of multi-level analyses revealed within-person effects: weekly changes in adaptive anger regulation and hostile intent attribution covaried with changes in children's aggression. This corresponded with between-person findings on the same data: children with lower levels of adaptive anger regulation and higher levels of hostile intent attribution reported more aggression than other children. These findings support the idea that targeting anger regulation and hostile intent attribution in interventions may lead to changes in individual children's aggression.

Keywords
Emotion regulation, hostile intent attribution, childhood aggression, within-person analyses, diary report

INTRODUCTION

Aggressive behavior problems in children are among the most common reasons for referral to mental health care (Lochman & Matthys, 2017; Merikangas et al., 2009). Left untreated, aggressive behavior problems are persistent and relatively stable over time (Burks et al., 2001; Girard et al., 2019; Jester et al., 2008), predicting later delinquency, substance abuse, lower academic achievement, disturbances in relationships with peers, and high costs to society (Evans et al., 2021; Foster et al., 2005; Loeber & Farrington, 2000; Stipek & Miles, 2008). Interventions for children's aggression typically target assumed underlying mechanisms, such as anger regulation and hostile intent attribution (Bookhout et al., 2017). The expectation here is that targeting these mechanisms will result in *within-person* changes in aggression. However, evidence for the associations between these mechanisms and children's aggression consists almost exclusively of findings from *between-person* analyses (e.g., Crick & Dodge, 1996; de Castro et al., 2005). These between-person analyses may reveal, for example, that, on average, children who make more hostile intent attributions, become more aggressive over time compared to children who make less hostile intent attributions (i.e., interindividual differences). However, these findings will not reveal whether within-person changes in children's hostile intent attribution covary with changes in their own aggression (i.e., intraindividual processes). To truly understand mechanisms of change, we need research that examines within-person change instead of between-person differences. Our aim of the present study was to examine within-person covariation in anger regulation, hostile intent attribution, and children's aggression.

Within-person studies are an important next step in clinical psychology research. Although between-person evidence is valuable to identify variables that can be targeted in interventions, we cannot conclude that associations found in between-person analyses are similar to within-person associations (Burke & Loeber, 2016; Kazdin, 2011). In fact, previous studies have shown that conflating the two can lead to biased results and potentially incorrect conclusions (Berry & Willoughby, 2017; Hoffman & Stawski, 2009). This issue is less abstract than it may seem. Consider the relation between speed of typing and number of typos (Litschge et al., 2010)— even though some people - such as typists - will type faster and make less typos than others (i.e., a *negative* between-person association), they will also make more mistakes when they type faster (i.e., a *positive* within-person association; Hamaker, 2012). Another illustrative example comes from developmental psychology research. In one study, between-person analyses showed that adolescents who were more secretive than others, also perceived *more* privacy invasion by their parents. In contrast, within-person analyses showed that when an adolescent

became more secretive, parental privacy invasion actually *decreased* (Dietvorst et al., 2018). These examples show that, at least in some cases, within- and between-person analyses can yield opposite conclusions. This has important implications for intervention research, where targeting mechanisms based on between-person findings might inadvertently cause iatrogenic effects.

Many interventions for children's aggression are based on between-person findings. The present study therefore seeks to investigate within-person associations for two frequently targeted mechanisms of change in interventions for children's aggression: anger regulation and hostile intent attribution (Bookhout et al., 2017). According to the social information processing model, both anger regulation and hostile intent attribution should predict within-person changes in aggressive behavior (Crick & Dodge, 1994; Lemerise & Arsenio, 2000). This model assumes that children process social information in ordered steps (e.g., encoding, interpretation, goal selection, response generation), resulting in a behavioral response. However, empirical research examining anger regulation and hostile intent attribution as predictors of aggression has predominantly used between-person analyses, such as regression analyses or cross-lagged panel models at the group level (Hamaker et al., 2015). From these studies, we know that children with higher levels of aggressive behavior also have more difficulties regulating their anger and frustration than other children (Eisenberg et al., 2005; Rothbart et al., 1994), have a limited repertoire of adaptive anger regulation strategies (de Castro et al., 2005; Roberton et al., 2012; Röll et al., 2012), and displayed emotion regulation problems already earlier in their development (Röll et al., 2012). Moreover, children with aggressive behavior problems display a stronger tendency to interpret ambiguously intended social behavior as stemming from hostile intent (Crick & Dodge, 1996; Verhoef et al., 2019), and both experimental and longitudinal research have shown that hostile intent attribution triggers and predicts children's aggression (de Castro et al., 2003; Dodge et al., 2015). Although this body of between-person evidence is substantive, it is not enough to support these constructs as mechanisms of change in interventions (Hamaker et al., 2015). Only within-person analyses can inform us whether changes in children's anger regulation and hostile intent attribution will indeed coincide with changes in their aggression.

Research on within-person associations requires that data are collected at multiple timepoints from multiple individuals (Curran & Bauer, 2011). An appropriate approach for this goal are diary report methods (Bolger et al., 2003; Esposito et al., 2005), which are used to study individuals' behavior on repeated measurements over a predefined period (ranging from days to months; Lischetzke, 2014). Clinical

researchers, for instance, have used diary reports to assess weekly changes in children's well-being, such as the Brief Problem Checklist and the Child Outcome Rating Scale (Casey et al., 2020; Weisz et al., 2012). This approach seems particularly relevant for the study of anger regulation and hostile intent attribution since short-term variability in these constructs is found to be high. Anger regulation varies over days and situations (Colasante et al., 2016; McMahon & Naragon-Gainey, 2019) and hostile intent attribution may vary within children depending on the moment and context (de Castro et al., 2003). We therefore developed weekly report measures to assess children's adaptive anger regulation, hostile intent attribution, and aggression on a weekly basis.

Our aim of the present study was to investigate within-person covariation in adaptive anger regulation, hostile intent attribution, and children's aggression. To this end, we first examined the psychometric properties of our newly developed weekly report measure by testing the internal consistency, convergent validity, and concurrent validity. Second, we investigated our main research question: whether within-person changes in adaptive anger regulation and hostile intent attribution covaried with within-person changes in aggression—mirroring the between-person findings of previous research. We used multi-level analyses to test whether children would report higher levels of aggression in weeks when they reported lower levels of adaptive anger regulation and higher levels of hostile intent attribution. Third, we examined whether our within-person findings would correspond with between-person findings with the same data, expecting that children with lower levels of adaptive anger regulation and higher levels of hostile intent attribution, reported more aggression than other children. With our study, we hope to provide more insight into a key assumption underlying current interventions: that changes in anger regulation and hostile intent attribution are related to changes in individual children's aggression.

METHOD

Participants

Participants were 223 children, 7 to 12 years of age (54% girls, 46% boys; M_{age} = 10.18, SD = 1.21). We recruited children from Dutch primary education schools in (sub)urban communities. The schools served mostly middle-class communities (income inequality in The Netherlands is relatively low; U.S. Central Intelligence Agency, 2018). The six participating schools distributed consent letters to all parents/caregivers of children from grades 3 to 6. An overview of descriptive statistics for each school separately is provided in Table 1. Active written informed

consent was obtained from all parents and twelve-year-old children (consent rate 44%). A cinema gift card (€30) was raffled among participating children. The study was approved by the Ethics Review Board of Utrecht University's Faculty of Social and Behavioral Sciences (No. 20-0204).

Table 1
Descriptive statistics of the participants per school.

School	n	% boys	% girls	M_{age}	SD_{age}
1	87	37.9%	62.1%	9.84	1.21
2	39	51.3%	48.7%	10.64	1.02
3	14	64.3%	35.7%	11.67	0.30
4	15	46.7%	53.3%	11.16	0.84
5	25	56.0%	44.0%	9.77	1.13
6	43	46.5%	53.5%	9.87	1.05

Procedure
Data collection took place in children's classrooms during four weekly sessions of 5 minutes (week 1-3) or 30 minutes (week 4), which were spaced exactly one week apart. During the first session, research assistants provided children with instructions and a paper booklet containing all study measures. Children filled out the first weekly report, with research assistants present to answer any questions. During the second and third session, children filled out the second and third weekly report accompanied by their own teacher. At the fourth session, research assistants asked children to fill out the fourth weekly report, as well as several validated measures assessing anger regulation, hostile intent attribution, and aggression.

Weekly report measures
Based on existing questionnaires, we developed a weekly report to assess adaptive anger regulation, hostile intent attribution, and aggression that we expected to be sensitive to weekly changes. Constructing a short, feasible scale was important because longer or more complicated instruments are not suited for repeated measurements in children (Casey et al., 2020). For the aggression and anger regulation scales, we used similar items as assessed in a recently published intervention trial examining weekly emotion regulation and aggression in adolescents (te Brinke et al., 2021). We conducted a pilot study in another sample of children (n = 89) to assess the quality of these items, which led us to replace the anger regulation item 'This week I was angry' with 'This week I managed to

do something against my anger' to improve internal consistency. By changing this, internal consistency of the adaptive anger regulation scale increased from low (Cronbach's α ranging from .12 to 39 across weeks) in the pilot study to adequate (α ranging from .67 to .72) in the current study. Internal consistencies were already adequate in the pilot study for the hostile intent attribution scale (α ranging from .65 to .75) and aggression scale (α ranging from .69 to .80).

Adaptive anger regulation
We assessed weekly adaptive anger regulation by asking children to rate three items: 'This week I managed to do something against my anger,' 'This week I was so angry that I couldn't stop myself,' 'This week I was able to calm myself down when I got angry,' on a 5-point scale (1 = *never*; 5 = *very often*). We averaged across items to calculate an adaptive anger regulation score for each week, allowing for missing data in item scores (1.2% missed one item).

Aggression
To assess children's weekly aggression, we asked children to rate three items: 'This week I fought with someone,' 'This week I kicked or beat someone,' and 'This week I called someone names,' on a 5-point scale (1 = *never*; 5 = *very often*). Items were averaged for each week, allowing for missing data in item scores (2.2% missed one item; 0.3% missed two items).

Hostile intent attribution
To assess children's weekly hostile intent attribution, we asked children to rate three items: 'This week people were mean to me,' 'This week people were nice to me,' and 'This week people wanted to bother me,'. Children rated the items on a 5-point scale (1 = *never*; 5 = *very often*) and items were averaged for each week, allowing for missing data in item scores (2.2% missed one item; 0.6% missed two items).

Validation measures
Adaptive anger regulation strategies
Children filled out the anger scale of the FEEL-KJ (Braet et al., 2013), rating their anger regulation strategies over the past month on a 5-point scale (1 = *almost never*; 5 = *almost always*). Only the adaptive scale was used in this study (14 items; e.g., 'When I'm angry I think about how I could solve the problem'). We computed scores as the average across items (Cronbach's α = .88), allowing for missing data in item scores (9.0% missed one item, 0.4% missed three items and 1.3% missed seven items).

Aggression

We measured children's aggression using the 7-item Instrument for Reactive and Proactive Aggression (IRPA; Polman et al., 2009). Both children and teachers rated the frequency of children's aggressive behaviors in the past month (e.g., 'How often did you/this child kick other children in the past month?') on a 5-point scale (1 = *did not occur*; 5 = *daily*). We computed aggression scores as the average across items (Cronbach's $\alpha_{teacher}$ = .82 and $\alpha_{children}$ = .73), allowing for missing data in item scores (0.4% of the teachers missed one item; 3.1% of the children missed one item and 0.4% of the children missed four items).

Hostile intent attribution

Four audiotaped vignettes describing hypothetical, ambiguous peer provocations were used to assess children's hostile intent attribution (adapted from de Castro et al., 2005). Research assistants told children that they would listen to vignettes about daily social events. Children were asked to imagine each story was happening to them. After each story, children filled out two questions: 'The other boy did [behavior other boy]. Did he intend to be mean?' and 'Did he do this to bother you?' on a 10-point scale (1 = *not at all*; 10 = *very much*). The eight items were averaged (Cronbach's α = .83), allowing for missing data in item scores (2.2% missed one item and 0.4% missed two items).

Data analyses

We first examined three psychometric properties of our weekly report measures using IBM SPSS Statistics 26. First, we assessed whether internal consistency was adequate, using Cronbach's alpha's (α > .60) and item-total correlations (r > .20; Evers, Lucassen, Meijer, & Sijtsma, 2010). Second, we examined convergent validity by testing whether the weekly reports were significantly positively associated with validated questionnaires assessing the same construct. Third, we examined concurrent validity by testing whether, in each week, adaptive anger regulation and hostile intent attribution reports were significantly associated with the weekly reports of aggression in the same week.

We examined within-person and between-person associations using multilevel analyses in Mplus 8 (Muthén & Muthén, 2019). We took a three-step approach. First, we executed three random intercept models to assess whether there was significant variance at the within- and between-person level in adaptive anger regulation, hostile intent attribution, and aggression. As significant variance is required to examine within-person and between-person associations, this step serves as a prerequisite for the next steps. Second, we executed one model to investigate within-person associations, entering adaptive anger regulation and

hostile intent attribution as predictors for aggression at the within person level (i.e., level 1). We used person-mean centred variables for these analyses, which we created by subtracting children's own mean score across the four weeks from each of their weekly scores. This allowed us to examine whether lower (than their own average) levels of adaptive anger regulation and higher (than their own average) levels of hostile intent attribution predicted higher levels of aggression within each week. The resulting betas represent the average within-subject effects across the four weeks. Third, we investigated between-person associations by adding adaptive anger regulation and hostile intent attribution as predictors to the model at the between person level (i.e., level 2). For these analyses, we created grand mean centred variables by subtracting the sample's mean score from children's mean scores across the four weeks. This allowed us to examine whether children with lower (than the sample average) levels of adaptive anger regulation and higher (than the sample average) levels of hostile intent attribution also displayed higher levels of aggression. The raw data and analysis code are available at the Open Science Framework.

RESULTS

4

Preliminary analyses
Missing data
We inspected missingness in our weekly measures. In total, 162 children completed questionnaires in all four weeks (72.6%) and almost all children completed questionnaires in at least three weeks (97.3%). We compared children that completed all four weeks ($n = 162$) with children with at least one missing week ($n = 61$) and found no significant differences in levels of adaptive anger regulation, hostile intent attribution, and aggression. To check for missing data patterns on item level across assessments, we conducted Little's test which produced a normed χ^2 (χ^2/df) of 1.33, indicating that data were missing at random (Bollen, 1989). We therefore used default settings for multilevel data in Mplus to estimate missing data, which is maximum likelihood (MLR; Muthén & Muthén, 2007). Missingness for validation measures was low (3.8%) and was handled using pairwise deletion in SPSS.

Descriptive statistics of the weekly report measures
Descriptive statistics and intercorrelations of children's mean scores across the four weeks were calculated. Children scored on average 4.05 on adaptive anger regulation ($SD = 0.78$; ranging from 1.44 to 5.00), 1.75 on hostile intent attribution ($SD = 0.62$; ranging from 1.00 to 4.33), and 1.58 on aggression ($SD = 0.59$; ranging from 1.00 to 3.89). As expected, children with lower levels of adaptive anger

regulation scored higher on hostile intent attribution ($r = - .37$, $p < .001$) and aggression ($r = - .43$, $p < .001$). Children with higher levels of hostile intent attribution also scored higher on aggression ($r = .53$, $p < .001$).

Table 2
Pearson's correlations of the weekly reports of adaptive anger regulation, hostile intent attribution, and aggression with validated measures assessing the same constructs.

	Validation measures			
	Adaptive anger regulation	Hostile intent attribution	Aggression child-report	Aggression teacher-report
Weekly report week 1	.27**	.24**	.50**	.30**
Weekly report week 2	.30**	.24**	.60**	.32**
Weekly report week 3	.20**	.15*	.63**	.22**
Weekly report week 4	.25**	.17*	.57**	.23**

* $p < .05$ ** $p < .01$

Psychometric properties of the weekly report measures
The internal consistencies of the weekly measures were adequate: Cronbach's α's ranging from .61 to .96, and item-total correlations ranging from .22 to .72 (see Appendix B). The convergent validity of the weekly measures was adequate: Correlations between the weekly reports and validated measures of the same constructs were all significant, with small-to-moderate correlations for adaptive anger regulation, small correlations for hostile intent attribution, and large correlations for child-reported aggression (see Table 2; Cohen, 1988). Last, attesting to the concurrent validity, the weekly reports of aggression were significantly correlated with weekly reports of both adaptive anger regulation (ranging from $r = -.29$ to $-.43$; all ps $< .05$) and hostile intent attribution in the same week (ranging from $r = .44$ to $.53$; all ps $< .05$; see Appendix A).

Main analyses
Within-person and between-person variance
There was significant variance at both the within- and between-level in each of the three weekly report variables (all ps $< .001$) of adaptive anger regulation (41.7% within; 58.3% between), hostile intent attribution (45.5% within, 54.5% between), and aggression (37.9% within; 62.1% between). These *within-person* variances indicate that children fluctuated in their levels of adaptive anger regulation, hostile intent attribution, and aggression over the four weeks, whilst the *between-person*

variances indicate that children differed from each other in their average levels of these variables across the four weeks.

Within-person associations

As expected, we found that within-person changes in adaptive anger regulation (B = -0.11, SE = 0.04, β = -.14, p = .002) and hostile intent attribution (B = 0.28, SE = 0.04, β = .30, p < .001) were significantly related to within-person changes in aggression during the four weeks (see Table 3). Together, adaptive anger regulation and hostile intent attribution explained 17.2% of variance in aggression at the within-person level. These findings indicate that children reported more aggression in weeks they reported less adaptive anger regulation and more hostile intent attribution. To illustrate these within-person effects, Figure 1 presents scores of the four children with the highest variation in aggression.

Between-person associations

As expected, we found that adaptive anger regulation (B = -0.20, SE = 0.06, β = -.30, p < .001) and hostile intent attribution (B = 0.42, SE = 0.06, β = .49, p < .001) were significantly related to aggression at the between-person level across the four weeks (see Table 3). Adaptive anger regulation and hostile intent attribution together explained 38.3% of the variance in aggression at the between-person level. These findings indicate that children who reported lower levels of adaptive anger regulation and higher levels of hostile intent attribution than others, also showed more aggression than others.

Table 3

Results of the multilevel analyses of the within and between person effects of adaptive anger regulation and hostile intent attribution on aggression over four weeks

	B	*SE*	β	*p*
Within person				
Adaptive anger regulation[a]	-0.11	0.04	-.14	.002
Hostile intent attribution[a]	0.28	0.04	.30	< .001
Between person				
Adaptive anger regulation[b]	-0.20	0.06	-.30	<.001
Hostile intent attribution[b]	0.42	0.42	.49	<.001

[a] Person mean centered; [b] Grand mean centered

Figure 1

Within-person change of adaptive anger regulation and hostile intent attribution with aggression in four children with the highest variation in aggression.
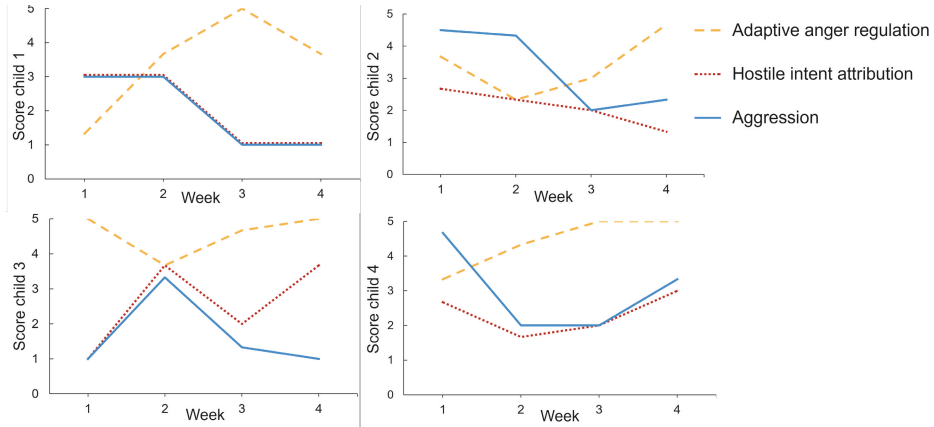
DISCUSSION

Interventions for children's aggression typically target assumed underlying mechanisms, such as anger regulation and hostile intent attribution. The expectation here is that targeting these mechanisms will result in *within-person* changes in aggression. However, evidence for these mechanisms is mostly based on between-person analyses. Therefore, in the present study we examined within-person covariation in adaptive anger regulation, hostile intent attribution, and children's aggression over a four-week period. We developed weekly report measures to assess adaptive anger regulation, hostile intent attribution, and aggression. These measures showed adequate psychometric quality. Results revealed within-person associations: weekly changes in adaptive anger regulation and hostile intent attribution covaried with changes in children's aggression. Similar patterns were found at the between-person level: children who reported lower levels of adaptive anger regulation and higher levels of hostile intent attribution than others, reported more aggression than others over the four weeks.

The present study is the first to replicate findings from earlier between-person analyses at the within-person level: changes in adaptive anger regulation and hostile intent attribution were related to changes in aggression *within* children, as depicted in Figure 1 (Crick & Dodge, 1994; de Castro et al., 2005; Verhoef et al., 2019). This finding is crucial for interventions, as it supports the use of anger regulation and hostile intent attribution as mechanisms of change to target

in interventions for children's aggression (Bookhout et al., 2017; Hamaker et al., 2015). Future intervention research could build on these findings by target children's anger regulation and hostile intent attribution, while assessing within-person changes in both these mechanisms and children's aggression. That way, researchers may learn whether induced changes in the assumed mechanisms indeed predict decreases in individual children's aggression over the treatment weeks (Kazdin, 2011). Our newly developed weekly report measures may provide an easy and valid tool to do so.

A strength of our study was that it included a relatively large sample of children followed over four weeks, which allowed us to apply a multilevel model. To our knowledge, this study was the first to examine whether within-person changes in anger regulation and hostile attribution are associated with changes in aggression. In addition, we developed weekly report measures of anger regulation, hostile intent attribution, and aggression, which demonstrated adequate psychometric qualities. If these promising findings are replicated in clinical samples, our weekly report measures could be valuable instruments to monitor mechanisms of change and treatment progress over the course of an intervention.

Our study also had its limitations. First, our main findings relied solely on self-report. Although self-reports of children's aggression have been associated with parent- and teacher-report (Achenbach et al., 1987; Marsee et al., 2014), using only self-reports raises the issue of common method variance. In fact, this issue might have contributed to the high amount of explained variance in aggression that we observed at the between-person level (38.3%). Future research could build on our findings by studying weekly changes in aggression with reports of multiple informants or observational measures. For hostile intent attribution and anger regulation, however, self-reports might be the preferred approach since these concepts concern internal processes that may be less visible to parents or teachers than external behavior (Cracco et al., 2015; Crick & Dodge, 1994). Second, the generalizability of our findings is still limited. We assessed only direct aggression, and data were collected in the Netherlands in a relatively well-functioning community sample of children ages 7 to 12 years (i.e., children recruited from the regular population with low mean levels of aggression). No data concerning ethnic background were collected. Future research is needed to examine whether our findings generalize to other forms of aggression (e.g., indirect aggression), and to other populations (e.g., children living in other regions, with diverse ethnic backgrounds, or children with aggressive behavior problems). Third, with our analyses we only examined covarying change and were not able to study temporal priority. It would be an interesting avenue for future research to

investigate whether fluctuations in anger regulation and hostile intent attribution at one moment temporally predict later changes in aggression. Fourth, the consent rate was relatively low in our study (44%). As consent rates are typically lower in schools serving children from lower socioeconomic backgrounds (Esbensen et al., 2008), future research may study within-person associations in more diverse samples including children showing higher levels of aggressive behavior.

Our findings open promising directions for future research. First, we showed evidence of spontaneous covarying change over a four-week period. An important next step may be to examine within-person associations when changes in anger regulation and hostile intent attribution are induced in therapy, which may inform us about the causal direction of within-person changes. Second, at a more fundamental level, it may also be relevant to consider the exact time intervals at which within-person associations are examined (Keijsers & van Roekel, 2018). For instance, research has shown that children's anger and aggression covary at a daily basis (Colasante et al., 2016), but conversely we know that children develop relatively consistent and stable emotion regulation styles and use these across different situations (Roberton et al., 2012). Third, an interesting avenue for future research might be to examine interaction effects of anger regulation and hostile intent attribution on children's day-by-day variations in aggression. For instance, it might be that children only become aggressive if they attribute hostile intent at moments when they are not able to regulate anger feelings effectively, for example because they are tired (Lemerise & Arsenio, 2000).

In conclusion, we have found that within-person changes in adaptive anger regulation and hostile intent attribution covaried with changes in children's aggression. These findings provide strengthened support for the assumption that targeting anger regulation and hostile intent attribution in interventions may lead to reductions in individual children's aggression. As such, our study may inspire researchers to conduct within-person studies to investigate assumed mechanisms of change in clinical interventions.

APPENDIX A

Pearson's correlations of the weekly reports and validated measures (assessed in week 4) of adaptive anger regulation and hostile intent attribution with the weekly reports of aggression in each of the four weeks.

	Weekly measure		Validated measures	
	Adaptive anger regulation	Hostile intent attribution	Adaptive anger regulation	Hostile intent attribution
Aggression week 1	-.35**	.44**	-.15*	.16*
Aggression week 2	-.43**	.50**	-.17*	.16*
Aggression week 3	-.35**	.53**	-.13	.11
Aggression week 4	-.29**	.51**	-.16*	.12

** $p < .01$ * $p < .05$

APPENDIX B

Cronbach's α and item-total correlations of the weekly reports of adaptive anger regulation, hostile intent attribution, and aggression.

Measure	Cronbach's α	Minimum - maximum of the item-total correlations
Adaptive anger regulation week 1	.67	.27 - .61
Adaptive anger regulation week 2	.69	.22 - .69
Adaptive anger regulation week 3	.70	.24 - .70
Adaptive anger regulation week 4	.72	.28 - .72
Hostile intent attribution week 1	.61	.32 - .58
Hostile intent attribution week 2	.67	.44 - .52
Hostile intent attribution week 3	.66	.34 - .58
Hostile intent attribution week 4	.74	.39 - .68
Aggression week 1	.67	.42 - .61
Aggression week 2	.69	.46 - .61
Aggression week 3	.64	.41 - .56
Aggression week 4	.67	.46 - .55

APPENDIX C

Pearson's correlations of the weekly reports of adaptive anger regulation and hostile intent attribution with the validated measures (assessed in week 4) of aggression reported by children and teachers.

	Validated measures	
	Child-reported aggression	**Teacher-reported aggression**
Anger regulation week 1	-.32**	-.13*
Anger regulation week 2	-.29**	-.13
Anger regulation week 3	-.33**	-.06
Anger regulation week 4	-.30**	-.19**
Hostile intent attribution week 1	.23**	.20**
Hostile intent attribution week 2	.25**	.20**
Hostile intent attribution week 3	.41**	.21**
Hostile intent attribution week 4	.36**	.19**

$** p < .01 * p < .05$
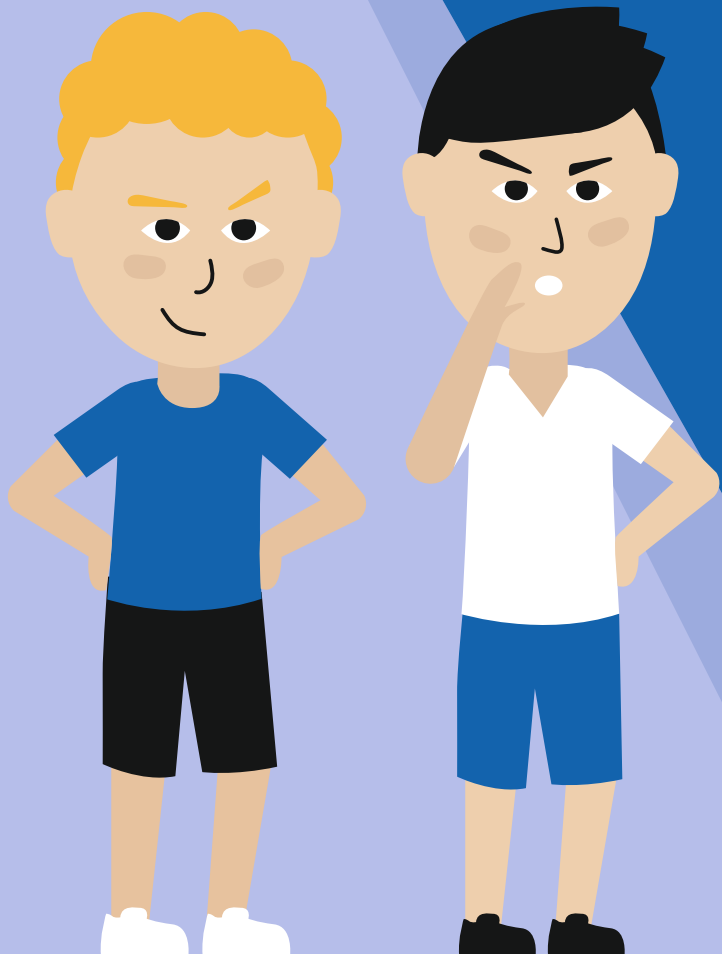
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Within intervention change:
Anger regulation and hostile intent attribution
as mechanisms reducing children's
aggressive behavior

ABSTRACT

Intervention programs can effectively reduce children's aggressive behavior problems. However, surprisingly few studies have investigated through what underlying mechanisms these interventions exert their beneficial effects. This requires high-frequency measurements of change mechanisms throughout the course of treatment. We used such a design to examine adaptive anger regulation and hostile intent attribution as mechanisms of change in an intervention to reduce children's aggressive behavior problems. In total, 76 boys with aggressive behavior problems (M_{age} = 10.58, SD = 1.52; 96.1% born in Netherlands) participated in an 11-session cognitive behavioral therapy intervention. During each treatment session, we used brief 3-item measures to assess children's self-reported anger regulation, hostile intent attribution and aggression, as well as parent-reported child aggression. We analyzed these high-frequency measurements using latent growth curve models, providing an empirical test of individual-level change mechanisms. Results showed that individual change in child-reported aggression was associated with individual change in adaptive anger regulation and hostile intent attribution. For parent-reported aggression, such associations were found only for hostile intent attribution. These findings provide support for anger regulation and hostile intent attribution as within intervention change mechanisms, supporting the idea that these mechanisms are effective intervention targets to reduce children's aggressive behavior problems.

Keywords
Within intervention change, aggressive behavior problems, mechanisms of change, children.

Author contributions
All authors were involved in conceptualizing the study. SA coordinated the data collection, analyzed the data, and wrote the first draft of the manuscript. All authors provided feedback on the manuscript. The data and syntax of this study are available through the Open Science Framework at https://osf.io/fmecd/

INTRODUCTION

Aggressive behavior problems in childhood have a negative impact on children and their environment (Girard et al., 2019). When left untreated, the prognosis of children with aggressive behavior problems is poor, with increased risk for delinquency, substance abuse, and poor school adjustment, resulting in high costs to society (Evans et al., 2021; Loeber & Farrington, 2000). To prevent escalation of aggressive behavior problems, interventions are needed to treat these problems effectively as they arise in childhood (Lochman & Matthys, 2017). Several intervention programs for children with aggressive behavior problems have yielded promising effects (Weisz & Kazdin, 2017). However, surprisingly few studies have investigated through what underlying mechanisms these interventions exert their beneficial effects (Kazdin, 2009). The aim of the current study was to investigate two possible mechanisms of change in an intervention to reduce children's aggressive behavior problems: anger regulation and hostile intent attribution.

Identifying mechanisms of change is important for several reasons. First, identifying and understanding the mechanisms of change in therapy can improve our understanding of aggressive behavior problems in children (Kazdin & Nock, 2003). Second, current interventions can be optimized by ensuring that they target the relevant underlying mechanisms and do not contain unnecessary components (Kraemer et al., 2002). Third, identifying mechanisms of change can facilitate parsimony across the variety of interventions for different problems, by focusing on important mechanisms of change that cut across diverse problems (Kazdin & Nock, 2003). Fourth, mechanisms of change can be used as 'tailoring variables' by providing clinicians with the flexibility to adapt treatments to variations in the mechanisms underlying children's problems (Collins et al., 2004; Kazdin & Nock, 2003).

Interventions to reduce children's aggressive behavior problems have frequently targeted anger regulation and hostile intent attribution as possible mechanisms of change (for a review, see: Chorpita & Daleiden, 2009). Both mechanisms are part of the social information processing (SIP) model (Crick & Dodge, 1994; Lemerise & Arsenio, 2000), which assumes that biases or deficiencies in a series of ordered processing steps contribute to aggressive behavior (Crick & Dodge, 1996). Indeed, empirical research has shown that children with aggressive behavior problems often have difficulties with anger regulation (for reviews see: Roberton et al., 2012; Röll et al., 2012) and display a stronger tendency to interpret ambiguously intended social behavior as stemming from hostile intent (for a review, see: Verhoef et al., 2019). From meta-analytical research, we know that targeting anger regulation and

problem solving in treatments is associated with larger reductions in aggression (Landenberger & Lipsey, 2005; Sukhodolsky et al., 2016). However, to test anger regulation and hostile intent attribution as mechanisms of change, intervention studies are required that directly assess these mechanisms and investigate how treatment change is produced (Greca et al., 2009; Weisz & Hawley, 2002). Of the few studies examining mechanisms of change, one intervention study has found indications that children's hostile attributions assessed at post-treatment may have functioned as a mediator between the intervention effect and children's aggressive behavior at follow-up (although the mediation effect was not statistically significant; Lochman & Wells, 2002). Another intervention study with four measurements has shown that emotion regulation skills partially mediated reductions in child aggression (Burke & Loeber, 2016). Thus, there are some indications that hostile intent attribution and anger regulation may mediate intervention effects on aggression.

An important next step in mapping anger regulation and hostile intent attribution as mechanisms of change, is to use high-frequency measurements of these variables during an intervention study (Kazdin, 2007; Laurenceau et al., 2007). This has three advantages. First, repeated measurements allow us to not only capture group-level change in mechanisms and outcomes but also examine change and variability at the individual-level (Laurenceau et al., 2007). Investigating individual-level change is needed as this indicates whether changes in a mechanism within a specific child are related to changes in treatment outcomes for *that* child. This has not been possible with traditional mediation analyses using group-level analyses (e.g., regression or repeated measures analyses) over a few measurements, as those analyses can only examine whether differences between children on the mechanism predict differences between children on the outcomes. Second, high-frequency measurements enhance the chance of identifying a mechanism of change (Kazdin, 2007). For example, when the trajectory of a mechanism emerges as cubic or S-shaped and only few measurements are taken, conclusions are highly dependent on the moment of the measurements and cannot identify the shape of the trajectory (Laurenceau et al., 2007). Including multiple measurements decreases this risk and enables researchers to obtain an accurate and informative picture of how change unfolds over time (Laurenceau et al., 2007; Moldovan & Pintea, 2015). Third, high-frequency measurements better correspond with the theorized change processes for anger regulation and hostile intent attribution. That is, changes in children's anger regulation and hostile intent attribution are expected to directly affect their subsequent (aggressive) response, rather than changing children's aggressive behavior in a process that unfolds over months between measurement occasions (de Castro et al., 2015).

To examine mechanisms of change, the timing and spacing of the repeated measurements is essential, and should be carefully based upon theory and prior work of the expected mechanisms of change (Laurenceau et al., 2007). According to the SIP model, anger regulation and hostile intent attribution are situation-dependent fast mental processes, and may therefore likely be susceptible to rapid change. An intervention with weekly sessions should, in theory, be able to produce weekly changes in these mechanisms. Indeed, a recent study has revealed that weekly changes in adaptive anger regulation and hostile intent attribution covaried with weekly changes in children's aggression (Alsem, Keulen, et al., 2022). The present study builds on these findings by examining, within an intervention study, whether *causing* changes in these mechanisms would go together with reductions in children's aggressive behavior.

The current study examined anger regulation and hostile intent attribution as mechanisms of change to reduce children's aggressive behavior problems. Our first aim was to examine whether adaptive anger regulation increased, whereas hostile intent attribution and child- and parent-reported aggression decreased over the intervention weeks. Our second aim was to investigate whether changes in anger regulation and hostile intent attribution were associated with changes in aggression over the weeks. We expected parallel change, given the theorized immediate effects of children's anger regulation and interpretation on their subsequent (aggressive) behavior (de Castro et al., 2015).

We examined our research questions within the intervention YourSkills. In this manualized cognitive behavioral therapy (CBT), children practice anger regulation and intent attribution skills during social interactions that are either simulated in virtual reality or roleplayed by a therapist (Alsem et al., 2021). In a previous study, we found that both the virtual reality and roleplay versions of YourSkills were more likely to reduce children's aggressive behavior than care-as-usual for six out of seven aggression outcomes, with some indications that virtual reality outperformed roleplay (Alsem, van Dijk, et al., 2022). We assessed children's self-reported anger regulation, hostile intent attribution, and aggression at each weekly treatment session. Parents also provided weekly reports of children's aggression. These high-frequency measurements enabled us to provide an empirical test of individual-level change mechanisms.

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METHOD

Participants

Participants were 76 children, 8 to 13 years of age (M_{age} = 10.58, SD = 1.52), who participated in a randomized controlled trial. This trial investigated the effectiveness of YourSkills, a newly developed cognitive behavioral therapy (Alsem, van Dijk, et al., 2022). Children were recruited at fifteen clinical centers in the Netherlands providing mental health care for children who have severe problems that impair daily functioning and require treatment. Recruitment began in September 2019 and the study ended in July 2021. Therapists working at the clinical centers were asked to approach parents of boys whose casefiles met the inclusion criteria: age 8-13 years, aggressive behavior problems, estimated intelligence level above 80, no severe autism spectrum disorder, and no epilepsy or severe visual or auditory limitations.

The randomized controlled trial included 115 children, randomized to three groups: YourSkills virtual reality, YourSkills roleplay, or care-as-usual (for the flowchart see Alsem, van Dijk, et al., 2022). In this study, we only included children who were randomized to the two YourSkills groups, because our aim was to examine the mechanisms of change of interventions for children's aggression. We excluded children in the care-as-usual group as we had no information about what mechanisms were targeted in the care-as-usual treatments. In addition, we only included children who participated in at least five of the intervention sessions, because children should have had the opportunity to learn the expected mechanisms of change.[1] Of the included children, 36 participated in YourSkills virtual reality and 40 in YourSkills roleplay. Most children (96.1%) were born in the Netherlands and in most families, both biological parents were born in the Netherlands as well (73.7%). In 14.5% of the families only one parent was born in the Netherlands and in 11.8% of the families both parents were born elsewhere. Parents attained middle levels of education (44.7%; ISCED 3-4), high education (39.5%; ISCED 5-8), or low education (15.8%; ISCED 0-2; UNESCO, 2012).

We obtained written informed consent from parents and 12- and 13-year-old children. Participation was voluntary and children and parents were assured of confidential use of their data. Children received a small gift after filling out the last assessment (e.g., a multicolor pen). This study was approved by the Ethics Committee of the University Medical Center Utrecht (NL67139.041.18) and the trial was registered in the Dutch Trial Register (NTR; https://www.trialregister.nl/trial/7959).

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1 We conducted sensitivity analyses including the five children that participated in less than half of the treatment sessions and results revealed similar conclusions.

Procedure

The current study consisted of eleven weekly assessments scheduled at each of the eleven YourSkills treatment sessions; one introduction session with parents and ten sessions with children. Therapists scheduled all sessions and invited researchers to conduct the first assessment during the introduction session (i.e., our baseline assessment). This assessment took place in another room with the first author or a trained research assistant. Children first completed a short task and then filled out the weekly assessments used in this study, as well as some other questionnaires (20-30 minutes in total). Directly after the session ended, the researcher asked parents to fill out questionnaires on a laptop. The ten other assessments were integrated within the treatment sessions with the child: all sessions started with children filling out the brief measures of anger regulation, hostile intent attribution, and aggression in a paper booklet (5 minutes). Parents or caregivers who brought the child to the treatment session were asked to fill out a brief measure of aggression in the clinical center's waiting room.

YourSkills treatment

YourSkills is a manualized CBT, developed based on evidence-based treatments for children with aggressive behavior problems. The effectiveness of YourSkills is examined in a previous study (Alsem, van Dijk, et al., 2022). Results of this study showed that both the virtual reality and roleplay versions of YourSkills were more likely to reduce aggressive behavior than care-as-usual for six out of seven aggression outcomes, suggesting that YourSkills successfully reduced children's aggressive behavior. When we directly compared virtual reality to roleplays, results favored virtual reality above roleplays on four of seven aggression measures (Alsem, van Dijk, et al., 2022).

The aim of YourSkills is to reduce children's aggressive behavior problems by enhancing emotion regulation and social information processing skills. Children practice anger recognition, anger regulation, nonhostile intent attribution, and other social problem solving skills in social interactions (for an overview of the treatment sessions, see: Alsem et al., 2021). To enable children to practice their skills or new cognitions whilst being emotionally engaged, therapists create challenging social situations for children in virtual reality or roleplays. In each session, therapists first explain a new skill, then model the skill using roleplay, and then—depending on the YourSkills version—use virtual reality or roleplays to let children practice the skill in anger-provoking social situations, such as being disadvantaged, having authority conflicts or being rejected by a peer. The details of the virtual reality and roleplay version of YourSkills are described in detail elsewhere (Alsem, van Dijk, et al., 2022).

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Measures
The psychometric quality of the weekly measures used in the current study were investigated in an earlier study. Results showed adequate internal consistency, convergent, and concurrent validity for the child-report version (Alsem, Keulen, et al., 2022).

Aggression
To assess children's aggression over the weeks, we asked both parents and children to rate three items (e.g., 'This week my child/I fought with someone') on a scale from 1 (never) to 5 (very often). Ratings were averaged across items. The internal consistency in the current study was adequate over the weeks for both children (α_{mean} = .79, α_{range} = .75-.87) and parents (α_{mean} = .79, α_{range} = .69-.83).

Adaptive anger regulation
We assessed weekly adaptive anger regulation by asking children to rate three items (e.g., 'This week I managed to do something against my anger') on a scale from 1 (never) to 5 (very often). The internal consistency in the current study was adequate over the weeks (α_{mean} = .64, α_{range} = .58-.71).

Hostile intent attribution
To assess children's weekly hostile intent attribution, we asked children to rate three items (e.g., 'This week people were mean to me'). Children rated the items on a scale from 1 (never) to 5 (very often). The internal consistency in the current study was adequate over the weeks (α_{mean} = .71, α_{range} = .52-.83).

Analyses
We ran all analyses in Mplus 8.4 (Muthén & Muthén, 2019). Before we tested our hypotheses, we explored whether there was variability in children's individual scores on mechanisms and outcomes over the weeks. We ran four random intercept models (i.e., for anger regulation, hostile intent attribution, and child- and parent-reported aggression) to estimate the amount of variance at the within- and between-person level for each variable. We expected substantial individual within-person variation over the weeks, reflecting intervention effects on children's adaptive anger regulation, hostile intent attribution, and aggression. We did not expect much variation at the between-person level because of our homogenous sample (i.e., participants all had aggressive behavior problems).

To test our first research question, whether children's adaptive anger regulation increased and their hostile intent attribution and aggressive behavior decreased across the course of the intervention, we estimated four univariate latent growth

models (LGMs) using an intercept factor and a linear slope factor. We expected that slope factors would significantly increase for adaptive anger regulation and decrease for hostile intent attribution and child- and parent-reported aggression. We modelled linear slopes because we expected change over the whole treatment period, and this approach is more parsimonious, preventing power problems in our relatively small sample.

Next, we investigated our second research question, whether individual-level increases in adaptive anger regulation and decreases in hostile intent attribution were associated with decreases in child- and parent-reported aggression. We estimated four bivariate LGMs, each estimating the slope factors of two variables at a time: 1) one of the two mechanisms and 2) children's aggressive behavior, either child- or parent-reported. We expected significant correlations in between slope factors in each of the four models. As LGMs estimate individual-level change trajectories, these models are suitable to examine mechanisms of change (Laurenceau et al., 2007).

Last, as a control analysis, we checked whether children's change trajectories differed between the virtual reality and the roleplay group, using Wald tests. If slopes differed between these two intervention groups, we corrected for this difference by adding intervention group as predictor to the slope factors. Results are presented in Appendix A.

For all LGM models, we examined the model fit using the Chi-square test statistic (χ^2), the Comparative Fit Index (CFI), and the Root Mean Square Error of Approximation (RMSEA). However, we did not necessarily expect a good model fit because we had many parameters in the model (i.e., eleven weeks of assessment) and a relatively small sample size. We hoped to obtain adequate model fit: CFI above .90, RMSEA below .10 and the ratio between the χ^2 test statistic and the degrees of freedom below 3 (this was not based on the χ^2 significance value to avoid problems with sample size; Schermelleh-Engel et al., 2003).

We inspected missingness in our measurements over the weeks. Most children completed questionnaires in all eleven weeks (78.9%) and all children completed questionnaires in at least six weeks. We compared children who completed all weeks ($n = 60$) with children who missed at least one week ($n = 16$) and found no significant differences in levels of adaptive anger regulation, hostile intent attribution, and aggression. To check for missing data patterns on the item-level across assessments, we conducted Little's test. This test yielded a normed χ^2 (χ^2/df) of 0.10, indicating that data was missing completely at random (Bollen, 1989).

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We therefore used default settings for multilevel data in Mplus to estimate missing data (i.e., maximum likelihood; Muthén & Muthén, 2007).

RESULTS

Preliminary analysis: Individual variability in change mechanisms and aggression
Our models revealed that there was significant variance at both the within- and between-level in adaptive anger regulation (57.9% within; 42.1% between), hostile intent attribution (58.0% within, 42.0% between), child-reported aggression (47.4% within; 52.6% between), and parent-reported aggression (51.9% within, 48.1% between). The within-person variances were substantial, and indicated, as expected, that children showed variability in their levels of adaptive anger regulation, hostile intent attribution, and aggression over the intervention weeks.

Research question 1: Individual-level change
Next, we examined whether we found the expected individual-level changes in adaptive anger regulation, hostile intent attribution, and child-and parent-reported aggression over the intervention weeks. Fit statistics of the LGMs are reported in Table 1. Not all fit statistics supported an adequate fit of our models. Although the chi-square ratio was adequate, CFI and RMSEA were not adequate for three out of four models. However, none of the modification indices improved the model and explained variances were substantial in all models (R^2 range .27 to .74). We continued with these models, because they provide a good test of our research questions and the lower fit is likely caused by the high amount of estimated parameters and small sample size (Stull, 2008).

As expected, results showed a significant linear increase in adaptive anger regulation, $B = 0.04$, $SE = 0.01$, $\beta = .57$, $p < .001$, and a significant linear decrease in hostile intent attribution over the intervention weeks, $B = -0.02$, $SE = 0.01$, $\beta = -.43$, $p = .021$. We also found the expected significant linear decreases in child-reported aggression, $B = -0.03$, $SE = 0.01$, $\beta = -.51$, $p = .01$, and parent-reported aggression over the intervention weeks, $B = -0.05$, $SE = 0.01$, $\beta = -.83$, $p < .001$. Descriptively, we inspected the percentage of children who changed in the expected direction (i.e., a slope factor above or below zero). We found that 72.4% of children increased in anger regulation, 64.9% decreased in hostile intent attribution, 71.2% decreased in self-reported aggression, and 79.0% decreased in parent-reported aggression. Thus, on average and for most children in the YourSkills intervention group, both mechanisms and outcomes changed in the expected direction.

Table 1

Model fit statistics of the individual-level change models and parallel change models for both child- and parent-reported aggression.

	χ^2 / df	CFI	RMSEA
Within intervention change			
Adaptive anger regulation	1.78	.88	.10
Hostile intent attribution	1.79	.87	.10
Child-reported aggression	1.97	.88	.11
Parent-reported aggression	1.45	.93	.08
Parallel change child-reported aggression			
Adaptive anger regulation	1.66	.84	.09
Hostile intent attribution	2.28	.72	.13
Parallel change parent-reported aggression			
Adaptive anger regulation	1.58	.83	.09
Hostile intent attribution	1.68	.81	.10

Note. Model fit guidelines: χ^2/df < 3, CFI > .90, RMSEA < .10 (Schermelleh-Engel et al., 2003).

Research question 2: Parallel change in mechanisms and outcomes

For child-reported aggression, results supported both anger regulation and hostile intent attribution as mechanisms of change. The bivariate LGM revealed that the slopes of adaptive anger regulation and child-reported aggression were strongly and significantly correlated, r = -.51, p = .018, indicating that children's increases in adaptive anger regulation over the weeks were related to decreases in their aggressive behavior. Similarly, the slopes of hostile intent attribution and child-reported aggression were strongly significantly correlated, r = .73, p = .002. Figure 1 illustrates these parallel change trajectories, presenting the average change trajectory of each variable over the intervention weeks.

For parent-reported aggression, results supported only hostile intent attribution as mechanism of change. Our bivariate LGMs revealed that the slope of hostile intent attribution was strongly significantly correlated with the slope of parent-reported aggression, r = .62, p = .006, but not with the slope of adaptive anger regulation, r = -.20, p = .357. Thus, decreases in parent-reported aggression were related to decreases in children's hostile intent attribution over the weeks, but not to increases in adaptive anger regulation.

Figure 1

Mean-level changes in anger regulation, hostile intent attribution, child-reported aggression, and parent-reported aggression over the intervention weeks.
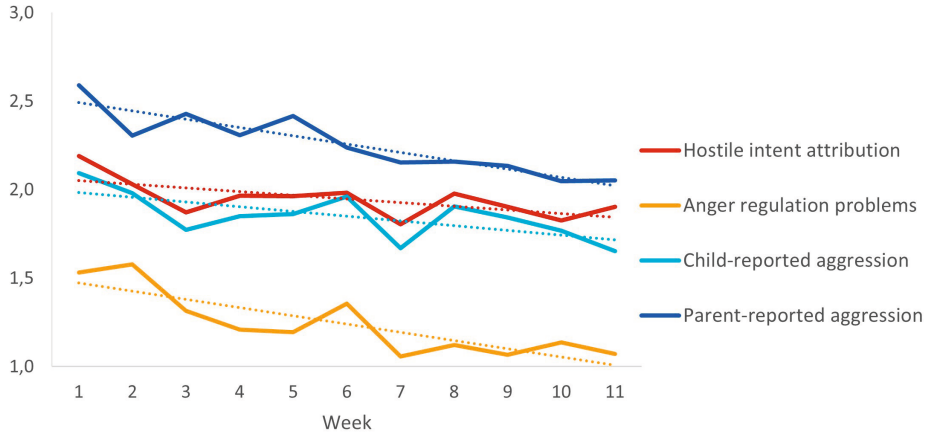
Note. Solid lines represent estimated mean scores at each measurement point. Dotted lines show estimated linear trendlines. For illustrative purposes, adaptive anger regulation scores were reversed so that lower scores represented less anger regulation problems.

DISCUSSION

The present study extends prior research on child interventions to reduce aggressive behavior problems, by investigating anger regulation and hostile intent attribution as mechanisms of change. We examined how interventions exert their beneficial effects, by providing an empirical test of individual-level change mechanisms. Therefore, we used high-frequency measurements of anger regulation, hostile intent attribution, and aggression throughout the course of treatment allowing us to not only capture group-level change in mechanisms and outcomes but also examine change and variability at the individual-level (Kazdin, 2007; Laurenceau et al., 2007). When modeling individual change across the eleven sessions of treatment, we found that children's adaptive anger regulation increased and hostile intent attribution decreased over the intervention weeks. Importantly, changes in these mechanisms were strongly associated with child-reported aggression. For parent-reported aggression, such associations were found only for hostile intent attribution. These findings provide support for anger regulation and hostile intent attribution as within intervention change mechanisms.

Our high-frequency measurements allowed us to also investigate individual variation over the treatment course. We found that within-child variances were substantial, highlighting the necessity of an individual-child approach to capture

variation in children over the weeks. The high within-child variances were in line with the social information processing model (Crick & Dodge, 1996; Lemerise & Arsenio, 2000), suggesting that anger regulation and hostile intent attribution are indeed situation-dependent fast mental processes, being susceptible to rapid changes. The relatively low between-children variances were not surprising, given our homogenous sample of boys with aggressive behavior problems. When we examined for how many children the intervention mechanisms and outcomes changed, we found that the majority of children changed in the expected directions (64.9% to 79.0% across mechanisms and outcomes). As not all children did benefit from targeting anger regulation and hostile intent attribution, future research might investigate whether other change mechanisms need to be targeted in CBT for these children, or that more intensive treatment programs are necessary (e.g., CBT combined with parent training). Our study showed that it is possible to identify the children who do change and who do not change or deteriorate during the treatment course. This could help clinicians to decide whether they need to adapt their treatment strategy.

Unexpectedly, we found no association between individual changes in child-reported anger regulation and parent-reported aggression. This could be due to a possible informant effect as the correspondence between the reportages of parents and children is found to be relatively low (De Los Reyes et al., 2015). Alternatively, it could be that some of the children that did not improve in anger regulation over the treatment course (27.6% of children remained stable or decreased in anger regulation), did reduce in parent-reported aggression. For this group it could be that only hostile intent attribution was a working mechanisms of change. Future research is needed to investigate the association between anger regulation as mechanisms of change for parent-reported aggression.

Our study had its limitations. First, we examined parallel change and can therefore not conclude that the mechanisms *caused* the decreases in aggression. To investigate causality, it is necessary to experimentally manipulate the mechanisms, for example by comparing children in an intervention group with children in a control group for whom the mechanisms were not targeted. Although our randomized controlled trial did include a control group, we could not use it for the current study because we were unable to conduct the weekly measures due to practical limitations in routine care. Since our intervention targeted anger regulation and hostile intent attribution, and we found in the trial that children in the intervention groups were more likely to reduce in aggression than children in the control group (Alsem, van Dijk, et al., 2022), it seems plausible that these mechanisms may have a causal effect. Second, our findings cannot be generalized

to girls. We included only boys because the intervention was initially developed for this group, considering that girls' development, forms, and outcomes of aggression may be different from boys (Underwood, 2002). Future research could examine whether girls with aggressive behavior problems benefit equally from changes in anger regulation and hostile intent attribution. Third, our sample size was too small to allow for the examination of more complex statistical models, such as parallel change quadratic growth models. Future research might also examine quadratic slopes and by doing so identify the shape of the growth trajectories (Laurenceau et al., 2007).

A strength of our study was the high-frequency of the measurements that enabled us to examine individual-level change in children's mechanisms and outcomes (Laurenceau et al., 2007). We conducted our intervention study in a naturalistic setting by including multiple clinical centers, recruiting children in routine care, and examine effects under real-world conditions, promoting external validity. Using brief weekly measures in clinical practice is feasible, and these 3-items measures were well-validated in a previous study (Alsem, Keulen, et al., 2022). Last, we used a multi-informant approach to assess aggressive behavior problems, as the correspondence between informants in aggression reports is relatively low (De Los Reyes et al., 2015). This way, we could investigate whether *child*-reported changes in anger regulation and hostile intent attribution were also related to *parent*-reported changes in aggression.

The identification of hostile intent attribution and anger regulation as mechanisms of change has clinical implications. First, in clinical practice, it is important to know whether and how treatment elements work. These elements can be used by clinicians deciding which mechanisms to target when deficits in these mechanisms are expected to underlie children's aggressive behavior problems (Collins et al., 2004; Kazdin & Nock, 2003). Our present findings suggest that anger regulation and hostile intent attribution provide good starting points for the majority of children, and frequent measurements may identified the few children for whom standard CBT does not influence these mechanisms, or does not change aggressive behavior. Second, existing interventions can be optimized by focusing on anger regulation and hostile intent attribution, while changing or omitting elements with smaller effects (Kraemer et al., 2002). Third, our study with high-frequency measurements highlights the clinical utility of weekly measures. These measures can be a valuable instrument to easily monitor mechanisms of change and treatment progress over the course of an intervention. Clinicians and clients have been shown to manage to administer these brief measures and use this for productive shared decision making during treatment (Campbell & Hemsley, 2009).

Our findings open directions for future research. First, as we found evidence for anger regulation and hostile intent attribution as mechanisms of change in interventions for children with aggressive behavior problems, it may be interesting to examine these mechanisms in interventions for other problems as well. Anger regulation and hostile intent attribution contribute transdiagnostically to diverse problems, such as externalizing and internalizing problems, and addressing them may thus facilitate parsimony across interventions (Granic, 2014; Kazdin & Nock, 2003). Second, it might be interesting to examine the influence of other mechanisms of change, such as therapeutic alliance or treatment engagement. There is a need to investigate the potential contribution of therapeutic variables to child treatment outcomes, preferably with mechanisms measured at multiple time points, examining their influence over the course of treatment (Shirk & Karver, 2003).

In conclusion, we have found support for adaptive anger regulation and hostile intent attribution as mechanisms of change for child-reported aggression. For parent-reported aggression, results supported only hostile intent attribution as mechanism of change. These findings provide evidence for the idea that targeting anger regulation and hostile intent attribution in interventions relates to reductions in individual children's aggressive behavior problems. Our study may inspire researchers to conduct intervention studies with high-frequency measurements to track client progress and to investigate through what mechanisms interventions exert their beneficial effects.

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APPENDIX A:

Group differences check

As a control analysis, we checked for possible differences in change trajectories between children who received the virtual reality versus roleplay version of YourSkills groups. Results showed no differences between the two groups in slopes of adaptive anger regulation, χ^2_{wald} (1) = 0.01, p = .922, hostile intent attribution, χ^2_{wald} (1) = 0.44, p = .510, and child-reported aggression, χ^2_{wald} (1) = 3.82, p = .051. However, we did find group differences for parent-reported aggression, χ^2_{wald} (1) = 5.69, p = .017. Children in the YourSkills virtual reality group showed a linear decrease in parent-reported aggression, B = -.07, SE = 0.01, β = -1.23, p < .001, whereas children in the YourSkills roleplay group remained stable, B = -.03, SE = 0.01, β = -.55, p = .078. We therefore checked whether our results changed if we added group as predictor for the slope factors of the mechanism and outcome variables in the models for parent-reported aggression. Results did not change: the correlation between slopes remained significant for hostile intent attribution and parent-reported aggression, r = .68, p = .006, and nonsignificant for adaptive anger regulation and parent-reported aggression, r = -19, p = .457.
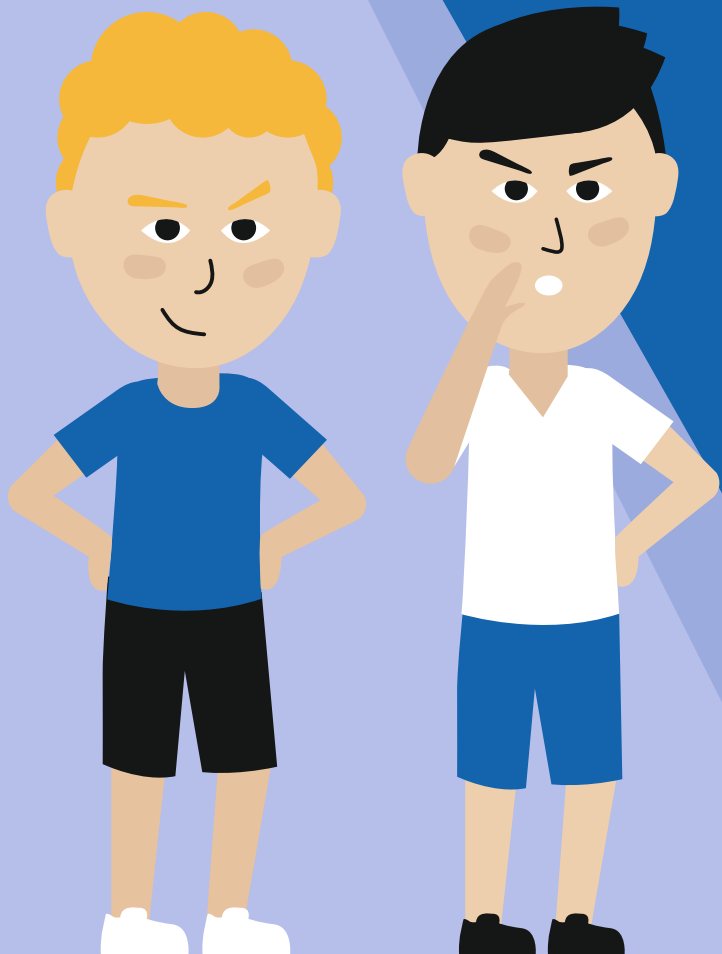
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Hostile interpretation as a transdiagnostic factor for cooccurring anxiety in children with aggressive behavior problems

ABSTRACT

Many children with aggressive behavior problems also suffer from anxiety. This cooccurrence may perhaps be explained by transdiagnostic factors. Identifying these factors seems crucial, as they may be important targets to treat these cooccurring problems effectively. This two-study paper investigates whether children's hostile interpretation of others' intentions is a transdiagnostic factor for cooccurring aggression and anxiety problems. We assessed children's aggression and anxiety using teacher-report in Study 1 ($N = 84$, $M_{age} = 10.10$), and parent-report in Study 2 ($N = 115$, $M_{age} = 10.55$). In both studies, we assessed hostile interpretation using vignettes describing ambiguous provocations by peers. Both studies revealed a strong association between aggression and anxiety problems, underscoring the necessity to examine factors that can explain this cooccurrence. However, in neither study was this association reduced when we added hostile interpretation to the model, suggesting that hostile interpretation did not function as a transdiagnostic factor in our samples. One possible explanation for these findings is that hostile interpretation predicts both aggression and anxiety problems, but in different children. We therefore encourage scholars to conduct more research to explain the high comorbidity of aggression and anxiety problems in children.

Keywords
Aggression, anxiety, comorbidity, transdiagnostic factors, children

INTRODUCTION

Many children who display aggressive behavior problems also suffer from anxiety (Boylan et al., 2007; Granic, 2014; Marsee et al., 2008). In children with aggressive behavior problems, rates of anxiety disorders range from 22% in community samples up to 75% in clinically referred samples (Frick et al., 1999; Zoccolillo, 1992). Both aggression and anxiety problems can affect children's social relations and interactions with peers (Prinstein et al., 2005). Until now, little attention has been devoted to factors that may be responsible for the high cooccurrence between aggression and anxiety problems (McLaughlin et al., 2014). Transdiagnostic frameworks aim to identify factors that cut across multiple cooccurring symptoms or disorders, such as cognitive, emotional, neurobiological, or environmental factors (Aldao & Nolen-Hoeksema, 2012; McLaughlin et al., 2014; Nolen-Hoeksema & Watkins, 2011). Identified factors underlying multiple, comorbid problems are called transdiagnostic factors. Identifying such transdiagnostic factors seems crucial, as they may be important intervention targets to treat cooccurring problems effectively. In fact, untreated cooccurring anxiety problems may be one reason why current treatments targeting children's aggressive behavior problems have only modest effects (Granic, 2014; Granic et al., 2012; McCart et al., 2006). Possibly, children with cooccurring problems may benefit more from one comprehensive treatment targeting identified transdiagnostic factors than from separate treatments targeting one problem each (Oland & Shaw, 2005). The present study therefore took a transdiagnostic approach to explain comorbid aggression and anxiety problems in two independent samples of boys in middle childhood (7-13 years old). We chose to focus on this population, as comorbidity rates between aggression and anxiety are more common in boys than in girls (Marmorstein, 2007; Marsee et al., 2008) and the cooccurrence between aggression and anxiety problems has been found to be strongest in children until the age of 14 years old (Marmorstein, 2007).

There is a growing call for transdiagnostic research. Many clinicians and scholars are worried about the fragmentation of explanatory frameworks and treatments for an ever growing number of highly specific diagnostic labels, such as numerous subtypes of aggressive behavior disorders and anxiety disorders (Barlow et al., 2004; Chorpita et al., 2005). Many psychological problems in children are studied and targeted in isolation, which may not only obscure their cooccurrence in children, but may also prevent researchers from identifying transdiagnostic factors explaining their cooccurrence. This practice may lead to a cumulation of apparently distinct treatment protocols that cannot realistically be combined for children suffering from cooccurring problems. Specifically, it seems unattainable

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for clinicians to incorporate multiple protocols for a single client with comorbid conditions. As transdiagnostic frameworks aim to identify factors that are shared across multiple cooccurring symptoms or disorders, these frameworks have the potential to more parsimoniously advance our understanding of developmental psychopathology, and improve treatments for children with cooccurring problems (McLaughlin & Nolen-Hoeksema, 2011). Specifically, transdiagnostic treatments could be more effective, less time consuming, and might save costs in the long-term (Lucassen et al., 2015). An integrative, modular intervention method targeting comorbid problems showed beneficial effects by outperforming usual care and standard evidence-based treatments on multiple clinical outcome measures (Weisz et al., 2012). This highlights the importance of taking comorbidity into account and assess potential transdiagnostic factors underlying comorbidity.

One likely transdiagnostic factor that may underlie both aggression and anxiety problems is children's hostile interpretation of other children's behavior (Crick & Dodge, 1996). Hostile interpretation reflects the tendency to interpret neutral or ambiguous behavior as negative, threatening or conducted with hostile intent (Crick & Dodge, 1994). Hostile interpretation is part of the social information processing model (Crick & Dodge, 1994; Lemerise & Arsenio, 2000), stating that children's interpretation of social situations influences their related behavior. According to this model, children's hostile interpretations may result in both feelings of anxiety and feeling impelled to defend themselves aggressively. Consequently, these feelings and behaviors will maintain children's hostile interpretation as children will more frequently evoke problematic social interactions (Granic, 2014). For example, when a peer bumps into a child while playing catch, this child may interpret this act as hostile or negative ("He wanted to hurt me"), even though the peer could have done it by accident or intended to engage in friendly rough play. Such a hostile interpretation may elicit feelings of anger ("He did it on purpose, I'll get him!), anxiety ("He did it on purpose... Oh no, he's after me!"), or both ("I have to stand up to him, so he doesn't see I'm scared").

There is a host of empirical research supporting the association of hostile or negative interpretation with either aggression (Lansford et al., 2010; Lochman & Wells, 2002; Verhoef et al., 2019) or anxiety (Bogels & Zigterman, 2000; Luebbe et al., 2010; Stuijfzand et al., 2018). Evidence from the separate fields of aggression and anxiety research, however, cannot support hostile interpretation as a transdiagnostic factor, because it has been assessed as different concepts. For aggression, studies have mainly used scenarios describing *social interactions with peers* (e.g., a peer bumping into a child; de Castro & van Dijk, 2017). For anxiety, however, interpretation is often assessed as a broader concept, including not

only scenarios with peers but also with *adults* (e.g., the head teacher is looking for you) or *non-social threats* (e.g., hearing a big crash in the night; Barrett et al., 1996; Creswell et al., 2014). To examine interpretation as transdiagnostic factor, it is important to assess the exact same concept in both aggression and anxiety. In the present study, we focused on hostile interpretation of peer behavior because children in middle childhood spend much time with peers (Lam et al., 2014), and so it seems plausible that a tendency to make hostile interpretations is associated to both aggression and anxiety problems.

Whereas research on the association of hostile peer interpretation with aggression is abundant (for a meta-analysis, see: Verhoef et al., 2019), research on the association with anxiety is scarce. One study has found that anxious children were more likely to make hostile interpretations of benign peer interactions than non-anxious children, but revealed no such difference for ambiguous peer interactions (Bell-Dolan, 1995). Another study has found no associations between children's hostile interpretation and their anxiety or fear (Reid et al., 2006). Unexpectedly, this study also found no associations between hostile interpretation and aggression, which is in contrast to most earlier research (Verhoef et al., 2019). Last, a longitudinal study has shown that children's hostile interpretations in grade 6 were not associated with their anxious/depressed and withdrawn behavior one year later (Perren et al., 2013). Based on these studies, the support for an association between hostile interpretation and anxiety seems limited. However, these three studies examined community samples, which may have reduced the variance in hostile interpretation, obscuring a potentially relevant association. The present study therefore examines hostile interpretation as transdiagnostic factor in a mixed community-clinical sample and a full-clinical sample of children with aggressive behavior problems.

As a second goal, we examined whether hostile interpretation is a transdiagnostic factor for specifically *reactive* aggression and anxiety. Reactive aggression is defined as an emotional, impulsive reaction in response to a perceived provocation or threat. In contrast, proactive aggression is seen as planned behavior oriented towards instrumental or social gain (Dodge, 1990). These different types of aggression have been proposed to have distinct etiologies, with anxiety as a precursor of specifically reactive aggression (de Castro et al., 2005; Polman et al., 2009). Anxious children may more quickly feel threatened and react with defensive aggression (Granic, 2014). Indeed, research has shown that reactive aggression is related to anxiety and internalizing symptoms, whilst proactive aggression is not (Card & Little, 2006; Day et al., 1992; Fung et al., 2015; Kovacs & Devlin, 1998; Vitaro et al., 2002; but for an exception see: Tanaka et al., 2010). In line with this idea,

hostile interpretation of peer behavior has consistently been linked to reactive aggression, and not proactive aggression (Arsenio et al., 2009; Crick & Dodge, 1996; Dodge & Coie, 1987).

The present study investigated hostile interpretation as transdiagnostic factor for cooccurring anxiety problems in two samples of boys with aggressive behavior problems. Study 1 used teacher-report to assess children's aggression and anxiety, and Study 2 used parent-report. In both studies, we first investigated if there was a significant correlation between aggression and anxiety problems. For illustrative purposes, we also calculated percentage of boys displaying clinical levels of aggression and anxiety problems. Second, we examined whether hostile interpretation predicted both aggression and anxiety problems. When hostile interpretation would indeed predict both problems, this would provide an indication of the function as transdiagnostic factor. Third, to examine whether hostile interpretation may function as a transdiagnostic factor, we tested whether the association between children's aggression and anxiety decreased when we entered hostile interpretation as a predictor for both problems. A decrease in the association would imply that hostile interpretation (partly) accounts for the overlap between aggression and anxiety problems, and would thus provide additional indications for hostile interpretation as transdiagnostic factor. Last, we repeated these analyses to test whether hostile interpretation was a significant predictor and transdiagnostic factor for anxiety and reactive, but not proactive, aggression.

STUDY 1

Method

Participants

We used data from an earlier study (de Castro et al., 2005). The sample consisted of 84 boys ages 7 to 13 years (M = 10.10, SD = 17 months). All children were in elementary school during the study period. This study increased variance in aggression and anxiety by oversampling children with aggressive behavior problems. Children were recruited in two elementary schools (n = 30), two schools providing special education (n = 30), and two clinical centers in the Netherlands (n = 24). Most boys were born in the Netherlands (83.3%). Most parents were unemployed or performed manual labor jobs: mothers (70.6%) and fathers (52.6%). Parents provided active written consent for participation in this study.

Procedure

For this study, children were individually interviewed at their school by trained graduate students. Sessions lasted between 1 and 1.5 hours and included vignettes assessing social information processing steps, intelligence tasks, and a questionnaire. Interviews always started with the hostile interpretation assessment. Children were assured of the confidentiality of their answers. Teachers were asked to fill out questionnaires on paper.

Measures

Aggression and anxiety problems

We assessed children's aggression and anxiety problems using the Teacher Rating Form (TRF; Achenbach & Rescorla, 2001). Teachers rated all 118 items of the TRF on a 3-point scale (0 = *not true*, 1 = *somewhat true*, 2 = *very true or often true*). For the current study, we used only the aggressive behavior scale (20 items; e.g., 'screams a lot') and the anxious/depressed scale (16 items; e.g., 'fearful, anxious'). We used norm scores for Dutch children to calculate T-scores to examine the cooccurrence of (sub)clinical levels of aggression and anxiety problems, and used summed raw scores for all other analyses. The TRF showed good test-retest reliabilities, internal consistencies, content validity, criterion-related validity, and content validity (Achenbach et al., 2008).

Reactive and proactive aggression

We assessed children's reactive and proactive aggression using the Dutch translation of the Reactive and Proactive Aggression Questionnaire (Dodge & Coie, 1987; Hendrickx et al., 2003). Teachers rated three items on reactive aggression (e.g., 'when this child has been teased or threatened, he or she gets angry easily and strikes back') and three items on proactive aggression (e.g., 'his child uses physical force in order to dominate other kids') on a 5-point scale ranging from 1 (*never*) to 5 (*almost always*). Earlier research demonstrated good discriminant, convergent and construct validity of the IRPA (Polman et al., 2009). In the current study, internal consistency of the scales was adequate for both reactive aggression (α = .87) and proactive aggression (α = .90).

Hostile interpretation

We assessed hostile interpretation using four audiotaped vignettes describing ambiguous provocation by a peer (de Castro et al., 2005). For the previous study purposes, two parallel sets of vignettes were used (i.e., describing different provocation situations), which were randomly distributed over participants. No difference between the sets in mean scores of hostile interpretation were found,

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$t(76) = -0.36$, $p = .724$, so scores were combined for this study. Children were told that they would listen to stories about daily social events and were asked to imagine each story was really happening to them. One example vignette is: '*Imagine: You and a boy in your class are taking turns at a computer game. Now it's your turn, and you are doing great. You are reaching the highest level, but you only have one life left. You never came this far before, so you are trying very hard. The boy you are playing with watches the game over your shoulder. He sees how far you have come. Then he shouts "Watch out! You got to be fast now!" and he pushes a button. But it was the wrong button, and now you have lost the game!*'.

Children answered two questions following each vignette. First, they answered one open-ended question 'Why did he [provocative behavior in vignette]?'. Answers to this question were coded as *benign*, *accidental*, *ambiguous*, or *hostile*. Hostile codes were scored 1, all other codes were scored 0. The interrater agreement was high (i.e., 94%). Second, children answered the question 'What was the boy's intention?' on a 5-point rating scale ranging from *very nice* to *very mean*. We summed the hostile codes and averaged the rating scores across vignettes, and created a hostile interpretation scale by taking the standardized average of these two scores, which were highly correlated ($r = .82$). The internal consistency of this scale was adequate ($\alpha = .77$). Previous research showed that these hypothetical vignettes had satisfactory inter-rater reliability, as well as good discriminant and criterion validity (de Castro, 2000; de Castro et al., 2003; de Castro & Koops, 2005)

Analytical approach

We conducted our analyses using Structural Equation Modeling (SEM) in Mplus 8. To test our first hypothesis on the cooccurrence of aggression and anxiety, we calculated the zero-order correlation between aggression and anxiety (Figure 1, path a). For illustrative purposes, we also calculated the percentage of boys with comorbid clinical levels of aggression and anxiety problems, using the TRF's T-score cut-offs for the 'subclinical range' (i.e., T > 65, 93rd percentile). To investigate our second hypothesis on hostile interpretation as predictor for both aggression and anxiety problems, we tested the significance of both predictive paths (Figure 1, path b and c). When both predictive paths are significant, this provides a first indication of hostile interpretation as transdiagnostic factor. To investigate our third hypothesis, whether hostile interpretation functioned as a transdiagnostic factor for the cooccurrence, we tested whether the association between children's aggression and anxiety decreased after including hostile interpretation as a predictor for both problems. If the association indeed significantly decreased, this would imply that hostile interpretation (partly) accounts for the overlap between aggression and anxiety problems, and would thus provide additional indications for

hostile interpretation as transdiagnostic factor. To analyze this, we first estimated the partial correlation between aggression and anxiety problems (Figure 1, path d). We then fixed the zero-order correlation (path a) to the value of the partial correlation (path d), and compared these correlations using a chi-square test. Last, to test our fourth hypothesis on hostile interpretation as transdiagnostic factor for the cooccurrence of anxiety and specifically *reactive* aggression, we repeated these analyses with both reactive and proactive aggression, expecting a significant chi-square for the reactive, but not for the proactive model. As earlier research showed inflated overlap in reactive and proactive aggression scores measured by instruments such as the REPRO (Polman et al., 2007), we ran sensitivity analyses for reactive aggression while controlling for proactive aggression, and vice versa. We used default settings in Mplus, maximum likelihood (MLR; Muthén & Muthén, 2007), to estimate missing data (4.3%).

Figure 1

Statistical models used to estimate the cooccurrence of aggression and anxiety (left) and to examine hostile interpretation as transdiagnostic factor (right).
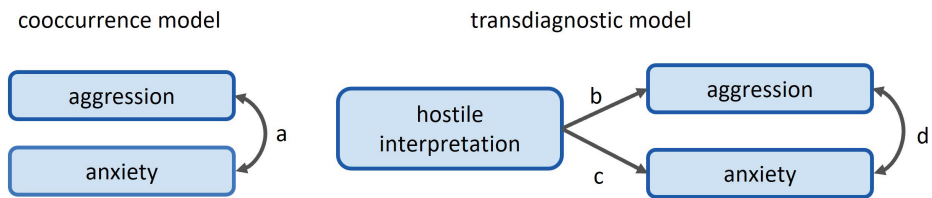
Results

Before we analyzed the research questions, we explored the parametric nature of the data with scatterplots, boxplots, p-p plots, and the Durbin-Watson test, indicating that parametric analyses were warranted.

Cooccurrence of anxiety and aggression

Aggression and anxiety were strongly correlated, $r = .47$, $p < .001$ (Table 1). Results based on subclinical range cut-offs showed that 18 children (24.0%) scored above the cut-off on both aggression and anxiety, 17 children (22.7%) scored above the cut-off only on aggression, 8 children (10.7%) scored above the cut-off only on anxiety, and 32 children (42.7%) scored in the normal range for both anxiety and aggression. Thus, 18 out of 43 children with (sub)clinical problems (41.9%) had comorbid aggression and anxiety problems.

Hostile interpretation as transdiagnostic factor

As expected, results showed that hostile interpretation was a significant predictor of both aggression, $\beta = .32$, $B = 3.89$, $SE = 1.34$, $p = .004$, $R^2 = .10$, and anxiety, $\beta = .27$, $b = 1.64$, $SE = 0.69$, $p = .017$, $R^2 = .07$. Next, we investigated whether the correlation between aggression and anxiety problems was significantly reduced after we entered hostile interpretation as a predictor for both aggression and anxiety. We found a small and nonsignificant reduction from $r = .48$ to $r = .44$, $\chi^2(1) = 0.49$, $p = .482$.

Table 1

Means (M), standard deviations (SD), minimum (Min), maximum (Max) and zero-order Pearson correlations of the study variables ($N = 84$).

	M	*SD*	Min	Max	1	2	3	4	5
1. Hostile interpretation	0.00	0.95	-1.80	1.75	-				
2. Aggression	14.32	11.04	0.00	38.00	.34**	-			
3. Anxiety	6.26	5.83	0.00	26.00	.26*	.47**	-		
4. Reactive aggression	3.07	1.03	1.00	4.67	.30**	.68**	.29**	-	
5. Proactive aggression	2.19	1.00	1.00	4.67	.26**	.72**	.32**	.71**	-

Note. Missing data on hostile interpretation for 1 child and for TRF aggression and anxiety scales for 9 children. Values reported in this table can slightly differ from reported statistics of the SEM models, as these models used missing data estimation. Children reported on hostile interpretation, whilst teachers reported on all forms of children's aggression and anxiety.
* $p < .05$; ** $p < .001$

Reactive versus proactive aggression

We found similar results for reactive aggression as for general aggression: Hostile interpretation was a significant predictor of both reactive aggression, $\beta = .30$, $B = 0.33$, $SE = 0.11$, $p = .004$, $R^2 = .09$ and anxiety, $\beta = .28$, $B = 1.73$, $SE = 0.69$, $p = .012$, $R^2 = .08$. We found a small and nonsignificant reduction in the association between reactive aggression and anxiety (i.e., from $r = .29$ to $r = .24$) after hostile interpretation was added, $\chi^2(1) = 0.39$, $p = .531$. When we controlled for proactive aggression in these models, the relation between hostile interpretation and reactive aggression disappeared (see Appendix A).

For proactive aggression, we did not expect associations with anxiety or hostile interpretation. However, results showed that hostile interpretation was a significant predictor of both proactive aggression, $\beta = .26$, $B = 0.27$, $SE = 0.11$, $p = .015$, $R^2 = .07$ and anxiety, $\beta = .28$, $B = 1.73$, $SE = 0.69$, $p = .012$, $R^2 = .08$. We found a small and nonsignificant reduction in the association between proactive aggression

and anxiety (i.e., from $r = .33$ to $r = .29$) after hostile interpretation was added, $\chi^2(1) = 0.27$, $p = .601$. When we controlled for reactive aggression in these models, the relation between hostile interpretation and proactive aggression disappeared (see Appendix A).

Discussion

Study 1 showed that aggression and anxiety problems were strongly associated in children, and that hostile interpretation predicted both problems. However, findings provided no evidence for hostile interpretation as transdiagnostic factor explaining the cooccurrence of aggression and anxiety. One explanation may be that our sample included relatively few children displaying aggression and anxiety problems in the clinical range. As earlier research showed stronger associations between hostile interpretation and aggression in clinical samples (Verhoef et al., 2019), we chose to also test the hypotheses regarding hostile interpretation as transdiagnostic factor for aggression and anxiety in a clinical sample in Study 2.

Also, we found no evidence for hostile interpretation as transdiagnostic factor for specifically reactive aggression and anxiety. However, analyses of the specific contributions of reactive and proactive aggression were hindered by the strong association between these two types of aggression. This may be due to our measure, which tends to confound both types of aggression (Polman et al., 2007), which may explain why results for reactive aggression become nonsignificant after controlling for proactive aggression, and vice versa. In Study 2, we therefore used another measure with clearer discriminant validity (Polman et al., 2009).

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STUDY 2

Method

Participants

Participants were 115 Dutch boys between 8 and 13 years old ($M = 10.58$, $SD = 1.44$), recruited from 15 clinical centers in the Netherlands providing mental health care for children with mild problems to serious and complex psychiatric disorders, including children with aggressive behavior problems. Therapists working in these institutions were asked to approach parents of children whose casefiles met the following inclusion criteria: age 8-13 years, aggressive behavior problems, intelligence level above 80, no severe autism spectrum disorder, and no epilepsy or severe visual or auditory limitations. Most participating children (95.7%) were born in the Netherlands. In most families, both biological parents were born in the Netherlands (71.3%). In 14.8% of the families only one parent was born in the

Netherlands, and in 13.9% both parents were born elsewhere. Parents attained middle levels of education (44.4%; ISCED 3-4), high education (39.1%; ISCED 5-8), or low education (16.5%; ISCED 0-2; UNESCO, 2012). Participation was voluntary and children and parents were assured of confidential use of their data. Parents provided written consent for participation in this study; 12- and 13-year old children also provided written consent themselves. This study was approved by the Ethics Committee of the University Medical Center Utrecht.

Procedure

This study was part of a randomized controlled trial investigating a cognitive behavioral treatment for boys with aggressive behavior problems (Alsem, van Dijk, et al., 2022). For the current study, we used data from the pre-intervention assessment. Assessments were conducted face-to-face, either at the clinical institution or at families' homes. Children were individually interviewed. They always completed the hostile interpretation vignettes first to avoid priming towards hostility by other questions, for example on their aggressive behavior. The interview lasted 20-30 minutes and was conducted by the first author or a research assistant. At the same time, parents were also asked to fill out questionnaires. In most cases, this was only one parent (75.7%). When both parents filled out the questionnaires (n = 20), we used mothers' report. The analyzed data came from 71 mothers and 44 fathers[2].

Measures

Aggression and anxiety problems

We measured children's aggression and anxiety problems using the aggressive behavior and anxious/depressed scale of the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001). Parents rated the items on a 3-point scale (0 = *not true*, 1 = *somewhat true*, 2 = *very true or often true*). The aggressive behavior scale consists of 18 items (e.g., 'argues a lot') and the anxious/depressed scale of 13 items (e.g., 'fears school'). Similar to Study 1, we used norms for Dutch children to calculate T-scores to examine percentages of (sub)clinical levels of aggression and anxiety, and calculated sum scores for all other analyses. Earlier research has reported good test-retest reliabilities, content validity, criterion-related validity, and content validity for the CBCL (Achenbach et al., 2008). In the current study, the internal consistency was adequate for both the aggressive behavior (α = .89) and the anxious/depressed scale (α = .86).

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2   Results were the same when data of these 20 mothers were replaced by data of fathers.

Reactive and proactive aggression

We measured reactive and proactive aggression using an adapted version of the Instrument for Reactive and Proactive Aggression (IRPA; (Polman et al., 2009). Parents first rated the frequency of aggression on 7 items (e.g., 'How often did your child hit someone in the past month?'). Different than in the original version of the IRPA, parents then rated reactive and proactive motives for all aggression items at once, rather than for each aggression item separately. Parents rated three items on reactive aggression (e.g., 'Because he was angry') and three items on proactive aggression (e.g., 'Because he wanted to dominate others') on a 5-point scale (1 = *never*, 2 = *rarely*, 2 = *sometimes*, 3 = *most of the times*, 4 = *always*). Scores for reactive and proactive aggression were averaged across items. Children who scored zero on all aggression items had missing scores on the reactive and proactive aggression scales. Previous research has reported good discriminant, convergent and construct validity for the IRPA (Polman et al., 2009). The internal consistency was adequate for both reactive aggression (α = .73) and proactive aggression (α = .69), and the correlation between reactive and proactive aggression was small (r = .26, p = .007).

Hostile interpretation

We measured children's hostile interpretation using two parallel sets of four audiotaped vignettes, each describing ambiguous peer provocations (adapted from de Castro et al., 2005). This assessment was similar to Study 1, except for two changes which were made to be able to compare the pre-intervention to the post-intervention assessment in the randomized controlled trial. First, instead of a parallel set with different provocation situations, we now used a parallel set with the same situations in a different context (e.g., we described the situation of losing a game on a tablet instead of on a computer). We counterbalanced the order of sets on the pre-and post-intervention assessment across participants. The situations used in this study were highly similar to the situations used in Study 1. Pre-assessment scores on hostile interpretation used for this study did not differ between sets, t(112) = -1.16, p = .251. Second, the open-ended question and 5-point rating scale were replaced by two 10-point rating scale questions (i.e., 'The other boy did [provocative behavior other boy]. Did he intend to be mean?' and 'Did he do this to bother you?'), which children answered on a 10-point scale (1 = *not at all*; 10 = *very much*). The eight items were averaged to create a single hostile interpretation score (α = .89). We did not expect that changing the response format influenced children's scores or study effects, as a recent meta-analysis showed similar effect sizes for hypothetical vignettes open and closed questions (Verhoef et al., 2019). Previous research demonstrated good discriminant and criterion

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validity for audiotaped hypothetical vignettes (de Castro, 2000; de Castro et al., 2003; de Castro & Koops, 2005).

Analytical approach

We investigated the same hypotheses as in Study 1, using the same analytical approach. To estimate cooccurrence rates, we used parent-reported CBCL T-score cut-offs for the subclinical range (T-score > 64, 93rd percentile). Missing data (1.9%) were accounted for by default settings in Mplus.

Results

Before we analyzed the research questions, we explored the parametric nature of the data with scatterplots, boxplots, p-p plots, and the Durbin-Watson test, indicating that parametric analyses were warranted.

Cooccurrence of anxiety and aggression

To investigate the cooccurrence of aggression and anxiety, we first calculated the zero-order correlation between aggression and anxiety problems. As expected, these problems were strongly correlated, $r = .42$, $p < .001$ (Table 2). Results based on subclinical cut-offs showed that 49 children (42.6%) scored above the cut-off on both aggression and anxiety, 39 children (33.9%) scored above the cut-off only on aggression, 6 children (5.2%) scored above the cut-off only on anxiety, and 21 children (18.3%) scored in the normal range for both aggression and anxiety. Thus, 49 out of 94 children with (sub)clinical problems (41.5%) had comorbid aggression and anxiety problems.

Table 2

Means (*M*), standard deviations (*SD*), minimum (Min), maximum (Max), and Pearson correlations of the study variables (*N* = 115).

	M	*SD*	Min	Max	1	2	3	4	5
1. Hostile interpretation	4.26	2.31	1.00	9.88	-				
2. Aggression	17.26	7.01	3.00	34.00	-.05	-			
3. Anxiety	7.97	5.24	0.00	24.00	-.05	.42**	-		
4. Reactive aggression	3.45	0.93	1.00	5.00	.23*	.41**	.16	-	
5. Proactive aggression	2.23	0.91	1.00	4.67	-.03	.52**	.17	.26**	-

Note. Missing data on hostile interpretation for 1 child and for reactive and proactive aggression for 5 children. Values reported in this table can slightly differ from reported statistics of the SEM models, as these models used missing data estimation. Children reported on hostile interpretation, whilst parents reported on all forms of children's aggression and anxiety.
* $p < .05$; ** $p < .001$

Hostile interpretation as transdiagnostic factor

Unexpectedly, results showed that hostile interpretation did not predict aggression, β = -.05, B = -0.16, SE = 0.29, p = .570, R^2 < .01, or anxiety, β = -.04, B = -0.10, SE = 0.21, p = .637, R^2 < .01. Next, we investigated whether the correlation between aggression and anxiety problems was significantly reduced when we entered hostile interpretation as a predictor for aggression and anxiety. This was not the case: the correlation remained the same (r = .42) after hostile interpretation was added to the model, $\chi^2(1)$ < 0.01, p = .981.

Reactive versus proactive aggression

Hostile interpretation was a significant predictor of reactive aggression, β = .24, B = 0.10, SE = 0.04, p = .012, R^2 = .06, but not of anxiety, β = -.05, B = -0.11, SE = 0.21, p = .620, R^2 < .01. We found that the correlation between reactive aggression and anxiety did not change significantly, with r = .15 before, and r = .17 after hostile interpretation was added, $\chi^2(1)$ < 0.01, p = .940.

For proactive aggression, we did not expect associations with either anxiety or hostile interpretation. Indeed, results showed that hostile interpretation did not predict proactive aggression, β = -.03, B = -0.01, SE = 0.04, p = .786, R^2 < .01, or anxiety, β = -.05, B = -0.10, SE = 0.21, p = .633, R^2 < .01. The correlation between proactive aggression and anxiety remained r = .17 after hostile interpretation was added, $\chi^2(1)$ < 0.01, p = .993.

Discussion

Findings from our Study 2 clinical sample replicated Study 1, in that the cooccurrence of aggression and anxiety problems was high. In this Study, however, hostile interpretation did not predict aggression or anxiety, although it did predict reactive aggression. We again found no evidence for hostile interpretation as transdiagnostic factor.

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GENERAL DISCUSSION

This study is the first to examine hostile interpretation as transdiagnostic factor for cooccurring anxiety in children with aggressive behavior problems. We used a multi-informant approach and tested our hypotheses in two independent samples. In both studies, we found strong associations between aggression and anxiety problems. Comorbidity rates of (sub)clinical aggression and anxiety problems were substantial in both studies (i.e., 42%), which is in line with previous studies (Frick et al., 1999; Zoccolillo, 1992). This high level of comorbidity underscores the necessity to investigate transdiagnostic factors.

We found no support for hostile interpretation as transdiagnostic factor for the cooccurrence of aggression and anxiety problems. As expected, Study 1 showed that hostile interpretation predicted both aggression and anxiety. However, it did not reduce the association between these problems. One explanation for these findings may be that hostile interpretation, anxiety, and aggression may have a different temporal sequence than we supposed. Instead of hostile interpretation leading to both aggression and anxiety, it may be that both hostile interpretation and anxiety precede, and act as risk factors for, the development of aggression in children (Granic, 2014). Alternatively, hostile interpretation may predict both aggression and anxiety but in different children—that is, children may follow divergent developmental trajectories (Nolen-Hoeksema & Watkins, 2011). Some children high on hostile interpretation may develop anxiety problems, whereas others may develop aggressive behavior problems—possibly because of different underlying social problems or temperamental vulnerabilities (Rydell et al., 2003). Longitudinal research is needed to examine the temporal order and possible developmental trajectories in children's aggression and anxiety problems (Granic, 2014).

Study 2, unexpectedly, showed no associations between hostile interpretation and aggression or anxiety problems. This is in contrast with the findings of Study 1 and earlier studies (e.g., Creswell et al., 2005; Verhoef et al., 2019). A reason for this discrepancy might be that the clinical sample in Study 2 yielded only limited variation in aggression (i.e., SD = 7.01 versus 11.04 in Study 1), restraining the potential explanatory power of independent variables such as hostile interpretation (Field, 2017). Most earlier studies examined transdiagnostic factors in much larger samples (i.e., Ns > 400), or, as our Study 1, in samples with both clinical and non-clinical participants (e.g., Brenning et al., 2021; Heleniak et al., 2016; McLaughlin et al., 2014), enhancing the amount of variance to explain. To explore if using clinical-only samples indeed reduces variance, we reanalyzed our Study 1 data for only the subset of children recruited from special education and clinical centers (n = 54; see Appendix B). In line with our reasoning, we found substantial reductions in the expected correlations of hostile interpretation with aggression (i.e., from r = .34 to r = .12) and anxiety (i.e., r = .26 to r = .12). This suggests that future research on transdiagnostic factors may best recruit samples of children with both clinical and non-clinical levels of problem behavior.

In both studies, hostile interpretation predicted reactive aggression. This finding is in line with the definition of reactive aggression, which is described as aggressive behavior in response to a perceived threat or provocation (Dodge, 1990). Besides theoretical reasoning, also empirical evidence consistently showed a relation

between hostile interpretation and reactive aggression (Verhoef et al., 2019). It is interesting though, that hostile interpretation did not predict the frequency of children's aggressive behavior in Study 2. This finding may suggest that boys low on hostile interpretation still engaged in aggression, but for other motives than we assessed (de Castro et al., 2012). In clinical samples where levels of aggression are high, it may be especially important to zoom in on children's motives for their aggression, providing tailored inroads for intervention.

Our study findings warrant further reflection on the role of hostile interpretation. Study 1 revealed that hostile interpretation predicted both anxiety and aggression, but did not explain their cooccurrence, suggesting that our hostile interpretation assessment may have tapped different aspects of interpretation in children with anxiety versus aggression. Perhaps not only the interpretation of hostility, but also other interpretations may affect how children feel and behave in a certain situation (Frijda, 1988). For instance, the same interpretation that a peer acted by hostile intent may enhance feelings of fear or anxiety when children are uncertain about their ability to handle the situation, but may enhance feelings of anger when children feel certain that they can influence the situation. Our assessment may have tapped only one expression of hostile interpretation in each child, whereas in practice, the same child may express both, depending on the situation or his internal state (de Castro & van Dijk, 2017). If future research would support this hypothesis, this may imply that it is still relevant to target hostile interpretation in treatments for both aggression and anxiety, along with additional aspects of interpretation, such as the perceived controllability of social situations.

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The present study had several strengths. First, we conducted thorough transdiagnostic analyses: we did not only investigate whether hostile interpretation predicted both aggression and anxiety problems but also tested whether the cooccurrence between these problems decreased due to this supposed transdiagnostic factor. Second, we tested our hypotheses across informants by examining both teacher- and parent-reports of children's problem behavior. As anxiety and aggression can be context-dependent (De Los Reyes et al., 2015), such cross-informant research is important. Third, we used a two-study approach, which enabled us to overcome methodological limitations of the first study in the second study.

This research also had several limitations. First, as we used cross-sectional data to examine a predictor of aggression and anxiety problems in children, we could not conclude anything about directions or causality. Future research could build upon our findings and adapt a longitudinal or experimental research to analyze hostile interpretation as transdiagnostic factor. Second, we used hypothetical vignettes to

assess hostile interpretation, which might not be the most valid way to assess this construct. Hostile interpretation is an automatic and emotional process. Indeed, research has shown that hostile interpretation assessed in emotionally engaging situations predicts real-life aggression better than vignettes (Verhoef, van Dijk, et al., 2021). Future research may use more engaging methods such as virtual reality environments to assess hostile interpretation (Verhoef, Verhulp, et al., 2021). Third, we asked teachers and parents to report about children's anxiety problems, but did not include child report which might have resulted in the under- or overestimation of anxiety problems. As anxiety can be covert in nature, other informants might not be aware of these problems or over-report them if they are very attuned to their child's anxiety (Barbosa et al., 2002; Merrell et al., 2002). Fourth, aggression and anxiety problems measured in both studies were assessed by the same reporter, which may have artificially inflated associations due to shared method variance. Although the correlation we found between anxiety and aggression was of similar magnitude as in studies using multiple informants (Marsee et al., 2008), future researchers should consider the use of multiple informants to prevent the possibility of single-informant inflation. Fifth, we measured anxiety by the anxiety/depression scale, which might have influenced our results. Although hostile interpretation seems similarly related to depressive symptoms (Quiggle et al., 1992), future research could examine hostile interpretation as transdiagnostic factor specifically for anxiety or depression, and aggression. Sixth, only boys from middle childhood were included in both studies and findings can thus not be generalized to girls. We chose to focus on a relatively homogenous sample of boys from 7-13 years as comorbidity rates between aggression and anxiety are highest in this population (Marmorstein, 2007; Marsee et al., 2008). Future research could examine whether hostile interpretation is a predictor and transdiagnostic factor for the cooccurrence of aggression and anxiety problems in other populations. Last, we tried to explain the cooccurrence between aggression and anxiety by focusing on only one potential transdiagnostic factor, whilst we know that other factors such as emotion regulation, parenting practices, peer victimization or environmental stressors might also explain the cooccurrence of aggression and anxiety (Granic, 2014). Future research could examine whether other factors can account for the cooccurrence between aggression and anxiety in children.

In conclusion, we have found that many children with aggressive behavior problems also displayed comorbid anxiety problems, indicating that it is important to take this cooccurrence into account in current interventions for children with aggressive behavior problems. Hostile interpretation could not explain this cooccurrence as transdiagnostic factor, but did predict children's reactive aggression in both studies, and anxiety in study 1. This suggests that hostile interpretation may

be a relevant target for the treatment of children with cooccurring aggression and anxiety problems—although our findings do underscore the need for more research into the precise interpretation processes underlying these cooccurring problems. We hope that our study may inspire researchers to conduct further research to explain the high comorbidity of aggression and anxiety problems in children.
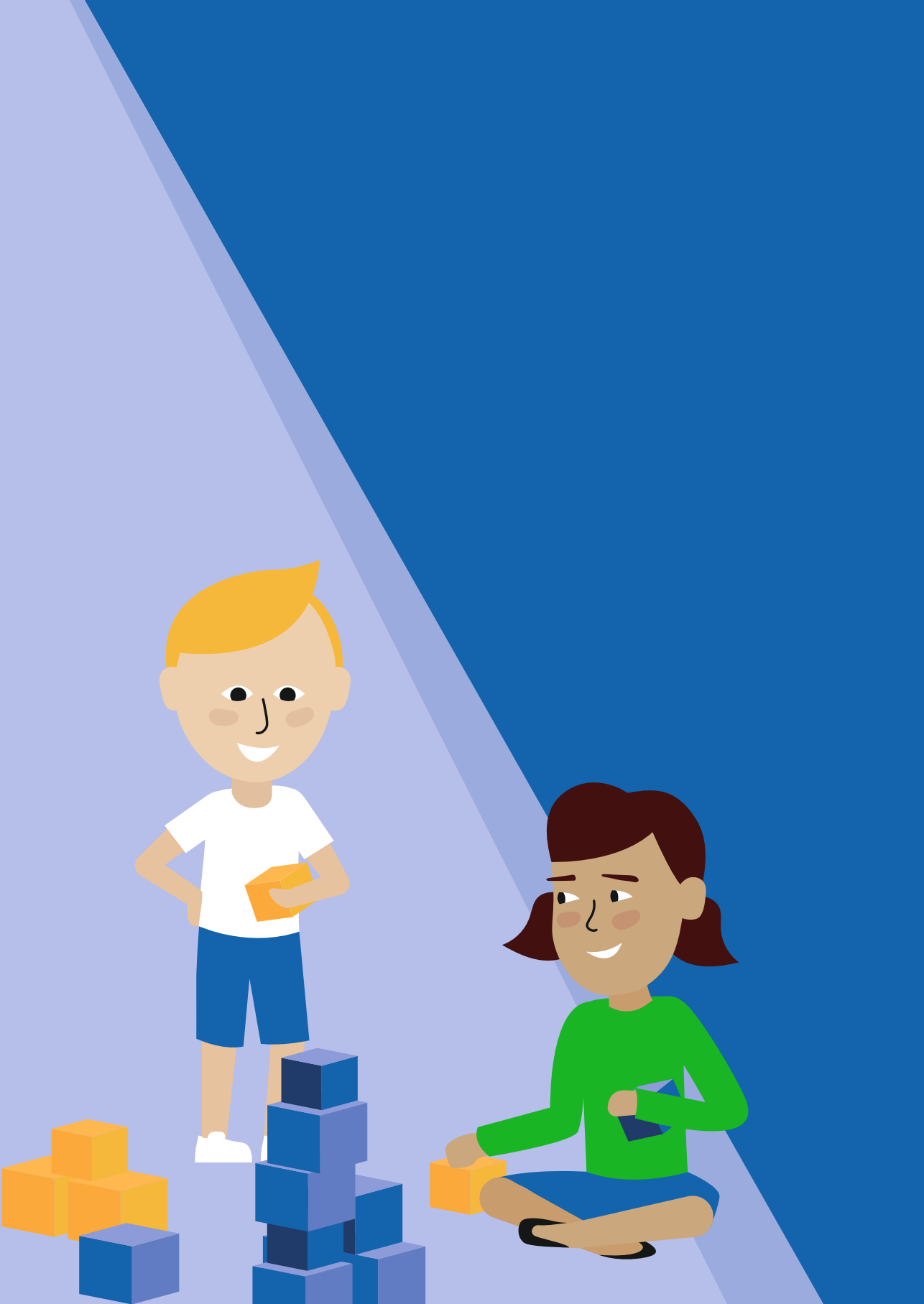
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APPENDIX A

As earlier research showed high overlap in reactive and proactive aggression scores measured by instruments such as the REPRO (Polman et al., 2007), we aimed to account for this by repeating the Study 1 analyses on reactive and proactive aggression, this time controlling for the other type of aggression. Specifically, we added proactive aggression as predictor for reactive aggression to the model and vice versa. Findings for reactive aggression, which was first significantly predicted by hostile interpretation, became non-significant as a consequence:

In the reactive aggression model, results showed that hostile interpretation was a significant predictor of anxiety, $\beta = .28$, $B = 1.75$, $SE = 0.69$, $p = .011$, $R^2 = .08$, but—in contrast to our main analyses—not for reactive aggression, $\beta = .13$, $B = 0.14$, $SE = 0.09$, $p = .097$, $R^2 = .01$, when we controlled for proactive aggression, $\beta = .67$, $B = 0.69$, $SE = 0.08$, $p < .001$, $R^2 = .50$. As in our main analyses, we found a small and nonsignificant reduction from $r = .09$ to $r = .07$ when hostile interpretation was added, $\chi^2(1) = 0.07$, $p = .789$.

For proactive aggression, results were the same as for our main analyses. We found that hostile interpretation was a significant predictor of anxiety, $\beta = .28$, $B = 1.75$, $SE = 0.69$, $p = .011$, $R^2 = .08$, but not for proactive aggression, $\beta = .05$, $B = 0.05$, $SE = 0.09$, $p = .558$, $R^2 < .01$, when we controlled for reactive aggression, $\beta = .69$, $B = 0.68$, $SE = 0.08$, $p < .001$, $R^2 = .50$. We found no change in the correlation between anxiety and aggression problems, which remained $r = .16$ when hostile interpretation was added, $\chi^2(1) = 0.01$, $p = .926$.

APPENDIX B

Previous studies showed stronger associations between hostile interpretation and problem behavior in samples with both typically developing children and clinically-referred children (Verhoef et al., 2019). As our Study 1 included such as sample, but Study 2 included a restricted range of only clinically-referred children, we were wondering whether this difference could explain our contrasting study findings. To explore whether using a clinical-only sample indeed reduced variance in aggression and anxiety, we reanalyzed our Study 1 data. We therefore excluded children recruited in primary education ($n = 30$) and analyzed the subset of children recruited from special education and clinical centers ($n = 54$). In the original analyses with all children ($n = 84$), hostile interpretation was significantly associated with aggression ($r = .34$, $p = .004$) and anxiety ($r = .26$, $p = .023$). For the clinical-only sample, correlations decreased and hostile interpretation was no longer associated with aggression ($r = .12$, $p = .428$) and anxiety ($r = .12$, $p = .421$). This provides support to our hypothesis that hostile interpretation is more strongly related to problem behavior in samples with both typically developing and clinically-referred children than within a clinical sample with a restricted range.

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CHAPTER

7

General discussion

AIMS

The general aim of this dissertation was to enhance and better understand treatment effects for children with aggressive behavior problems. Aggressive behavior problems in school-aged children are of high concern, given the high prevalence and risk for continuing problems and adverse outcomes later in life (Girard et al., 2019; Loeber & Farrington, 2000; Merikangas et al., 2009). Intervention programs therefore target these problems as they arise in childhood (Lochman & Matthys, 2017). The most effective interventions for aggressive behavior problems in middle childhood are parent training programs and cognitive behavioral therapy (CBT; Kaminski & Claussen, 2017; Litschge et al., 2010). However, so far treatment effects on aggressive behavior problems are modest and do not benefit all children (Bennett & Gibbons, 2000; McCart et al., 2006). Seeking to enhance treatment effects for CBT, the present dissertation focused on two overarching aims. The first aim was to examine whether treatment effects of CBT for children with aggressive behavior problems can be enhanced using virtual reality. The second aim was to increase our understanding of potential treatment mechanisms, where we focused on anger regulation and hostile intent attribution.

SUMMARY OF FINDINGS

Aim 1: Enhancing treatment effects using virtual reality

Current CBTs for children with aggressive behavior problem often make use of roleplays (Menting et al., 2015), so that children can practice with solving real-life social problems whilst cognitions and emotions are actively challenged (de Mooij et al., 2020; Landenberger & Lipsey, 2005). However, roleplays can be less involving and limited by children's lack of motivation or abilities in perspective taking and imagination (Hadley et al., 2019; Park et al., 2011). This dissertation was the first to investigate interactive virtual reality as alternative practice method in CBT for children with aggressive behavior problems. Interactive virtual reality offers a realistic and engaging environment for children to practice in during treatment (Lindner, 2021). Children can walk around freely, interact, talk, and play with virtual peers and adults in various situations. Virtual reality may have three important benefits to optimize treatment effectiveness: 1) it provides an involving and immersive environment to practice in; 2) it may enhance treatment motivation; and 3) it allows for individually tailored exercises. Given the potential advantages of using virtual reality, we developed the individual CBT 'YourSkills' with interactive virtual reality for children with aggressive behavior problems. Children practiced

emotion regulation and social information processing skills in virtual reality to decrease their aggressive behavior.

Chapter 2 presented a small-scale feasibility study, that for the first time implemented interactive virtual reality in a new intervention 'YourSkills' for boys with aggressive behavior problems. The aim of this study was to describe the content, appreciation, and feasibility of virtual reality as new treatment approach for children with aggressive behavior problems. Results were promising: therapists indicated that providing the treatment and working with the virtual reality equipment was feasible. They were able to complete the sessions, deliver the recommended amount of practice time in virtual reality, and they experienced few technical issues. Children highly appreciated the treatment, which was also recognized by therapists, who indicated that children actively participated in the virtual environment. The exploration of changes in aggression indicated that parents reported decreases in children's aggressive problem behavior. However, children reported low levels of aggression at pretest that did not decrease. Taken together, our feasibility study showed that using interactive virtual reality in CBT is feasible and appealing to boys and therapists and has the potential to reduce aggressive behavior.

These findings suggested enough promise to conduct a larger study to determine whether virtual reality actually enhances CBT—that is, whether CBT with interactive virtual reality is more effective than the same CBT without virtual reality. As no earlier studies compared CBT with virtual reality to CBT with roleplays (Hadley et al., 2019), a three-armed design was needed to investigate the added value of virtual reality compared to an identical intervention without virtual reality and to care as usual (Lindner, 2021). In **Chapter 3,** we compared these three conditions in a multicenter randomized controlled trial. We designed two versions of YourSkills with identical content, but with different practice modes: one using virtual reality and one using roleplay. Results showed that CBT with virtual reality was more likely to reduce aggressive behavior than care-as-usual. The same pattern of results was found when we compared both CBT groups (i.e., virtual reality and roleplays) to care-as-usual. When we directly compared virtual reality versus roleplays, results moderately favored virtual reality on four of seven aggression measures. Virtual reality clearly outperformed roleplays on other aspects: it was very likely that boys were more emotionally engaged and immersed during virtual reality practice than in roleplays. It was also more likely that boys appreciated virtual reality more and perceived this method as more effective than roleplays.

Together, the two studies in the first part of this dissertation showed that interactive virtual reality is a feasible and promising tool to enhance children's motivation

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during treatment and to increase the effectiveness of CBT in clinical practice for boys with aggressive behavior problems.

Aim 2: Understanding treatment mechanisms

A next step towards the optimalization of interventions, was increasing our understanding of treatment mechanisms. So far, only few studies have investigated the mechanisms through which interventions exert their beneficial effects (Kazdin, 2009; Lochman & Matthys, 2017). When aiming to identify treatment mechanisms, we want to know whether changes in a potential mechanism within a child are related to changes in treatment outcomes in that particular child. Therefore, this dissertation took a within-person individual approach to investigate two frequently targeted treatment mechanisms: anger regulation and hostile intent attribution (Bookhout et al., 2017; Chorpita & Daleiden, 2009).

In **Chapter 4,** we investigated a sample of school-aged children and examined within-person covariation in adaptive anger regulation, hostile intent attribution, and children's aggression over a 4-week period. We first developed brief weekly report measures to assess adaptive anger regulation, hostile intent attribution, and aggression, which demonstrated adequate psychometric qualities. Results revealed within-person associations: weekly changes in adaptive anger regulation and hostile intent attribution covaried with changes in children's aggression. Similar patterns were found at the between-person level: children who reported lower levels of adaptive anger regulation and higher levels of hostile intent attribution than others, reported more aggression than others over the four weeks. In sum, this study was the first to replicate findings from earlier between-person analyses at the within-person level by showing evidence of spontaneous covarying change over a 4-week period.

Subsequently, we took the next step in **Chapter 5** by examining anger regulation and hostile intent attribution as mechanisms of change in the YourSkills intervention. This intervention study allowed us to see whether changes in the assumed mechanisms indeed predicted decreases in individual children's aggression over the treatment weeks (Kazdin, 2009). We included a subsample of the Chapter 3 study by only including boys who were randomized to the two YourSkills conditions, as this intervention targeted anger regulation and hostile intent attribution. We used our newly developed weekly report measures (Chapter 4), which provided an easy and valid tool to examine individual change across the eleven sessions of treatment. Results showed that children's adaptive anger regulation increased and hostile intent attribution decreased over the intervention weeks. Importantly, changes in these mechanisms were strongly associated with

child-reported aggression. For parent-reported aggression, results supported only hostile intent attribution as mechanism of change. In sum, results of Chapter 4 and 5 provide evidence for the idea that targeting anger regulation and hostile intent attribution in interventions relates to reductions in individual children's aggressive behavior problems.

As we found evidence for hostile intent attribution as mechanism of change for children's aggressive behavior problems, we broadened our perspective and investigated whether this mechanism might account for other problems of children as well (Granic, 2014; Kazdin & Nock, 2003). Specifically, we wondered whether hostile intent attribution could serve as a transdiagnostic factor, indicating that one mechanism in a child accounts for multiple problems that a child experiences. Identifying transdiagnostic factors seems crucial, as they may be important intervention targets to treat cooccurring problems effectively (Oland & Shaw, 2005). We focused on the cooccurrence of aggressive behavior problems with anxiety, as these comorbidity rates are high in school-aged children (Levy et al., 2007; Marmorstein, 2007).

Chapter 6 describes two studies that examined hostile interpretation as transdiagnostic factor for cooccurring anxiety in children with aggressive behavior problems. In both studies, we found substantial comorbidity rates of (sub)clinical aggression and anxiety problems (i.e., 42%), underscoring the necessity to investigate transdiagnostic factors. Results showed limited support for hostile interpretation as transdiagnostic factor for the cooccurrence of aggression and anxiety problems. A possible explanation for these findings is that hostile interpretation may predict both aggression and anxiety problems, but in different children. Hence, it is still unclear whether hostile interpretation may function as transdiagnostic factor.

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SCIENTIFIC IMPLICATIONS

Taken together, this dissertation has found evidence for interactive virtual reality as an effective and feasible treatment method for children with aggressive behavior problems and has identified anger regulation and hostile intent attribution as within-person treatment mechanisms. With interactive virtual reality as new practice method in CBT, an important step has been taken to enhance treatment effects for children. Our research showed that providing children with an interactive, real-life environment, yields improvements of treatment outcomes as well as higher levels of children's treatment appreciation, emotional engagement and immersion. This opens up a broad variety of opportunities to use and study virtual reality in treatments for children with other problems. For instance, researchers could

investigate whether virtual reality can be used to let children with autism practice social skills (Ke et al., 2020), to expose children with social anxiety to different situations with peers, or to teach children how to behave when peers are being bullied. A great advantage of virtual reality in these examples is that therapists can use virtual reality in a flexible way and easily adapt exercises to children's specific needs and problems.

When investigating virtual reality as new method in interventions, some considerations require attention. First, when developing an intervention with virtual reality it is important to carefully think about how and why this treatment might benefit from virtual reality. Over the past years there is a trend in interest in virtual reality in both science and clinical practice (Lindner, 2021), which comes with the risk of implementing this method in interventions that are not suited for it, or may not benefit from it. As virtual reality is a costly tool, integration in interventions should be based upon careful theoretical and practical reasoning. Given the attractiveness of virtual reality, there seems to be a risk for the development of ineffective – or even iatrogenic – virtual reality interventions that do not contain evidence-based and developmentally appropriate treatment elements (Halldorsson et al., 2021). Second, to be able to examine the effectiveness of virtual reality as treatment method, it is essential to conduct multi-armed trials that directly compare virtual reality to the same intervention using another method, such as roleplays (Lindner, 2021). This evidence is needed to establish the added value of virtual reality compared to less costly tools. Third, an important consideration when aiming to implement virtual reality in treatments is to weigh the costs and benefits of different types of virtual reality. For instance, interactive virtual reality, used in this dissertation, provides a dynamic environment allowing for real-time interactions in the virtual world, such as talking and playing games with virtual peers. This makes it highly involving and adaptable, but also costly. In comparison, 360 degrees virtual reality offers a more simple static immersive video or photo environment that can be viewed from all possible angles. This may not suffice when actual responses to child behavior in the virtual environment are required – as is the case when we want to reinforce client behavior, or when we want a client to experience that different behaviors evoke different responses form peers. But it may suffice when only exposure to a social stimulus is required, such as in specific phobias. Although interactive virtual reality offers more practice possibilities, it comes with higher costs and with more equipment and preparation, and should thus only be implemented when the added value is clear.

A theoretical implication of this dissertation is that our findings align with the dual-mode social information processing model (Verhoef et al., 2022). We found

that children practicing in virtual reality were more emotionally engaged and immersed than children practicing in traditional roleplays (Chapter 3). This fits with the dual-mode model proposing that children with aggressive behavior problems process social information in either the automatic mode (i.e., fast, emotion-driven aggression) or the reflective mode (i.e., slow, deliberately selected aggression). Based on this model, interventions may be most effective when children's social information processing patterns are targeted in the mode that is also active when they are emotionally triggered in daily life. Virtual reality may trigger the automatic mode more so than roleplays, as children practice in realistic environments and do not have to rely on their memory or imagination (Park et al., 2011), which would trigger the reflective mode.

This dissertations might also inspire other researchers to adopt a within-person approach with high-frequency measurements to investigate treatment mechanisms. We showed that anger regulation and hostile intent attribution covaried with aggression over weeks, and that weekly improvements in these mechanisms were associated with decreases in aggression over the 11-weeks treatment period (Chapter 4-5). These findings show that our treatment mechanisms and outcomes fluctuated together over a relatively short time period, rather than over months or years as often is assumed in longitudinal research. This highlights the importance of adequate timing of assessments in research. That is, deciding whether to measure a construct on a daily, weekly or monthly basis should be based upon theory and prior work of the expected mechanisms of change (Laurenceau et al., 2007). Subsequently, measures should be used that are validated over the predefined period and are thus sensitive to capture these (short-term) changes (Lischetzke, 2014).

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STRENGTHS AND LIMITATIONS

A strength of this dissertation is that we conducted a randomized controlled trial in a naturalistic setting, by implementing and investigating YourSkills in routine care in clinical centers (Chapter 3). This way, we were able to examine effectiveness rather than efficacy (Flay et al., 2005). In efficacy trials the beneficial effects of interventions are tested under optimal conditions, whilst in effectiveness trials, as conducted in this dissertation, these effects are tested under real-word conditions (Flay et al., 2005). A great advantage of effectiveness trials is that the naturalistic conditions highly promote external validity of the findings, and heighten the chances of effective implementation. Recruiting children in clinical centers also allowed us to focus on difficult-to-reach and often understudied children who were clinically referred for their aggressive behavior problems (Chapters 2, 3, 5 and 6).

This dissertation was the first to implement interactive virtual reality in interventions for children with aggressive behavior problems and to compare this new method with traditional roleplays and care-as-usual. In addition, we extended current knowledge about anger regulation and hostile intent attribution as treatment mechanisms for children's aggressive behavior problems. By adapting a within-person approach with high-frequency measurements, we were able to examine intra-individual change in children's mechanisms and outcomes (Laurenceau et al., 2007). Further, we used a multi-informant approach to assess aggressive behavior problems by using parent-, teacher-, and self-reports. This enabled us to obtain a comprehensive picture of children's behavior, which is important as aggression is context-dependent and correspondence between informants is relatively low (De Los Reyes et al., 2015).

The research in this dissertation also has its limitations. First, in most studies only boys were included, and findings can thus not be generalized to girls. We chose to focus on a relatively homogenous samples of boys, as aggression in girls in middle childhood is less common and its development, forms, and outcomes may be different from boys (Berkout et al., 2011; Fontaine et al., 2009; Underwood, 2002). Also, it has been argued that especially boys' aggression results from our studied mechanisms of change: reactions to negative emotions and responses in hostile social situations (Berkout et al., 2011). Future research should examine whether girls with aggressive behavior problems benefit equally from adding virtual reality to interventions and targeting the same mechanisms of change as studied in this dissertation.

Second, our research into treatment mechanisms for children's aggression was not suited to establish causality. Our findings were based on repeated measures (Chapters 4-5) and cross-sectional data (Chapter 6), allowing us to examine intra-individual changes in children but not to investigate causality. To do so, it is necessary to experimentally manipulate treatment mechanisms, for example by conducting a microtrial or longitudinal experiment (e.g., an intervention study with control group). Microtrials offer the unique opportunity to examine effects of specific treatment elements, such as anger regulation and hostile intent attribution, and can distinguish between less and more efficacious approaches to incorporate these elements in interventions (Leijten et al., 2015). Also, microtrials allow to directly test whether treatment mechanisms are dependent upon individual child characteristics and reveal which children benefit most from which (combination of) treatment elements (Leijten et al., 2015). Thus, although our findings on anger regulation and hostile intent attribution as mechanisms of change are promising, more research is needed to assess the causal influence on children's aggression.

Third, we assessed anger regulation, hostile intent attribution, and aggression by using questionnaires and vignettes, but these methods may lack ecologically validity. In questionnaires, children need to retrospectively reflect on their behavior in the past month or week, which may be difficult to remember, or children may answer in a socially desirable way. In vignettes, children are asked to image that a hypothetical social event is happing to them and then reflect on the other's intentions in that situation. However, hostile intent attributions are often only triggered when children experience strong emotions, such as anger or frustration (Anderson & Bushman, 2002; Lemerise & Arsenio, 2000), and so children's responses to vignettes may not accurately reflect their real-life attributions. To overcome these limitations, new assessment methods are needed that are able to capture children's processing and behavior in emotionally engaging situations in daily life. Interactive virtual reality might offer an unique opportunity to do so, as real-life social situations can be simulated and emotions can be triggered (Verhoef, van Dijk, et al., 2021). Recently, research has shown that hostile intent attribution assessed in standardized virtual reality situations indeed predicted real-life aggression better than vignettes did (Verhoef, Verhulp, et al., 2021). Thus, interactive virtual reality may provide a viable solution for the lack of ecological validity in current assessment methods for anger regulation, hostile intent attribution, and aggression.

RESEARCH DIRECTIONS

The findings from this dissertation provide novel insights into the enhancement of treatment effects in interventions for children's aggressive behavior problems, but at the same time raise new research questions and directions. A first avenue for future research might be to investigate long-term effectiveness of virtual reality in interventions for children with aggressive behavior problems. This seems crucial as the ultimate purpose of interventions is to reduce children's problems and risks in the long run. Earlier meta-analyses have shown that long-term follow-up effects can be maintained or become even larger after the intervention ends (Bennett & Gibbons, 2000; McCart et al., 2006). This might imply that children need time to practice and generalize their new cognitions and skills in daily life. Alternatively, it could be that treatment effects fade-out after the intervention, as children may slowly forget the learned skills and fall back in previous negative interaction patterns (van Aar et al., 2017). More research is needed to disentangle this issue.

Second, the first results on the effectiveness for CBT with virtual reality for children with aggressive behavior problems are promising, but also need replication. Conducting replication studies is a useful way to increase certainty in findings

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(Open Science Collaboration, 2015). Especially for clinical research, it is relevant to get insight in the certainty of findings, as clinicians need to outweigh whether or not to use a treatment in daily practice. We have taken a first step in providing clinicians with an indication of the certainty of our results, by using Bayesian statistics (Chapter 3) and reporting our findings in terms of likelihood. By doing so, clinicians can quantify the amount of support for the effectiveness of YourSkills (e.g., it was at least 187 times more likely that YourSkills outperformed care-as-usual than not) instead of having to make a dichotomous decision based on an arbitrary cut-off (e.g., *p* < .05; Cohen, 1988). Future replication research could adopt a Bayesian approach and use our findings as background knowledge (i.e., informative priors) in their analyses to continue to update our knowledge on the effectiveness of CBT with virtual reality for children with aggressive behavior problems (Hoijtink et al., 2019; van de Schoot et al., 2014).

A third direction for future work might be to investigate the cost-effectiveness of virtual reality in CBT for children with aggressive behavior problems. This seems necessary, as this new technology comes along with extra costs for equipment, licenses to use the virtual reality, and training professionals (Lindner, 2021). It could be worth the investment if converging evidence shows that CBT with virtual reality is more effective than current treatments and may result in shorter treatments, less drop out, and lower costs for society on the long-term (Geraets et al., 2021). In addition, it would be relevant to investigate whether the beneficial treatment effects found in this dissertation will be maintained when, instead of interactive virtual reality, cheaper types of virtual reality are used as intervention tool.

Fourth, our promising findings of using virtual reality open up possibilities to use virtual reality for other research purposes. As virtual reality allows for standardized scenarios that permits a wide range of options to manipulate and assess characteristics of social situations in real-time, it seems specifically useful when researchers aim to precisely manipulate or target social cues. Virtual reality additionally offers the opportunity to assess children's arousal, thoughts or behavior in a situation, by for example observing behavior or by using physiological or eye-tracking measures (Calvert & Tan, 1994). Another potential avenue to use virtual reality in research, is to study whether this method might increase the effectiveness of interventions targeting children's social environments, such as using virtual reality in parent and teacher training. Parents can practice positive parenting behaviors in virtual reality, get rewarded for using these new behaviors in the virtual situation, or experience the negative consequences of their current, less effective, parenting practices.

Fifth, researchers might study for whom interventions with virtual reality are most or least successful. Our findings showed that the majority of children participating in YourSkills decreased in aggressive behavior (i.e., self-report: 71%; parent-report: 79%; Chapter 6). However, these numbers also showed that not all children benefited from the treatment. For these children it might be that other mechanisms underlie their aggressive behavior problems (e.g., deficits in executive functioning, attention or prosocial skills, family and peer processes; Frick, 2012), or that more intensive treatment programs are necessary. Specifically, for these children it may be necessary to combine CBT with parenting programs, as this might be even more effective in reducing aggression than CBT alone (McCart et al., 2006). Thus, future research should draw attention to the less responsive children in interventions and investigate how effectiveness could be enhanced for this group.

Sixth, although our findings suggested improvements in anger regulation and hostile intent attribution for most children (Chapter 6), a remarkable number of children did not change in hostile intent attribution (i.e., 35%, as compared to 28% for anger regulation). Future research could focus on these children and examine whether and why hostile intent attribution may not be a mechanism of change for all children. Alternatively, it may be that some children's hostile intent attribution bias was too strongly ingrained to change with our intervention. In fact, hostile intent attributions may serve an adaptive function for some children. For instance, for children growing up in harsh and unpredictable environments it may be beneficial to recognize hostile intent on time, to be able to avoid negative interactions and harm (Ellis et al., 2017). The developmental cascade model posits that children's hostile intent attributions are often developed as a function of early social experiences and are maintained by a reciprocal association between biases and reoccurring negative social interactions (Lansford et al., 2010). For these children, more extensive treatments that also incorporate children's context (e.g., parents and school) may be necessary to break the negative spiral and induce change in hostile intent attribution.

Another avenue for future research might be to build upon the transdiagnostic research in this dissertation and further investigate trajectories of equifinality and multifinality in individual children (Cicchetti & Rogosch, 1996). Equifinality implies that the same outcome (e.g., aggression) can result from different processes or mechanisms (e.g., anger regulation and hostile intent attribution), whilst multifinality implies that one mechanism or risk factor (e.g., hostile intent attribution) may lead to many different outcomes (e.g., both aggression and anxiety; Cicchetti & Rogosch, 1996). We investigated multifinality by testing hostile intent attribution as transdiagnostic factor for children's cooccurring anxiety and aggression (Chapter

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6). Although we did find high cooccurrence rates between anxiety and aggression, and partial evidence that hostile intent attribution predicted both aggression and anxiety, hostile intent attribution could not explain the cooccurrence. If these findings are confirmed in other studies, this may imply that children may follow divergent developmental trajectories (Nolen-Hoeksema & Watkins, 2011). That is, some children high on hostile interpretation may develop anxiety problems, whereas others may develop aggressive behavior problems (Rydell et al., 2003). Future research could adopt a within-person approach and examine the temporal order and possible developmental trajectories in children's aggression and anxiety problems (Granic, 2014).

CLINICAL IMPLICATIONS

The most important implication for clinical practice is that practitioners can use the YourSkills intervention to treat children's aggressive behavior problems. We were able to implement and investigate this new intervention in fifteen clinical centers in the Netherlands. At the start of our study, we trained practitioners of these clinical centers in YourSkills and they incorporated this new treatment within their usual practices. Although our findings suggested that virtual reality provides additional benefits, results also showed that both the virtual reality and roleplay versions of YourSkills outperformed care-as-usual. Hence, both practice methods can be used in clinical practice. Clinicians could choose to practice in virtual reality when children's motivation for treatment is low, or when they want to create more emotionally engaging and immersive exercises. We hope that YourSkills can be implemented more broadly in clinical practice and can function as an example of how to effectively integrate virtual reality in interventions for children.

Second, this dissertation showed that many children with aggressive behavior problems also displayed comorbid anxiety problems (i.e., 42%). These high levels of comorbidity underscore the necessity to treat aggression and anxiety simultaneously, perhaps by targeting transdiagnostic factors. Until now, most evidence-based therapies focus on one disorder or problem. However, it may be beneficial to tailor treatments more to individual children's variety of needs and problems (rather than to one disorder) and take comorbidity into account. This could be a more effective way of treatment, which is less time consuming, and might safe costs on the long-term (Lucassen et al., 2015). Indeed, in one study, an integrative, modular intervention method targeting comorbid problems, outperformed usual care and standard evidence-based treatments on multiple clinical outcome measures (Weisz et al., 2012). This highlights that it is important for clinicians to take comorbidity into account in their interventions.

Third, findings from this dissertation provided evidence for anger regulation and hostile intent attribution as intervention targets for children's aggressive behavior problems. In clinical practice, it is important to know whether and how treatment mechanisms work. These elements can be used by clinicians to decide which mechanisms to target, when deficits in these mechanisms are expected to underlie children's aggressive behavior problems (Collins et al., 2004; Kazdin & Nock, 2003). Our findings suggest that anger regulation and hostile intent attribution provide good starting points for the majority of children. Hence, clinicians may assess if their clients display deficits in these mechanisms as a basis to tailor their treatments.

Fourth, we developed brief weekly measures that can be used in clinical practice to assess children's anger regulation, hostile intent attribution, and aggression. These measures can be a valuable instrument to easily monitor treatment mechanisms and progress over the course of an intervention. Our findings showed that the measures had good psychometric quality and were sensitive to capture weekly changes. In addition, using the three-item measures was feasible in both a school setting and in clinical practice (Chapter 4-5). Thus, our weekly measures have clinical utility and can be used to monitor treatment progress and for productive shared decision making during treatment (Campbell & Hemsley, 2009).

CONCLUSION

The present dissertation sought to enhance and understand treatment effects for children's aggressive behavior problems. Interactive virtual reality has proven to be an effective method to enhance treatment outcomes of a CBT intervention. Practicing in an emotionally emerging and immersive real-life environment yields not only improvements in treatment effectiveness but also higher levels of children's treatment appreciation. In addition, we expanded our understanding of treatment mechanisms by providing within-person evidence for anger regulation and hostile intent attribution as treatment mechanisms to reduce aggressive behavior problems. We hope that this dissertation may inspire scientists and practitioners to carefully use and investigate virtual reality in interventions to continue to enhance treatment effects and help children to improve their skills.
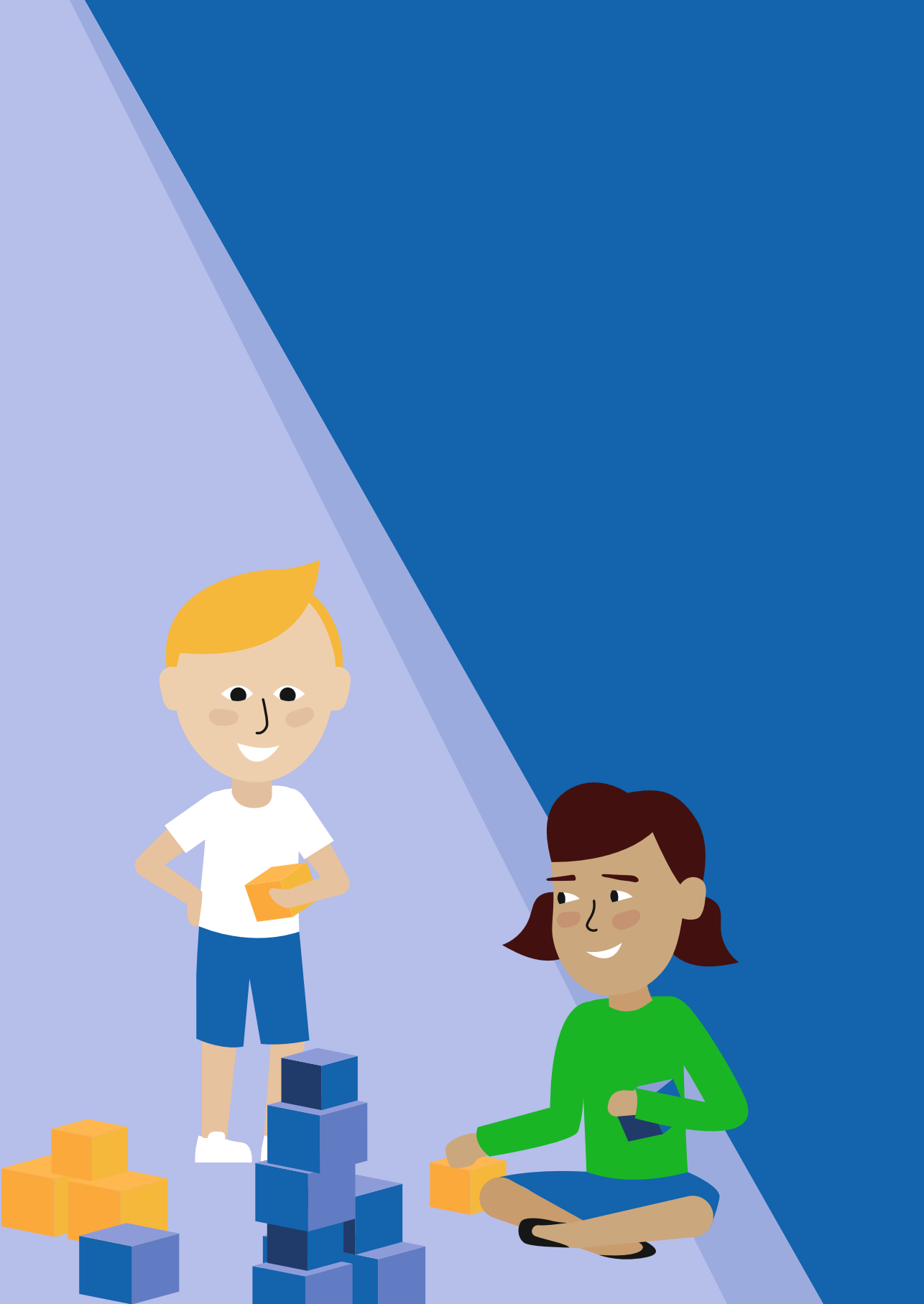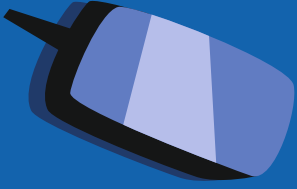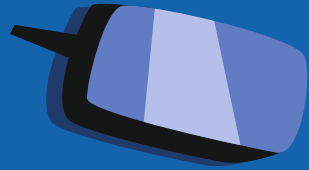
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REFERENCES

Abikoff, H., Courtney, M., Pelham, W. E., & Koplewicz, H. S. (1993). Teachers' ratings of disruptive behaviors: The influence of halo effects. *Journal of Abnormal Child Psychology*, *21*(5), 519–533. https://doi.org/10.1007/BF00916317

Achenbach, T. M., Becker, A., Döpfner, M., Heiervang, E., Roessner, V., Steinhausen, H. C., & Rothenberger, A. (2008). Multicultural assessment of child and adolescent psychopathology with ASEBA and SDQ instruments: Research findings, applications, and future directions. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *49*(3), 251–275. https://doi.org/10.1111/j.1469-7610.2007.01867.x

Achenbach, T. M., McConaughy, S. H., & Howell, C. T. (1987). Child/adolescent behavioral and emotional problems: Implications of cross-informant correlations for situational specificity. *Psychological Bulletin*, *101*(2), 213–232. https://doi.org/10.1037/0033-2909.101.2.213

Achenbach, T. M., & Rescorla, L. A. (2001). *Manual for the ASEBA school-age forms & profiles*. Research center for children, youth, and families, University of Vermont.

Aldao, A., & Nolen-Hoeksema, S. (2012). When are adaptive strategies most predictive of psychopathology? *Journal of Abnormal Psychology*, *121*(1), 276–281. https://doi.org/10.1037/a0023598

Alsem, S. C., Keulen, J., Verhulp, E. E., van Dijk, A., & de Castro, B. O. (2022). Capturing mechanisms of change: Weekly covariation in anger regulation, hostile intent attribution, and children's aggression. *Aggressive Behavior*, *48*, 232–240. https://doi.org/10.1002/ab.22019

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

Alsem, S. C., van Dijk, A., Verhulp, E. E., Dekkers, T. J., & de Castro, B. O. (2022). Treating children's aggressive behavior problems using cognitive behavioral therapy with virtual reality: A multicenter randomized controlled trial. *Manuscript Submitted for Publication*.

Anderson, C. a, & Bushman, B. J. (2002). Human aggression. *Annual Review of Psychology*, *53*(1), 27–51. https://doi.org/10.1146/annurev.psych.53.100901.135231

Arsenio, W. F., Adams, E., & Gold, J. (2009). Social information processing, moral reasoning, and emotion attributions: Relations with adolescents' reactive and proactive aggression. *Child Development*, *80*(6), 1739–1755. https://doi.org/10.1111/j.1467-8624.2009.01365.x

Bakker, D., Kazantzis, N., Rickwood, D., & Rickard, N. (2016). Mental health smartphone apps: Review and evidence-based recommendations for future developments. *JMIR Mental Health*, *3*(1), 1–31. https://doi.org/10.2196/mental.4984

Barbosa, J., Tannock, R., & Manassis, K. (2002). Measuring anxiety: Parent-child reporting differences in clinical samples. *Depression and Anxiety*, *15*(2), 61–65. https://doi.org/10.1002/da.10022

Barlow, D. H., Allen, L. B., & Choate, M. L. (2004). Toward a unified treatment for emotional disorders. *Behavior Therapy*, *35*, 205–230. https://doi.org/10.4324/9781315724539-12

Barrett, P. M., Rapee, R. M., Dadds, M. M., & Ryan, S. M. (1996). Family enhancement of cognitive style in anxious and aggressive children. *Journal of Abnormal Child Psychology*, *24*(2), 187–203. https://doi.org/10.1007/BF01441484

Bell-Dolan, D. J. (1995). Social cue interpretation of anxious children. *Journal of Clinical Child Psychology*, *24*(1), 1–10. https://doi.org/10.1207/s15374424jccp2401_1

A

Bennett, D. S., & Gibbons, T. A. (2000). Efficacy of child cognitive-behavioral interventions for antisocial behavior : A meta-analysis. *Child & Family Behavior Therapy*, *22*(1), 1–15. https://doi.org/10.1300/J019v22n01

Berkout, O. V., Young, J. N., & Gross, A. M. (2011). Mean girls and bad boys: Recent research on gender differences in conduct disorder. *Aggression and Violent Behavior*, *16*(6), 503–511. https://doi.org/10.1016/j.avb.2011.06.001

Berry, D., & Willoughby, M. T. (2017). On the practical interpretability of cross-lagged panel models: Rethinking a developmental workhorse. *Child Development*, *88*(4), 1186–1206. https://doi.org/10.1111/cdev.12660

Bogels, S. M., & Zigterman, D. (2000). Dysfunctional cognitions in children with social phobia, separation anxiety disorder, and generalized anxiety disorder. *Journal of Abnormal Child Psychology*, *28*(2), 74–76. https://doi.org/10.1023/a:1005179032470

Bolger, N., Davis, A., & Rafaeli, E. (2003). Diary methods: Capturing life as it is lived. *Annual Review of Psychology*, *54*(1), 579–616. https://doi.org/10.1146/annurev.psych.54.101601.145030

Bollen, K. A. (1989). A new incremental fit index for general structural equation models. *Sociological Methods & Research*, *17*(3), 303–316. https://doi.org/10.1177/0049124189017003004

Bookhout, M. K., Hubbard, J. A., & Moor, C. C. (2017). Emotion regulation. In J. E. Lochman & W. Matthys (Eds.), *The Wiley handbook of disruptive and impulse-control disorders* (pp. 221–236). John Wiley & Sons, Ltd.

Boylan, K., Vaillancourt, T., Boyle, M., & Szatmari, P. (2007). Comorbidity of internalizing disorders in children with oppositional defiant disorder. *European Child and Adolescent Psychiatry*, *16*(8), 484–494. https://doi.org/10.1007/s00787-007-0624-1

Braet, C., Cracco, E., & Theuwis, L. (2013). *FEEL-KJ: vragenlijst voor emotieregulatie bij kinderen en jongeren.* Hogrefe Uitgevers B.V.

Brenning, K., Soenens, B., Vansteenkiste, M., De Clercq, B., & Antrop, I. (2021). Emotion regulation as a transdiagnostic risk factor for (non)clinical adolescents' internalizing and externalizing psychopathology: Investigating the intervening role of psychological need experiences. *Child Psychiatry and Human Development*, *53*(1), 124–136. https://doi.org/10.1007/s10578-020-01107-0

Burke, J. D., & Loeber, R. (2016). Mechanisms of behavioral and affective treatment outcomes in a cognitive behavioral intervention for boys. *Journal of Abnormal Child Psychology*, *44*(1), 179–189. https://doi.org/10.1007/s10802-015-9975-0

Burkey, M. D., Hosein, M., Morton, I., Purgato, M., Adi, A., Kurzrok, M., Kohrt, B. A., & Tol, W. A. (2018). Psychosocial interventions for disruptive behavior problems in children in low- and middle-income countries: A systematic review and meta-analysis. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *59*(9), 982–993. https://doi.org/10.1111/jcpp.12894

Burks, V. S., Laird, R. D., Dodge, K. A., Pettit, G. S., & Bates, J. E. (2001). Knowledge structures, social information processing, and children's aggressive behavior. *Social Development*, *8*(2), 220–236. https://doi.org/10.1111/1467-9507.00092

Calvert, S. L., & Tan, S. L. (1994). Impact of virtual reality on young adults' physiological arousal and aggressive thoughts: Interaction versus observation. *Journal of Applied Developmental Psychology*, *15*(1), 125–139. https://doi.org/10.1016/0193-3973(94)90009-4

Campbell, A., & Hemsley, S. (2009). Outcome rating scale and session rating scale in psychological practice: Clinical utility of ultra-brief measures. *Clinical Psychologist*, *13*(1), 1–9. https://doi.org/10.1080/13284200802676391

Card, N. A., & Little, T. D. (2006). Proactive and reactive aggression in childhood and adolescence : A meta-analysis of differential relations with psychosocial adjustment. *International Journal of Behavioral Development*, *30*(5), 466–480. https://doi.org/10.1177/0165025406071904

Casey, P., Patalay, P., Deighton, J., Miller, S. D., & Wolpert, M. (2020). The Child Outcome Rating Scale: Validating a four-item measure of psychosocial functioning in community and clinic samples of children aged 10–15. *European Child and Adolescent Psychiatry*, *29*(8), 1089–1102. https://doi.org/10.1007/s00787-019-01423-4

Chorpita, B. F., & Daleiden, E. L. (2009). Mapping evidence-based treatments for children and adolescents: application of the distillation and matching model to 615 treatments from 322 randomized trials. *Journal of Consulting and Clinical Psychology*, *77*(3), 566–579. https://doi.org/10.1037/a0014565

Chorpita, B. F., Daleiden, E. L., & Weisz, J. R. (2005). Identifying and selecting the common elements of evidence based interventions: A distillation and matching model. *Mental Health Services Research*, *7*(1), 5–20. https://doi.org/10.1007/s11020-005-1962-6

Cicchetti, D., & Rogosch, F. A. (1996). Equifinality and multifinality in developmental psychopathology. *Development and Psychopathology*, *8*(4), 597–600. https://doi.org/10.1017/S0954579400007318

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Lawrence Earlbaum Associates.

Colasante, T., Zuffianò, A., & Malti, T. (2016). Daily deviations in anger, guilt, and sympathy: A developmental diary study of aggression. *Journal of Abnormal Child Psychology*, *44*(8), 1515–1526. https://doi.org/10.1007/s10802-016-0143-y

Cole, P. M., Martin, S. E., & Dennis, T. A. (2004). Emotion regulation as a scientific construct: Methodological challenges and directions for child development research. *Child Development*, *75*(2), 317–333. https://doi.org/10.1111/j.1467-8624.2004.00673.x

Collaboration, O. S. (2015). Estimating the reproducibility of psychological science. *Science*, *349*(6251), 943–951. https://doi.org/10.1126/science.aac4716

Collins, L. M., Murphy, S. A., & Bierman, K. L. (2004). A conceptual framework for adaptive preventive interventions. *Prevention Science*, *5*(3), 185–196. https://doi.org/10.1023/B:PREV.0000037641.26017.00

Costello, E. J., Mustillo, S., Erkanli, A., Keeler, G., & Angold, A. (2003). Prevalence and development of psychiatric disorders in childhood and adolescence. *Archives of General Psychiatry*, *60*(8), 837–844. https://doi.org/10.1001/archpsyc.60.8.837

Cracco, E., van Durme, K., & Braet, C. (2015). Validation of the FEEL-KJ: An instrument to measure emotion regulation strategies in children and adolescents. *PLoS ONE*, *10*(9), 1–18. https://doi.org/10.1371/journal.pone.0137080

Creswell, C., Murray, L., & Cooper, P. (2014). Interpretation and expectation in childhood anxiety disorders: Age effects and social specificity. *Journal of Abnormal Child Psychology*, *42*(3), 453–465. https://doi.org/10.1007/s10802-013-9795-z

A

Creswell, C., Schniering, C. A., & Rapee, R. M. (2005). Threat interpretation in anxious children and their mothers: Comparison with nonclinical children and the effects of treatment. *Behaviour Research and Therapy*, *43*(10), 1375–1381. https://doi.org/10.1016/j.brat.2004.10.009

Crick, N. R., & Dodge, K. A. (1994). Review of social information processing in children social adjustment. *Psychological Bulletin*, *115*(1), 74–101. https://doi.org/10.1037/0033-2909.115.1.74

Crick, N. R., & Dodge, K. A. (1996). Social information-processing mechanisms in reactive and proactive aggression. *Child Development*, *67*(3), 993–1002. https://doi.org/10.1111/j.1467-8624.1996.tb01778.x

Curran, P. J., & Bauer, D. J. (2011). The disaggregation of within-person and between-person effects in longitudinal models of change. *Annual Review of Psychology*, *62*(1), 583–619. https://doi.org/10.1146/annurev.psych.093008.100356

Day, D. M., Bream, L. A., & Pal, A. (1992). Proactive and reactive aggression: An analysis of subtypes based on teacher perceptions. *Journal of Clinical Child Psychology*, *21*(3), 210–216. https://doi.org/10.1207/s15374424jccp2103_2

de Castro, B. O. (2000). *Social information processing in antisocial boys*. Doctoral Dissertation: Vrije Universiteit Amsterdam.

de Castro, B. O., & Koops, W. (2005). Social information processing in delinquent adolescents. *Psychology, Crime and Law*, *11*(4), 363–375. https://doi.org/10.1080/10683160500255307

de Castro, B. O., Merk, W., Koops, W., Veerman, J. W., & Bosch, J. D. (2005). Emotions in social information processing and their relations with reactive and proactive aggression in referred aggressive boys. *Journal of Clinical Child and Adolescent Psychology*, *34*(1), 105–116. https://doi.org/10.1207/s15374424jccp3401_10

de Castro, B. O., Slot, N. W., Bosch, J. D., Koops, W., & Veerman, J. W. (2003). Negative feelings exacerbate hostile attributions of intent in highly aggressive boys. *Journal of Clinical Child and Adolescent Psychology*, *32*(1), 56–65. https://doi.org/10.1207/S15374424JCCP3201_06

de Castro, B. O., Thomaes, S., & Reijntjes, A. (2015). Using experimental designs to understand the development of peer relations. *Journal of Research on Adolescence*, *25*(1), 1–13. https://doi.org/10.1111/jora.12103

de Castro, B. O., & van Dijk, A. (2017). "It's gonna end up with a fight anyway". Social cognitive processes in children with disruptive behavior Disorders. In J. E. Lochman & W. Matthys (Eds.), *The Wiley handbook of disruptive and impulse-control disorders* (pp. 237–254). John Wiley & Sons Ltd.

de Castro, B. O., Verhulp, E. E., & Runions, K. (2012). Rage and revenge: Highly aggressive boys' explanations for their responses to ambiguous provocation. *European Journal of Developmental Psychology*, *9*(3), 331–350. https://doi.org/10.1080/17405629.2012.680304

De Los Reyes, A., Augenstein, T. M., Wang, M., Thomas, S. A., Drabick, D. A. G., Burgers, D. E., & Rabinowitz, J. (2015). The validity of the multi-informant approach to assessing child and adolescent mental health. *Psychological Bulletin*, *141*(4), 858–900. https://doi.org/10.1037/a0038498

De Los Reyes, A., & Kazdin, A. E. (2005). Informant discrepancies in the assessment of childhood psychopathology: A critical review, theoretical framework, and recommendations for further study. *Psychological Bulletin, 131*(4), 483–509. https://doi.org/10.1037/0033-2909.131.4.483

de Mooij, B., Fekkes, M., Scholte, R. H. J., & Overbeek, G. (2020). Effective components of social skills training programs for children and adolescents in nonclinical samples: A multilevel meta-analysis. *Clinical Child and Family Psychology Review, 23*(2), 250–264. https://doi.org/10.1007/s10567-019-00308-x

DeVries, L. N., Hartung, C. M., & Golden, T. L. (2017). Negative halo effects in parent ratings of ADHD and ODD. *Journal of Psychopathology and Behavioral Assessment, 39*(2), 179–188. https://doi.org/10.1007/s10862-016-9560-z

Dietvorst, E., Hiemstra, M., Hillegers, M. H. J., & Keijsers, L. (2018). Adolescent perceptions of parental rivacy invasion and adolescent secrecy: An illustration of Simpson's paradox. *Child Development, 89*(6), 2081–2090. https://doi.org/10.1111/cdev.13002

Dodge, K. A. (1990). The structure and function of reactive and proactive aggression. In D. Pepler & K. H. Rubin (Eds.), *The development and treatment of childhood aggression* (pp. 201–218). Erlbaum.

Dodge, K. A., & Coie, J. D. (1987). Social-information-processing factors in reactive and proactive aggression in children's peer groups. *Journal of Personality and Social Psychology, 53*(6), 1146–1158. https://doi.org/10.1037/0022-3514.53.6.1146

Dodge, K. A., Dishion, T. J., & Lansford, J. E. (2006). Deviant peer influences in intervention and public policy for youth. *Social Policy Report, 20*(1), 1–20. https://doi.org/10.1002/j.2379-3988.2006.tb00046.x

Dodge, K. A., Malone, P. S., Lansford, J. E., Sorbring, E., Skinner, A. T., Tapanya, S., Tirado, L. M. U., Zelli, A., Alampay, L. P., Al-Hassan, S. M., Bacchini, D., Bombi, A. S., Bornstein, M. H., Chang, L., Deater-Deckard, K., Di Giunta, L., Oburu, P., & Pastorelli, C. (2015). Hostile attributional bias and aggressive behavior in global context. *Proceedings of the National Academy of Sciences of the United States of America, 112*(30), 9310–9315. https://doi.org/10.1073/pnas.1418572112

Eisenberg, N., Sadovsky, A., Spinrad, T. L., Fabes, R. A., Losoya, S. H., Valiente, C., Reiser, M., Cumberland, A., & Shepard, S. A. (2005). The relations of problem behavior status to children's negative emotionality, effortful control, and impulsivity: Concurrent relations and prediction of change. *Developmental Psychology, 41*(1), 193–211. https://doi.org/10.1037/0012-1649.41.1.193

Ellis, B. J., Bianchi, J., Griskevicius, V., & Frankenhuis, W. E. (2017). Beyond risk and protective factors: An adaptation-based approach to resilience. *Perspectives on Psychological Science, 73657*, 1–42. https://doi.org/10.1177/1745691617693054

Esbensen, F. A., Melde, C., Taylor, T. J., & Peterson, D. (2008). Active parental consent in school-based research: How much is enough and how do we get it? *Evaluation Review, 32*(4), 335–362. https://doi.org/10.1177/0193841X08315175

Esposito, A. J., Kobak, R., & Little, M. (2005). Aggression and self-esteem: A diary study of children's reactivity to negative interpersonal events. *Journal of Personality, 73*(4), 887–906. https://doi.org/10.1111/j.1467-6494.2005.00332.x

A

Evans, S. C., Díaz, K. I., Callahan, K. P., Wolock, E. R., & Fite, P. J. (2021). Parallel trajectories of proactive and reactive aggression in middle childhood and their outcomes in early adolescence. *Research on Child and Adolescent Psychopathology*, *49*(2), 211–226. https://doi.org/10.1007/s10802-020-00709-5

Evers, A. V. A. M., Lucassen, W., Meijer, R. R., & Sijtsma, K. (2010). *COTAN Beoordelingssysteem voor de kwaliteit van tests [COTAN Assessment system for the quality of tests].*

Field, A. P. (2017). *Discovering Statistics Using IBM SPSS Statistics*. Sage Publications Ltd.

Flay, B. R., Biglan, A., Boruch, R. F., Castro, F. G., Gottfredson, D., Kellam, S., Mościcki, E. K., Schinke, S., Valentine, J. C., & Ji, P. (2005). Standards of evidence: Criteria for efficacy, effectiveness and dissemination. *Prevention Science*, *6*(3), 151–175. https://doi.org/10.1007/s11121-005-5553-y

Fontaine, N., Carbonneau, R., Vitaro, F., Barker, E. D., & Tremblay, R. E. (2009). Research review: A critical review of studies on the developmental trajectories of antisocial behavior in females. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *50*(4), 363–385. https://doi.org/10.1111/j.1469-7610.2008.01949.x

Foster, E. M., Jones, D. E., & Group, C. P. P. R. (2005). The high costs of aggression: Public expenditures resulting from conduct disorder. *American Journal of Public Health*, *95*(10), 1767–1772. https://doi.org/10.2105/AJPH.2004.061424

Frick, P. J. (2012). Developmental pathways to conduct disorder: Implications for future directions in research, assessment, and treatment. *Journal of Clinical Child and Adolescent Psychology*, *41*(3), 378–389. https://doi.org/10.1080/15374416.2012.664815

Frick, P. J., Lilienfeld, S. O., Ellis, M., Loney, B., & Silverthorn, P. (1999). The association between anxiety and psychopathy dimensions in children. *Journal of Abnormal Child Psychology*, *27*(5), 383–392. https://doi.org/10.1023/A:1021928018403

Fung, A. L. C., Gerstein, L. H., Chan, Y., & Engebretson, J. (2015). Relationship of aggression to anxiety, depression, anger, and empathy in Hong Kong. *Journal of Child and Family Studies*, *24*(3), 821–831. https://doi.org/10.1007/s10826-013-9892-1

Garland, A. F., Haweley, K. M., Brookman-Frazee, L., & Hurlburt, M. S. (2008). Identifying common elements of evidence-based psychosocial treatments for children's disruptive behavior problems. *Journal of the American Academy of Child & Adolescent Psychiatry*, *47*(5), 505–514. https://doi.org/10.1097/CHI.0b013e31816765c2

Geraets, C. N. W., van der Stouwe, E. C. D., Pot-Kolder, R., & Veling, W. (2021). Advances in immersive virtual reality interventions for mental disorders – a new reality? *Current Opinion in Psychology*, *41*, 40–45. https://doi.org/10.1016/j.copsyc.2021.02.004

Girard, L. C., Tremblay, R. E., Nagin, D., & Côté, S. M. (2019). Development of aggression subtypes from childhood to adolescence: A group-based multi-trajectory modelling perspective. *Journal of Abnormal Child Psychology*, *47*(5), 825–838. https://doi.org/10.1007/s10802-018-0488-5

Granic, I. (2014). The role of anxiety in the development, maintenance, and treatment of childhood aggression. *Development and Psychopathology*, *26*(4pt2), 1515–1530. https://doi.org/10.1017/S0954579414001175

Granic, I., Meusel, L. A., Lamm, C., Woltering, S., & Lewis, M. D. (2012). Emotion regulation in children with behavior problems: Linking behavioral and brain processes. *Development and Psychopathology*, *24*(3), 1019–1029. https://doi.org/10.1017/S095457941200051X

Greca, A. M. L., Silverman, W. K., & Lochman, J. E. (2009). Mechanisms of behavioral and affective treatment outcomes in a cognitive behavioral intervention for boys. *Journal of Consulting and Clinical Psychology*, *77*(3), 373–382. https://doi.org/10.1037/a0015954

Gupta, S. K. (2011). Intention-to-treat concept: A review. *Perspectives in Clinical Research*, *2*(3), 109–112. https://doi.org/10.4103/2229-3485.83221

Hadley, W., Houck, C., Brown, L. K., Spitalnick, J. S., Ferrer, M., & Barker, D. (2019). Moving beyond role-play: Evaluating the use of virtual reality to teach emotion regulation for the prevention of adolescent risk behavior within a randomized pilot trial. *Journal of Pediatric Psychology*, *44*(4), 425–435. https://doi.org/10.1093/jpepsy/jsy092

Halldorsson, B., Hill, C., Waite, P., Partridge, K., Freeman, D., & Creswell, C. (2021). Annual Research Review: Immersive virtual reality and digital applied gaming interventions for the treatment of mental health problems in children and young people: the need for rigorous treatment development and clinical evaluation. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *62*(5), 584–605. https://doi.org/10.1111/jcpp.13400

Hamaker, E. L. (2012). Why researchers should think "within-person": A paradigmatic rationale. In M. R. Mehl & T. S. Conner (Eds.), *Handbook of research methods for studying daily life* (pp. 43–61). Guilford.

Hamaker, E. L., Kuiper, R. M., & Grasman, R. P. P. P. (2015). A critique of the cross-lagged panel model. *Psychological Methods*, *20*, 102–116. https://doi.org/10.1037/a0038889

Heleniak, C., Lenness, J. L., van der Stoep, A., McCauley, E., & McLaughlin, K. A. (2016). Childhood maltreatment exposure and disruptions in emotion regulation: A transdiagnostic pathway to adolescent internalizing and externalizing psychopathology. *Cognitive Therapy and Research*, *40*(3), 394–415. https://doi.org/10.1007/s10608-015-9735-z

Hendrickx, M., Crombez, G., Roeyers, H., & de Castro, B. O. (2003). Psychometrische evaluatie van de Nederlandstalige versie van de Agressie Beoordelingsschaal van Dodge en Coie (1987) [Psychometric evaluation of the Dutch version of Doge & Coie's (1987) aggression rating scale]. *Tijdschrift Voor Gedragstherapie*, *36*, 33–43.

Hoffman, L., & Stawski, R. S. (2009). Persons as contexts: Evaluating between-person and within-person effects in longitudinal analysis. *Research in Human Development*, *6*(2–3), 97–120. https://doi.org/10.1080/15427600902911189

Hoijtink, H., Mulder, J., van Lissa, C., & Gu, X. (2019). A tutorial on testing hypotheses using the Bayes factor. *Psychological Methods*, *24*(5), 539–556. https://doi.org/10.1037/met0000201

Hollis, C., Falconer, C. J., Martin, J. L., Whittington, C., Stockton, S., Glazebrook, C., & Davies, E. B. (2017). Annual research review: Digital health interventions for children and young people with mental health problems – a systematic and meta-review. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *58*(4), 474–503. https://doi.org/10.1111/jcpp.12663

Hrabok, M., Brooks, B. L., Fay-Mcclymont, T. B., & Sherman, E. M. S. (2014). Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV) short-form validity: A comparison study in pediatric epilepsy. *Child Neuropsychology*, *20*(1), 49–59. https://doi.org/10.1080/09297049.2012.741225

Jacobson, N. S., & Truax, P. (1991). Clinical significance: A statistical approach to denning meaningful change in psychotherapy research. *Journal of Consulting and Clinical Psychology*, *59*(1), 12–19. https://doi.org/10.1037/0022-006X.59.1.12

A

Jester, J. M., Nigg, J. T., Buu, A., Puttler, L. I., Glass, J. M., Heitzeg, M. M., Fitzgerald, H. E., & Zucker, R. A. (2008). Trajectories of childhood aggression and inattention/hyperactivity: Differential effects on substance abuse in adolescence. *Journal of the American Academy of Child and Adolescent Psychiatry*, *47*(10), 1158–1165. https://doi.org/10.1097/CHI.0b013e3181825a4e

Kaminski, J. W., & Claussen, A. H. (2017). Evidence base update for psychosocial treatments for disruptive behaviors in children. *Journal of Clinical Child and Adolescent Psychology*, *46*(4), 477–499. https://doi.org/10.1080/15374416.2017.1310044

Kaminski, J. W., Valle, L. A., Filene, J. H., & Boyle, C. L. (2008). A meta-analytic review of components associated with parent training program effectiveness. *Journal of Abnormal Child Psychology*, *36*(4), 567–589. https://doi.org/10.1007/s10802-007-9201-9

Kandalaft, M. R., Didehbani, N., Krawczyk, D. C., Allen, T. T., & Chapman, S. B. (2013). Virtual reality social cognition training for young adults with high-functioning autism. *Journal of Autism and Developmental Disorders*, *43*(1), 34–44. https://doi.org/10.1007/s10803-012-1544-6

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

Kazdin, A. E. (2007). Mediators and mechanisms of change in psychotherapy research. *Annual Review of Clinical Psychology*, *3*(1), 1–27. https://doi.org/10.1146/annurev.clinpsy.3.022806.091432

Kazdin, A. E. (2009). Understanding how and why psychotherapy leads to change. *Psychotherapy Research*, *19*(4–5), 418–428. https://doi.org/10.1080/10503300802448899

Kazdin, A. E. (2011). Evidence-based treatment research: Advances, limitations, and next steps. *American Psychologist*, *66*(8), 685–698. https://doi.org/10.1037/a0024975

Kazdin, A. E. (2015). Treatment as usual and routine care in research and clinical practice. *Clinical Psychology Review*, *42*, 168–178. https://doi.org/10.1016/j.cpr.2015.08.006

Kazdin, A. E., & Nock, M. K. (2003). Delineating mechanisms of change in child and adolescent therapy: Methodological issues and research recommendations. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *44*(8), 1116–1129. https://doi.org/10.1111/1469-7610.00195

Ke, F., Moon, J., & Sokolikj, Z. (2020). Virtual reality–based social skills training for children with autism spectrum disorder. *Journal of Special Education Technology*, *37*(1), 49–62. https://doi.org/10.1177/0162643420945603

Keijsers, L., & van Roekel, E. (2018). Longitudinal methods in adolescent psychology. Where could we go from here? And should we? In L. B. Hendry & M. Kloep (Eds.), *Reframing Adolescent Research*. Routledge.

Kort, W., Schittekatte, M., Dekker, P. H., Verhaeghe, P., Compaan, E. L., Bosmans, M., & Vermeir, G. (2005). *Wechsler Intelligence Scale for Children - Third edition - Nederlandstalige bewerking (WISC-III NL)*. Harcourt Test Publishers/Nederlands Instituut voor Psychologen.

Kovacs, M., & Devlin, B. (1998). Internalizing disorders in childhood. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *39*(1), 47–63. https://doi.org/10.1017/S0021963097001765

Kraemer, H. C., Wilson, G. T., Fairburn, C. G., & Agras, W. S. (2002). Mediators and moderators of treatment effects in randomized clinical trials. *Archives of General Psychiatry*, *59*(10), 877–883. https://doi.org/10.1001/archpsyc.59.10.877

Lam, C. B., Mchale, S. M., & Crouter, A. C. (2014). Time with peers from middle childhood to late adolescence: Developmental course and adjustment correlates. *Child Development*, *85*(4), 1677–1693. https://doi.org/10.1111/cdev.12235

Landenberger, N. A., & Lipsey, M. W. (2005). The positive effects of cognitive-behavioral programs for offenders: A meta-analysis of factors associated with effective treatment. *Journal of Experimental Criminology*, *1*(4), 451–476. https://doi.org/10.1007/s11292-005-3541-7

Lansford, J. E., Malone, P. S., Dodge, K. a, Pettit, G. S., & Bates, J. E. (2010). Developmental cascades of peer rejection, social information processing biases, and aggression during middle childhood. *Development and Psychopathology*, *22*(3), 593–602. https://doi.org/10.1017/S0954579410000301

Laurenceau, J. P., Hayes, A. M., & Feldman, G. C. (2007). Some methodological and statistical issues in the study of change processes in psychotherapy. *Clinical Psychology Review*, *27*(6), 682–695. https://doi.org/10.1016/j.cpr.2007.01.007

Leijten, P., Dishion, T. J., Thomaes, S., Raaijmakers, M. A. J., de Castro, B. O., & Matthys, W. (2015). Bringing parenting interventions back to the future: How randomized microtrials may benefit parenting intervention efficacy. *Clinical Psychology: Science and Practice*, *22*(1), 47–57. https://doi.org/10.1111/cpsp.12087

Leijten, P., Overbeek, G., & Janssens, J. M. A. M. (2012). Effectiveness of a parent training program in (pre)adolescence: Evidence from a randomized controlled trial. *Journal of Adolescence*, *35*(4), 833–842. https://doi.org/10.1016/j.adolescence.2011.11.009

Lemerise, E. A., & Arsenio, W. F. (2000). An integrated model of emotion processes and cognition in social information processing. *Child Development*, *71*(1), 107–118. https://doi.org/10.1111/1467-8624.00124

Levy, K., Hunt, C., & Heriot, S. (2007). Treating comorbid anxiety and aggression in children. *Journal of the American Academy of Child and Adolescent Psychiatry*, *46*(9), 1111–1118. https://doi.org/10.1097/chi.0b013e318074eb32

Lindner, P. (2021). Better, virtually: the past, present, and future of virtual reality cognitive behavior therapy. *International Journal of Cognitive Therapy*, *14*(1), 23–46. https://doi.org/10.1007/s41811-020-00090-7

Lindner, P., Miloff, A., Zetterlund, E., Reuterskiöld, L., Andersson, G., & Carlbring, P. (2019). Attitudes toward and familiarity with virtual reality therapy among practicing cognitive behavior therapists: A cross-sectional survey study in the era of consumer VR platforms. *Frontiers in Psychology*, *10*(176), 1–10. https://doi.org/10.3389/fpsyg.2019.00176

Lischetzke, T. (2014). Daily diary methodology. In A. C. Michalos (Ed.), *Encyclopedia of quality of life and well-being research* (pp. 1413–1419). Springer.

Litschge, C. M., Vaughn, M. G., & McCrea, C. (2010). The empirical status of treatments for children and youth with conduct problems: An overview of meta-analytic studies. *Research on Social Work Practice*, *20*(1), 21–35. https://doi.org/10.1177/1049731508331247

A

Lochman, J. E., Boxmeyer, C. L., Jones, S., Qu, L., Ewoldsen, D., & Nelson, W. M. (2017). Testing the feasibility of a briefer school-based preventive intervention with aggressive children: A hybrid intervention with face-to-face and internet components. *Journal of School Psychology*, *62*, 33–50. https://doi.org/10.1016/j.jsp.2017.03.010

Lochman, J. E., Boxmeyer, C. L., Kassing, F. L., Powell, N. P., & Stromeyer, S. L. (2019). Cognitive behavioral intervention for youth at risk for conduct problems: Future directions. *Journal of Clinical Child and Adolescent Psychology*, *48*(5), 799–810. https://doi.org/10.1080/15374416.2019.1567349

Lochman, J. E., Dishion, T. J., Powell, N. P., Boxmeyer, C. L., Qu, L., & Sallee, M. (2015). Evidence-based preventive intervention for preadolescent aggressive children: One-year outcomes following randomization to group versus individual delivery. *Journal of Consulting and Clinical Psychology*, *83*(4), 728–735. https://doi.org/10.1037/ccp0000030

Lochman, J. E., Kassing, F. L., & Sallee, M. (2017). Factors influencing intervention delivery and outcomes. In *The Wiley handbook of disruptive and impulse-control disorders* (pp. 485–500). John Wiley & Sons, Ltd.

Lochman, J. E., & Matthys, W. (2017). *The Wiley handbook of disruptive and impulse-control disorders*. John Wiley & Sons, Ltd.

Lochman, J. E., & Wells, K. C. (2002). Contextual social-cognitive mediators and child outcome: A test of the theoretical model in the Coping Power program. *Development and Psychopathology*, *14*(4), 945–967. https://doi.org/10.1017/S0954579402004157

Lochman, J. E., Wells, K. C., & Lenhart, L. A. (2008). *Coping Power Cild Group Program*. Oxford University Press, Inc.

Loeber, R., & Farrington, D. P. (2000). Young children who commit crime: Epidemiology, developmental origins, risk factors, early interventions, and policy implications. *Development and Psychopathology*, *12*(4), 737–762. https://doi.org/10.1017/S0954579400004107

Lucassen, M. F. G., Stasiak, K., Crengle, S., Weisz, J. R., Frampton, C. M. A., Bearman, S. K., Ugueto, A. M., Herren, J., Cribb-Su'a, A., Faleafa, M., Kingi-'Ulu'ave, D., Loy, J., Scott, R. M., Hartdegen, M., & Merry, S. N. (2015). Modular approach to therapy for anxiety, depression, trauma, or conduct problems in outpatient child and adolescent mental health services in New Zealand: Study protocol for a randomized controlled trial. *Trials*, *16*(1), 1–12. https://doi.org/10.1186/s13063-015-0982-9

Luebbe, A. M., Bell, D. J., Allwood, M. A., Swenson, L. P., & Early, M. C. (2010). Social information processing in children: Specific relations to anxiety, depression, and affect. *Journal of Clinical Child and Adolescent Psychology*, *39*(3), 386–399. https://doi.org/10.1080/15374411003691685

Marmorstein, N. R. (2007). Relationships between anxiety and externalizing disorders in youth: the influences of age and gender. *Journal of Anxiety Disorders*, *21*(3), 420–432. https://doi.org/10.1016/j.janxdis.2006.06.004

Marsee, M. A., Lau, K. S. L., & Lapré, G. E. (2014). Parent and adolescent report of the forms and functions of aggression: Associations with delinquency, CU traits, and dysregulation. *Child and Youth Care Forum*, *43*(1), 27–39. https://doi.org/10.1007/s10566-013-9223-0

Marsee, M. A., Weems, C. F., & Taylor, L. K. (2008). Exploring the association between aggression and anxiety in youth: A look at aggressive subtypes, gender, and social cognition. *Journal of Child and Family Studies*, *17*(1), 154–168. https://doi.org/10.1007/s10826-007-9154-1

Marsman, M., & Wagenmakers, E. J. (2017). Bayesian benefits with JASP. *European Journal of Developmental Psychology*, *14*(5), 545–555. https://doi.org/10.1080/17405629.2016.1259614

Matthys, W., Maassen, G. H., Cuperus, J. M., & van Engeland, H. (2001). The assessment of the situational specificity of children's problem behaviour in peer-peer context. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *42*(3), 413–420. https://doi.org/10.1017/S002196300100703X

McCart, M. R., Priester, P. E., Davies, W. H., & Azen, R. (2006). Differential effectiveness of behavioral parent-training and cognitive-behavioral therapy for antisocial youth: A meta-analysis. *Journal of Abnormal Child Psychology*, *34*(4), 527–543. https://doi.org/10.1007/s10802-006-9031-1

McConaughy, S. H., & Skiba, R. J. (1993). Comorbidity of externalizing and internalizing problems. *School Psychology Review*, *22*(3), 421–436. https://doi.org/10.1080/02796015.1993.12085664

McLaughlin, K. A., & Nolen-Hoeksema, S. (2011). Rumination as a transdiagnostic factor in depression and anxiety. *Behaviour Research and Therapy*, *49*(3), 186–193. https://doi.org/10.1016/j.brat.2010.12.006

McLaughlin, K. A., Wisco, B. E., Aldao, A., & Hilt, L. M. (2014). Rumination as a transdiagnostic factor underlying transitions between internalizing symptoms and aggressive behavior in early adolescents. *Journal of Abnormal Psychology*, *123*(1), 13–23. https://doi.org/10.1037/a0035358

McMahon, T. P., & Naragon-Gainey, K. (2019). The multilevel structure of daily emotion-regulation-strategy use: An examination of within- and between-person associations in naturalistic settings. *Clinical Psychological Science*, *7*(2), 321–339. https://doi.org/10.1177/2167702618807408

Menting, A. T. A., Albrecht, G., & de Castro, B. O. (2015). *Effective elementen van interventies tegen externaliserende gedagsproblemen bij jeugd [Effective elements of interventions for externalizing problem behavior in youth]*. Utrecht University.

Menting, A. T. A., de Castro, B. O., & Matthys, W. (2013). Effectiveness of the Incredible Years parent training to modify disruptive and prosocial child behavior: A meta-analytic review. *Clinical Psychology Review*, *33*(8), 901–913. https://doi.org/10.1016/j.cpr.2013.07.006

Merikangas, K. R., Nakamura, E. F., & Kessler, R. C. (2009). Epidemiology of mental disorders in children and adolescents. *Dialogues in Clinical Neuroscience*, *11*(1), 7–20.

Merrell, K. W., McClun, L. A., Kempf, K. K. G., & Lund, J. (2002). Using self-report assessment to identify children with internalizing problems: Validity of the internalizing scale for children. *Journal of Psychoeducational Assessment*, *20*, 223–239.

Moldovan, R., & Pintea, S. (2015). Mechanisms of change in psychotherapy: Methodological and statistical considerations. *Cognition, Brain, Behavior*, *19*(4), 299–311.

Muthén, L. K., & Muthén, B. (2019). *Mplus user's guide (1998-2019)*. Muthén & Muthén.

A

Newbutt, N., Sung, C., Kuo, H. J., Leahy, M. J., Lin, C. C., & Tong, B. (2016). Brief report: A pilot study of the use of a virtual reality headset in autism populations. *Journal of Autism and Developmental Disorders*, *46*(9), 3166–3176. https://doi.org/10.1007/s10803-016-2830-5

Nolen-Hoeksema, S., & Watkins, E. R. (2011). A heuristic for developing transdiagnostic models of psychopathology: Explaining multifinality and divergent trajectories. *Perspectives on Psychological Science*, *6*(6), 589–609. https://doi.org/10.1177/1745691611419672

Oland, A. A., & Shaw, D. S. (2005). Pure versus co-occurring externalizing and internalizing symptoms in children: The potential role of socio-developmental milestones. *Clinical Child and Family Psychology Review*, *8*(4), 247–270. https://doi.org/10.1007/s10567-005-8808-z

Park, K. M., Ku, J., Choi, S. H., Jang, H. J., Park, J. Y., Kim, S. I., & Kim, J. J. (2011). A virtual reality application in role-plays of social skills training for schizophrenia: A randomized, controlled trial. *Psychiatry Research*, *189*(2), 166–172. https://doi.org/10.1016/j.psychres.2011.04.003

Perren, S., Ettekal, I., Ladd, G., Prinstein, M. J., Cheah, C. S. L., & Guyer, A. E. (2013). The impact of peer victimization on later maladjustment: Mediating and moderating effects of hostile and self-blaming attributions. *Journal of Clinical Child and Adolescent Psychology*, *34*(1), 46–55. https://doi.org/10.1207/s15374424jccp3401_2

Polman, H., de Castro, B. O., Koops, W., van Boxtel, H. W., & Merk, W. W. (2007). A meta-analysis of the distinction between reactive and proactive aggression in children and adolescents. *Journal of Abnormal Child Psychology*, *35*(4), 522–535. https://doi.org/10.1007/s10802-007-9109-4

Polman, H., de Castro, B. O. De, Thomaes, S., & van Aken, M. (2009). New directions in measuring reactive and proactive aggression: Validation of a teacher questionnaire. *Journal of Abnormal Child Psychology*, *37*, 183–193. https://doi.org/10.1007/s10802-008-9266-0

Prinstein, M. J., Cheah, C. S. L., & Guyer, A. E. (2005). Peer victimization, cue interpretation, and internalizing symptoms: Preliminary concurrent and longitudinal findings for children and adolescents. *Journal of Clinical Child and Adolescent Psychology*, *34*(1), 11–24. https://doi.org/10.1207/s15374424jccp3401_2

Quiggle, N. L., Garber, J., Panak, W. F., & Dodge, K. A. (1992). Social information processing in aggressive and depressed children. *Child Development*, *63*(6), 1305–1320.

Reid, S. C., Salmon, K., & Lovibond, P. F. (2006). Cognitive biases in childhood anxiety, depression, and aggression: Are they pervasive or specific? *Cognitive Therapy and Research*, *30*(5), 531–549. https://doi.org/10.1007/s10608-006-9077-y

Rioux, C., & Little, T. D. (2020). Underused methods in developmental science to inform policy and practice. *Child Development Perspectives*, *14*(2), 97–103. https://doi.org/10.1111/cdep.12364

Roberton, T., Daffern, M., & Bucks, R. S. (2012). Emotion regulation and aggression. *Aggression and Violent Behavior*, *17*(1), 72–82. https://doi.org/10.1016/j.avb.2011.09.006

Röll, J., Koglin, U., & Petermann, F. (2012). Emotion regulation and childhood aggression: Longitudinal associations. *Child Psychiatry and Human Development*, *43*(6), 909–923. https://doi.org/10.1007/s10578-012-0303-4

Romeo, R., Knapp, M., & Scott, S. (2006). Economic cost of severe antisocial behaviour in children - And who pays it. *British Journal of Psychiatry*, *188*(6), 547–553. https://doi.org/10.1192/bjp.bp.104.007625

Rothbart, M. K., Ahadi, S. A., & Hershey, K. L. (1994). Temperament and social behavior in childhood. *Merril-Palmer Quarterly*, *40*(1), 21–39.

Rydell, A. M., Berlin, L., & Bohlin, G. (2003). Emotionality, emotion regulation, and adaptation among 5- to 8-year-old children. *Emotion*, *3*(1), 30–47. https://doi.org/10.1037/1528-3542.3.1.30

Saiano, M., Pellegrino, L., Casadio, M., Summa, S., Garbarino, E., Rossi, V., Dall'Agata, D., & Sanguineti, V. (2015). Natural interfaces and virtual environments for the acquisition of street crossing and path following skills in adults with Autism Spectrum Disorders: A feasibility study. *Journal of NeuroEngineering and Rehabilitation*, *12*(1), 1–13. https://doi.org/10.1186/s12984-015-0010-z

Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003). Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods of Psychological Research Online*, *8*(2), 23–74. https://doi.org/10.1002/0470010940

Shirk, S. R., & Karver, M. (2003). Prediction of treatment outcome from relationship variables in child and adolescent therapy: A meta-analytic review. *Journal of Consulting and Clinical Psychology*, *71*(3), 452–464. https://doi.org/10.1037/0022-006X.71.3.452

Silverstein, A. B. (1970). Reappraisal of the validity of WAIS, WISC, and WPPSI short forms. *Journal of Consulting and Clinical Psychology*, *34*(1), 12–14. https://doi.org/10.1037/h0028680

Stipek, D., & Miles, S. (2008). Effects of aggression on achievement: Does conflict with the teacher make it worse? *Child Development*, *79*(6), 1721–1735. https://doi.org/10.1111/j.1467-8624.2008.01221.x

Stuijfzand, S., Creswell, C., Field, A. P., Pearcey, S., & Dodd, H. (2018). Research Review: Is anxiety associated with negative interpretations of ambiguity in children and adolescents? A systematic review and meta-analysis. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *59*(11), 1127–1142. https://doi.org/10.1111/jcpp.12822

Stull, D. E. (2008). Analyzing growth and change: Latent variable growth curve modeling with an application to clinical trials. *Quality of Life Research*, *17*(1), 47–59. https://doi.org/10.1007/s11136-007-9290-5

Sukhodolsky, D. G., Smith, S. D., McCauley, S. A., Ibrahim, K., & Piasecka, J. B. (2016). Behavioral interventions for anger, irritability, and aggression in children and adolescents. *Journal of Child and Adolescent Psychopharmacology*, *26*(1), 58–64. https://doi.org/10.1089/cap.2015.0120

Suveg, C., Southam-Gerow, M. A., & Goodman, K. L. (2007). The role of emotion theory and research in child therapy development. *Clinical Psychology: Science and Practice*, *14*(4), 358–371. https://doi.org/10.1111/j.1468-2850.2007.00096.x

Tanaka, A., Raishevich, N., & Scarpa, A. (2010). Family conflict and childhood aggression: The role of child anxiety. *Journal of Interpersonal Violence*, *25*(11), 2127–2143. https://doi.org/10.1177/0886260509354516

A

te Brinke, L. W., Menting, A. T. A., Schuiringa, H. D., Deković, M., Weisz, J. R., & de Castro, B. O. (2021). Emotion regulation training as a treatment element for externalizing problems in adolescence: A randomized controlled micro-trial. *Behaviour Research and Therapy*, *143*. https://doi.org/10.1016/j.brat.2021.103889

U.S. Central Intelligence Agency. (2018). *CIA World Factbook*.

Underwood, M. K. (2002). Sticks and stones and social exclusion: Aggression among girls and boys. In P. K. Smith & C. H. Hart (Eds.), *Blackwell handbook of childhood social development* (pp. 533–548). Blackwell Publishers Ltd.

UNESCO. (2012). International Standard Classification of Education (ISCED 2011). In *Prospects*. https://doi.org/10.1007/BF02207511

van Aar, J., Leijten, P., de Castro, B. O., & Overbeek, G. (2017). Sustained, fade-out or sleeper effects? A systematic review and meta-analysis of parenting interventions for disruptive child behavior. *Clinical Psychology Review*, *51*, 153–163. https://doi.org/10.1016/j.cpr.2016.11.006

van de Schoot, R., Kaplan, D., Denissen, J., Asendorpf, J. B., Neyer, F. J., & van Aken, M. A. G. (2014). A gentle introduction to Bayesian analysis: Applications to developmental research. *Child Development*, *85*(3), 842–860. https://doi.org/10.1111/cdev.12169

van Manen, T. G. (2001). *Zelfcontrole [Self-Control]*. Bohn Stafleu Van Loghum.

Verhoef, R. E. J., Alsem, S. C., Verhulp, E. E., & de Castro, B. O. (2019). Hostile intent attribution and aggressive behavior in children revisited: A meta-analysis. *Child Development*, *90*(5), 525–547. https://doi.org/10.1111/cdev.13255

Verhoef, R. E. J., van Dijk, A., & de Castro, B. O. (2022). A dual-mode social-information-processing model to explain individual differences in children's aggressive behavior. *Clinical Psychological Science*, *10*(1), 41–57. https://doi.org/10.1177/21677026211016396

Verhoef, R. E. J., van Dijk, A., Verhulp, E. E., & de Castro, B. O. (2021). Interactive virtual reality assessment of aggressive social information processing in boys with behaviour problems: A pilot study. *Clinical Psychology and Psychotherapy*, *28*(3), 489–499. https://doi.org/10.1002/cpp.2620

Verhoef, R. E. J., Verhulp, E. E., van Dijk, A., & de Castro, B. O. (2021). Interactive virtual reality versus vignette-based assessment of children's aggressive social information processing. *Research on Child and Adolescent Psychopathology*, *50*(5), 621–636. https://doi.org/10.1007/s10802-021-00879-w

Vitaro, F., Brendgen, M., & Tremblay, R. E. (2002). Reactively and proactively aggressive children: Antecedent and subsequent characteristics. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *43*(4), 495–505. https://doi.org/10.1111/1469-7610.00040

Weisz, J. R., Chorpita, B. F., Frye, A., Ng, M. Y., Lau, N., Bearman, S. K., Ugueto, A. M., Langer, D. A., & Hoagwood, K. E. (2011). Youth top problems: Using idiographic, consumer-guided assessment to identify treatment needs and to track change during psychotherapy. *Journal of Consulting and Clinical Psychology*, *79*(3), 369–380. https://doi.org/10.1037/a0023307

Weisz, J. R., Chorpita, B. F., Palinkas, L. A., Schoenwald, S. K., Miranda, J., Bearman, S. K., Daleiden, E. L., Ugueto, A. M., Ho, A., Martin, J., Gray, J., Alleyne, A., Langer, D. A., Southam-Gerow, M. A., Gibbons, R. D., Glisson, C., Green, E. P., Hoagwood, K. E., Kelleher, K., … Mayberg, S. (2012). Testing standard and modular designs for psychotherapy treating depression, anxiety, and conduct problems in youth: A randomized effectiveness trial. *Archives of General Psychiatry*, *69*(3), 274–282. https://doi.org/10.1001/archgenpsychiatry.2011.147

Weisz, J. R., & Hawley, K. M. (2002). Developmental factors in the treatment on adolescents. *Journal of Consulting and Clinical Psychology*, *70*(1), 21–43. https://doi.org/http://dx.doi.org/10.1037/0022-006X.70.1.21

Weisz, J. R., & Kazdin, A. E. (2017). *Evidence-based psychotherapies for children and adolescents*. Guilford Publications.

Weisz, J. R., Kuppens, S., Ng, M. Y., Vaughn-Coaxum, R. A., Ugueto, A. M., Eckshtain, D., & Corteselli, K. A. (2019). Are psychotherapies for young people growing stronger? Tracking trends over time for youth anxiety, depression, attention-deficit/hyperactivity disorder, and conduct problems. *Perspectives on Psychological Science*, *14*(2), 216–237. https://doi.org/10.1177/1745691618805436

White, I. R., Horton, N. J., Carpenter, J., & Pocock, S. J. (2011). Strategy for intention to treat analysis in randomised trials with missing outcome data. *BMJ*, *342*, d40. https://doi.org/10.1136/bmj.d40

Wilson, S. J., & Lipsey, M. W. (2006). The effects of school-based social information processing interventions on aggressive behavior, Part II: Selected/indicated pull-out programs. *Campbell Systematic Reviews*, *2*(1), 1–37. https://doi.org/10.4073/csr.2006.6

Wilson, S. J., & Lipsey, M. W. (2007). School-based interventions for aggressive and disruptive behavior. Update of a meta-analysis. *American Journal of Preventive Medicine*, *33*(2), 130–143. https://doi.org/10.1016/j.amepre.2007.04.011

Wise, E. A. (2004). Methods for analyzing psychotherapy outcomes: A review of clinical significance, reliable change, and recommendations for future directions. *Journal of Personality Assessment*, *82*(1), 50–59. https://doi.org/10.1207/s15327752jpa8201_10

Yaros, A., Lochman, J. E., Rosenbaum, J., & Jimenez-Camargo, L. A. (2014). Real-time hostile attribution measurement and aggression in children. *Aggressive Behavior*, *40*(5), 409–420. https://doi.org/10.1002/ab.21532

Zeman, J., Cassano, M., Perry-Parrish, C., & Stegall, S. (2006). Emotion regulation in children and adolescents. *Development and Behavioral Pediatrics*, *27*(2), 155–168. https://doi.org/0196-206X/06/2702-0155

Zoccolillo, M. D. (1992). Co-occurrence of conduct disorder and its adult outcomes with depressive and anxiety disorders: A review. *Journal of the American Academy of Child and Adolescent Psychiatry*, *31*(3), 547–556. https://doi.org/10.1097/00004583-199205000-00024

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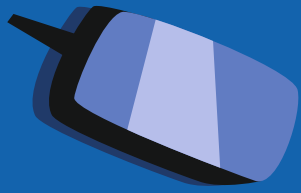
NEDERLANDSE SAMENVATTING

AANLEIDING

Agressieve gedragsproblemen behoren tot de meest voorkomende problemen bij schoolgaande kinderen (Costello et al., 2003; Merikangas et al., 2009). Agressieve gedragsproblemen is een verzamelnaam voor verschillende gedragingen, zoals schoppen, slaan, ruzie maken en iemand uitschelden. Agressieve gedragsproblemen zijn een veel voorkomende reden om kinderen door te verwijzen naar de geestelijke gezondheidszorg (Lochman & Matthys, 2017). Als agressie niet behandeld wordt is de kans groot dat de problemen blijven bestaan (Burks et al., 2001; Girard et al., 2019; Jester et al., 2008). Agressieve gedragsproblemen bij schoolgaande kinderen voorspellen nadelige uitkomsten later in het leven van kinderen, zoals delinquentie, middelenmisbruik, slecht presteren op school en verstoringen in relaties met leeftijdsgenoten (Burkey et al., 2018; Evans et al., 2021; Loeber & Farrington, 2000; Romeo et al., 2006). Daarbij kan agressie ook een blijvende negatieve impact hebben op de sociale omgeving van kinderen (McConaughy & Skiba, 1993; Wilson & Lipsey, 2006). Om escalatie van agressieve gedragsproblemen en negatieve uitkomsten te voorkomen, is het belangrijk om deze problemen te behandelen wanneer ze in de kindertijd ontstaan (Lochman & Matthys, 2017). Hoewel er behandelingen beschikbaar zijn om agressieve gedragsproblemen van kinderen te verminderen, zijn de huidige behandeleffecten bescheiden en werken deze behandelingen niet voor alle kinderen (McCart et al., 2006).

Dit proefschrift beschrijft onderzoek dat kan bijdragen aan het vergroten van de behandeleffecten voor kinderen met agressieve gedragsproblemen. In ons onderzoek stonden twee overkoepelende doelen centraal. Het eerste doel was te onderzoeken of behandeleffecten kunnen worden vergroot door gebruik te maken van interactieve virtual reality. Het tweede doel was het vergroten van ons begrip van potentiële behandelmechanismen, met de nadruk op twee bekende voorspellers van agressie: boosheidsregulatie en attributies van vijandige intenties.

BESTAANDE BEHANDELINGEN

De meest effectieve interventies voor agressieve gedragsproblemen voor schoolgaande kinderen zijn ouderinterventies en cognitieve gedragstherapie (Kaminski & Claussen, 2017; Litschge et al., 2010). Ouderinterventies kunnen opvoedvaardigheden verbeteren en vervolgens de agressieve gedragsproblemen van kinderen verminderen (Kaminski et al., 2008). Echter, deze programma's zijn niet altijd geschikt of even effectief voor alle gezinnen (Leijten et al., 2012), mogelijk omdat ze niet direct gericht zijn op de onderliggende emotieregulatie en sociaal-cognitieve processen van kinderen. Kindgerichte cognitieve gedragstherapie

(CGT) richt zich directer op deze factoren en kan agressie blijvend verminderen (Weisz & Kazdin, 2017). Tot nu toe zijn de effecten van CGT echter bescheiden en heterogeen: niet alle kinderen hebben er evenveel baat bij (McCart et al., 2006).

Uit onderzoek naar bestaande CGT behandelingen voor kinderen blijkt dat deze het meest effectief zijn wanneer cognities actief worden uitgedaagd en kinderen kunnen oefenen met het oplossen van levensechte sociale problemen (de Mooij et al., 2020; Landenberger & Lipsey, 2005). De meeste CGT behandelingen voor agressieve gedragsproblemen doen dat met behulp van rollenspellen (Menting et al., 2015). Zo kunnen kinderen nieuwe gedachten en vaardigheden oefenen in rollenspellen met hun behandelaar (in individuele CGT) of met andere kinderen met agressieve gedragsproblemen (in groeps-CGT). Hoewel rollenspellen flexibel en gemakkelijk in te zetten zijn, kunnen ze minder goed werken door gebrekkige motivatie van kinderen of doordat een te groot beroep wordt gedaan op hun capaciteiten tot perspectief nemen en verbeelding (Hadley et al., 2019; Park et al., 2011). In individuele CGT kunnen kinderen moeite hebben om te verbeelden dat ze met een leeftijdsgenoot interacteren terwijl ze met een behandelaar oefenen, en in groeps-CGT kunnen rollenspellen lastig zijn vanwege problemen met groepsmanagement en beperkte beschikbare tijd voor het individuele kind om te oefenen. Vandaar dat er nieuwe interventiemethoden nodig zijn die het realistisch oefenen in sociale interacties faciliteren (Weisz et al., 2019).

DOEL 1:
Het versterken van behandeleffecten met virtual reality

In dit proefschrift onderzoeken we interactieve virtual reality als nieuwe oefenmethode in CGT voor kinderen met agressieve gedragsproblemen. Interactieve virtual reality biedt een realistische en boeiende omgeving voor kinderen om in te oefenen tijdens de behandeling (Lindner, 2021). In deze virtual reality omgeving konden kinderen vrij bewegen, praten met virtuele kinderen en volwassenen, en spelletjes spelen, zoals het bouwen van een toren of het spelen van een computerspel. Virtual reality kan drie belangrijke voordelen hebben om de effectiviteit van behandelingen te optimaliseren: 1) het biedt een levensechte omgeving waarin kinderen emotioneel betrokken zijn, zodat ze echt kunnen oefenen met het reguleren van hun boosheid; 2) het kan de motivatie voor de behandeling vergroten; en 3) het maakt oefenen op maat mogelijk.

YourSkills

Gezien de potentiële voordelen van het gebruik van virtual reality, ontwikkelden wij de individuele CGT 'YourSkills' voor kinderen met agressieve gedragsproblemen. In YourSkills oefenen kinderen vaardigheden in emotieregulatie en sociale informatieverwerking om hun agressieve gedrag te verminderen. We ontwierpen twee versies van YourSkills met identieke inhoud, maar met verschillende oefenvormen: één met oefenen in virtual reality en één met oefenen in rollenspellen tussen de behandelaar en het kind. Zo konden we de behandeling met virtual reality vergelijken met de identieke behandeling met rollenspellen. YourSkills bestaat uit een introductiesessie van 45 minuten met ouders en tien sessies van 45 minuten met het kind. Tijdens de sessies oefenen kinderen het herkennen van boosheid, het reguleren van boosheid en het oplossen van problemen in sociale interacties. Hoewel YourSkills primair gericht is op het kind, bevordert het ook de betrokkenheid van de ouders door hen een introductiesessie te bieden en hen aan het eind van elke sessie met het kind te laten aansluiten en een samenvatting van de sessie te geven.

Figuur 1

Virtual reality klaslokaal, woonkamer en schoolplein.

Om kinderen in YourSkills hun regulatievaardigheden te laten oefenen terwijl ze emotioneel betrokken zijn, creëerden behandelaren uitdagende sociale situaties voor kinderen in virtual reality of rollenspellen. Hiervoor ontwierpen we drie interactieve en realistische virtuele omgevingen: een klaslokaal, een schoolplein

en een woonkamer (zie Figuur 1). In deze omgevingen konden kinderen oefenen in emotie-opwekkende situaties (bijvoorbeeld uitgelachen worden door een leeftijdsgenoot). Behandelaren konden de boosheid van de kinderen op laten lopen door de virtuele situatie te manipuleren (bv. het kind een spel laten verliezen of de televisie uitzetten) of door de spraak en de handelingen van de virtuele personen te manipuleren (bv. een leeftijdsgenoot een middelvinger laten opsteken).

Onderzoek naar YourSkills

In dit proefschrift beschrijven we twee studies die YourSkills met virtual reality hebben onderzocht. In **hoofdstuk 2** onderzochten we de haalbaarheid van de nieuwe YourSkills interventie met interactieve virtual reality in een kleinschalige studie met zes jongens. Het doel van deze studie was het beschrijven van de inhoud, haalbaarheid en waardering van virtual reality als nieuwe behandelmethode voor kinderen met agressieve gedragsproblemen. De resultaten waren veelbelovend: behandelaren gaven aan dat het geven van de behandeling en het werken met de virtual reality apparatuur haalbaar was. Ze ondervonden nauwelijks technische problemen en waren in staat om de sessies volledig af te ronden en kinderen de aanbevolen tijd in virtual reality te laten oefenen. Kinderen waardeerden de behandeling erg positief (gemiddeld rapportcijfer van 9.3), wat ook werd erkend door de behandelaren, die aangaven dat kinderen actief oefenden in de virtuele omgeving. Daarbij rapporteerden ouders een afname van het agressieve probleemgedrag van hun kinderen. Kinderen zelf rapporteerden echter geen afname. Een verklaring hiervoor is dat kinderen bij de start van de interventie al lagere niveaus van agressie rapporteerden, mogelijk door onderrapportage van de daadwerkelijke problemen (De Los Reyes & Kazdin, 2005). Al met al toonde onze haalbaarheidsstudie aan dat het gebruik van interactieve virtual reality in CGT haalbaar en aantrekkelijk is voor kinderen en behandelaren en de potentie heeft om agressief gedrag te verminderen.

Deze bevindingen waren veelbelovend genoeg voor een grotere studie om te bepalen of virtual reality daadwerkelijk de effectiviteit van CGT vergroot. Dat wil zeggen, of CGT met virtual reality effectiever is dan dezelfde CGT zonder virtual reality. De toegevoegde waarde van virtual reality werd onderzocht door deze niet enkel te vergelijken met een identieke interventie zonder virtual reality maar ook met standaardzorg (Lindner, 2021). In **hoofdstuk 3** vergeleken we deze drie soorten interventies in een multicenter gerandomiseerde gecontroleerde trial. De resultaten lieten zien dat CGT met virtual reality meer kans had om agressief gedrag te verminderen dan standaardzorg. Hetzelfde patroon van resultaten werd gevonden toen we beide YourSkills varianten (d.w.z. virtual reality en rollenspellen) vergeleken met standaardzorg. Wanneer we virtual reality vergeleken met

rollenspellen, had virtual reality iets meer kans om agressie te verminderen dan rollenspellen op vier van de zeven agressie uitkomstmaten. Op andere punten deed virtual reality het duidelijk beter dan rollenspellen: het was zeer waarschijnlijk dat kinderen meer emotionele betrokkenheid en inleving ervoeren tijdens het oefenen met virtual reality dan tijdens rollenspellen. Het was ook waarschijnlijker dat kinderen virtual reality leuker vonden en deze methode als effectiever ervoeren dan rollenspellen. Dit is belangrijk omdat kinderen met agressieve gedragsproblemen vaak niet gemotiveerd zijn voor behandeling (Frick, 2012; Lochman et al., 2019) en het vergroten van de behandelwaardering kan leiden tot hogere behandeleffectiviteit (Lochman, Kassing, et al., 2017).

Samen toonden de twee studies in het eerste deel van dit proefschrift aan dat interactieve virtual reality een haalbaar en veelbelovend instrument is om de motivatie van kinderen tijdens de behandeling te vergroten en de effectiviteit van CGT in de klinische praktijk voor kinderen met agressieve gedragsproblemen te vergroten.

DOEL 2:
Inzicht in behandelmechanismen

Een volgende stap naar het optimaliseren van interventies was het vergroten van ons inzicht in behandelmechanismen. Tot nu toe hebben slechts enkele studies onderzocht via welke mechanismen interventies hun gunstige effecten behalen (Kazdin, 2009; Lochman & Matthys, 2017). Door deze mechanismen van verandering te identificeren kunnen we meer inzicht krijgen in de ontwikkeling van agressieve gedragsproblemen bij kinderen (Kazdin & Nock, 2003) en ervoor zorgen dat huidige interventies uitsluitend relevante componenten bevatten (Kraemer et al., 2002). Daarnaast kunnen onderliggende mechanismen geassocieerd zijn met meerdere problemen, zoals externaliserende en internaliserende problemen, en het adresseren daarvan kan ervoor zorgen dat er minder overlap tussen interventies hoeft te zijn (Granic, 2014; Kazdin & Nock, 2003).

Mogelijke behandelmechanismen binnen interventies voor agressieve gedragsproblemen zijn boosheidsregulatie en vijandige intentie attributies (Bookhout et al., 2017; Chorpita & Daleiden, 2009). Boosheidsregulatie verwijst naar de processen die kinderen gebruiken om de intensiteit of duur van hun gevoelens van boosheid in stand te houden of te verminderen (Cole et al., 2004; Zeman et al., 2006). Met vijandige intentie attributies wordt bedoeld dat kinderen vaker geneigd zijn om het gedrag van anderen als negatief of gemeen te interpreteren, zelfs als het onduidelijk was wat de intenties van de ander waren. Onrechte attributies

dat anderen gedrag met vijandige bedoelingen hebben uitgevoerd, kunnen leiden tot agressie. Kinderen met agressieve gedragsproblemen blijken de intenties van anderen vaker te interpreteren als vijandig (Verhoef et al., 2019).

Wanneer we behandelmechanismen willen identificeren, willen we weten of veranderingen in een potentieel mechanisme binnen een kind gerelateerd zijn aan veranderingen in behandeluitkomsten bij dat specifieke kind. Daarom is het belangrijk om behandelmechanismen te onderzoeken op het binnen-personen niveau (Kazdin, 2011; Laurenceau et al., 2007).

Onderzoek naar behandelmechanismen

In **hoofdstuk 4** onderzochten we of veranderingen in adaptieve boosheidsregulatie en vijandige intentie attributie binnen personen samengingen met veranderingen in agressie van kinderen, over een periode van vier weken. Eerst ontwikkelden we een korte vragenlijst om adaptieve boosheidsregulatie, attributie van vijandige intenties en agressie wekelijks te meten. Deze vulden jongens en meisjes uit groep 5 t/m 8 op school vier weken achter elkaar in. Uit de resultaten bleek dat de psychometrische kwaliteit van onze vragenlijst goed was. Net als in eerder onderzoek lieten onze resultaten op het tussen-personen niveau zien dat kinderen die minder adaptieve boosheidsregulatie en meer vijandige attributies rapporteerden dan anderen, ook meer agressie toonden dan andere kinderen. Daarbij lieten wij als eersten zien dat binnen-personen wekelijkse veranderingen in adaptieve boosheidsregulatie en attributie van vijandige intenties samen gingen met veranderingen in agressie bij diezelfde kinderen. Deze studie geeft indicaties dat het focussen op boosheidregulatie en vijandige intenties mogelijk kan leiden tot vermindering van agressie bij individuele kinderen.

Vervolgens hebben we in **hoofdstuk 5** de volgende stap gezet door boosheidsregulatie en vijandige intentie attributie te onderzoeken als behandelmechanismen in de YourSkills interventie. Met deze interventiestudie konden we onderzoeken of veranderingen in de veronderstelde mechanismen inderdaad een afname van agressie van individuele kinderen voorspelden tijdens de behandeling (Kazdin, 2009). We namen een deelsteekproef van de studie uit hoofdstuk 3, door alleen kinderen te selecteren die waren gerandomiseerd naar de twee YourSkills groepen, omdat deze interventie zich richtte op boosheidsregulatie en vijandige intentie attributies. We gebruikten onze nieuw ontwikkelde wekelijkse vragenlijst (hoofdstuk 4), dat een eenvoudig en valide instrument bleek om individuele veranderingen gedurende de elf behandelsessies te onderzoeken. De resultaten toonden, zoals verwacht, aan dat gedurende de interventieweken adaptieve boosheidsregulatie van kinderen toenam en de attributie van vijandige

intenties afnam. De veranderingen in deze mechanismen hingen sterk samen met door kinderen gerapporteerde veranderingen in agressie. Voor ouder-gerapporteerde agressie vonden we alleen ondersteuning voor vijandige intentie attributie als behandelmechanisme. Kortom, de resultaten van hoofdstuk 4 en 5 laten zien dat het behandelen van boosheidsregulatie en vijandige intentie attributies samengaat met een vermindering van de agressieve gedragsproblemen van kinderen.

Nadat we bewijs vonden voor vijandige intentie attributie als verandermechanisme voor agressieve gedragsproblemen van kinderen, hebben we ons perspectief verbreed en onderzocht of dit mechanisme ook andere problemen van kinderen kan verklaren (Granic, 2014; Kazdin & Nock, 2003). Specifiek vroegen we ons af of vijandige intentie attributie een transdiagnostische factor zou kunnen zijn, wat betekent dat één mechanisme meerdere problemen bij een kind veroorzaakt of in stand houdt. Bij kinderen van schoolgaande leeftijd komen agressieve gedragsproblemen en angstproblemen vaak gelijktijdig voor (comorbiditeit tussen de 22 en 75%; Granic, 2014; Frick et al., 1999). Het identificeren van transdiagnostische factoren lijkt daarom cruciaal, omdat dit belangrijke mechanismen kunnen zijn om deze comorbide problemen gelijktijdig effectief te behandelen. Mogelijk hebben kinderen met comorbide gedrags- en angstproblemen meer baat bij één brede behandeling gericht op geïdentificeerde transdiagnostische factoren dan bij afzonderlijke behandelingen gericht op één enkel probleem (Oland & Shaw, 2005).

Hoofdstuk 6 beschrijft twee studies die vijandige interpretatie onderzochten als transdiagnostische factor voor comorbide angst bij kinderen met agressieve gedragsproblemen. In beide studies vonden we een hoge comorbiditeit van (sub)klinische agressie en angstproblemen (42%), wat de noodzaak benadrukt om transdiagnostische factoren te onderzoeken. Onze resultaten gaven geen bewijs voor vijandige interpretatie als transdiagnostische factor voor het samen voorkomen van agressie en angstproblemen. Een mogelijke verklaring hiervoor is dat attributies zowel angst als agressie voorspellen, maar dat het om verschillende vormen van attributies gaat. Het is dus daarom nog onduidelijk of vijandige interpretatie als transdiagnostische factor kan fungeren.

STERKE PUNTEN EN BEPERKINGEN

Een sterk punt van dit proefschrift is dat we een gerandomiseerde gecontroleerde trial hebben uitgevoerd waarbij we voor het eerst interactieve virtual reality hebben geïmplementeerd in een interventie voor kinderen met agressieve gedragsproblemen. Daarbij hebben we ons onderzoek in de praktijk uitgevoerd,

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door YourSkills te implementeren en te onderzoeken in klinische centra. Dit verhoogt de vertaalbaarheid van de bevindingen naar de praktijk en vergroot daarbij de kans op effectieve implementatie. Ook hebben we op deze manier kinderen kunnen werven in klinische centra en lukte het om ons onderzoek uit te voeren bij vaak moeilijk bereikbare kinderen die werden doorverwezen voor hun agressieve gedragsproblemen.

Het onderzoek in dit proefschrift heeft ook zijn beperkingen. Ten eerste werden in de meeste studies alleen jongens onderzocht omdat, waardoor de bevindingen niet kunnen worden gegeneraliseerd naar meisjes. We hebben ervoor gekozen om ons te richten op een relatief homogene steekproef van jongens, omdat agressie bij meisjes in de kindertijd minder vaak voorkomt en de ontwikkeling, vormen en uitkomsten ervan anders kunnen zijn dan bij jongens (Berkout et al., 2011; Fontaine et al., 2009; Underwood, 2002). Toekomstig onderzoek kan nagaan of meisjes met agressieve gedragsproblemen evenveel baat hebben bij interventies die virtual reality gebruiken en zich richten op dezelfde behandelmechanismen. Ten tweede was ons onderzoek naar behandelmechanismen voor agressie bij kinderen wel geschikt om causaliteit van de behandeling vast te stellen, maar niet om causaliteit van de mechanismen vast te stellen. Het is bijvoorbeeld ook mogelijk dat de afgenomen agressie bij kinderen ervoor zorgde dat ze minder ruzie kregen en dus minder vijandige interpretaties maakten. Vervolgonderzoek kan behandelmechanismen experimenteel manipuleren, in bijvoorbeeld een microtrial of een longitudinaal experiment met een controlegroep. Ten derde hebben wij boosheidsregulatie, vijandige intentie attributies en agressie gemeten met vragenlijsten en vignetten. Een nadeel hiervan is dat kinderen met terugwerkende kracht moeten nadenken over hun gedrag of zich een hypothetische sociale gebeurtenis moeten voorstellen. Aangezien vijandige intentie attributies vaak alleen worden geactiveerd wanneer kinderen sterke emoties ervaren (Anderson & Bushman, 2002; Lemerise & Arsenio, 2000a), weerspiegelen de antwoorden van kinderen mogelijk niet hun attributies in het echte leven. Virtual reality als meetinstrument kan hier uitkomst bieden, doordat realistische sociale situaties kunnen worden gesimuleerd en emoties kunnen worden uitgedaagd (Verhoef, van Dijk, et al., 2021). Vervolgonderzoek kan virtual reality inzetten als alternatieve methode om boosheidsregulatie, vijandige attributies en agressie in kaart te brengen (Verhoef, Verhulp, et al., 2021).

RICHTINGEN VOOR VERVOLGONDERZOEK

De bevindingen van dit proefschrift geven nieuwe inzichten in de behandeleffecten van interventies voor agressieve gedragsproblemen bij kinderen, en roepen

tegelijkertijd nieuwe onderzoeksvragen en -richtingen op. Een eerste richting voor vervolgonderzoek kan zijn om de lange termijn effectiviteit van virtual reality in interventies voor kinderen met agressieve gedragsproblemen te onderzoeken. Dit lijkt cruciaal aangezien het uiteindelijke doel van interventies het verminderen van de problemen en risico's van kinderen op de lange termijn is. Ten tweede zou vervolgonderzoek zich kunnen richten op het uitvoeren van replicatiestudies om de zekerheid van de bevindingen van het huidige onderzoek te vergroten (Open Science Collaboration, 2015). Een derde richting voor toekomstig onderzoek zou kunnen zijn om de kosteneffectiviteit van virtual reality in CGT voor kinderen met agressieve gedragsproblemen te onderzoeken. Dit lijkt noodzakelijk, aangezien deze nieuwe technologie gepaard gaat met extra kosten voor apparatuur en licenties om de virtual reality te gebruiken en het trainen van professionals (Lindner, 2021). Anderzijds kan virtual reality mogelijk ook kosten besparen door het verhogen van de behandeleffectiviteit, hogere motivatie, en mogelijk geringere uitval. Ook zouden onderzoekers kunnen bestuderen voor wie interventies met virtual reality het meest of het minst succesvol zijn. Hierbij is het belangrijk om aandacht te vestigen op de minder responsieve kinderen in interventies en te onderzoeken hoe de effectiviteit voor deze subgroep kan worden vergroot. Vervolgonderzoek kan daarnaast voortbouwen op de transdiagnostische benadering in dit proefschrift. Hierbij is het belangrijk is om naar veranderingen *binnen* kinderen te kijken, om op deze manier de volgorde en mogelijke ontwikkelingstrajecten in agressie- en angstproblemen van kinderen te onderzoeken (Granic, 2014).

IMPLICATIES

Dit proefschrift geeft ondersteuning voor interactieve virtual reality als effectieve en haalbare behandelmethode voor kinderen met agressieve gedragsproblemen. Dit opent mogelijkheden om virtual reality te gebruiken en onderzoeken in behandelingen voor kinderen met andere problemen. Bijvoorbeeld door kinderen met een autisme spectrum stoornis sociale vaardigheden te laten oefenen (Ke et al., 2020), kinderen met sociale angst bloot te stellen aan verschillende situaties met leeftijdsgenoten, of kinderen te leren hoe ze zich kunnen gedragen als leeftijdsgenoten gepest worden. In toekomstig virtual reality onderzoek is het belangrijk om na te denken over hoe en waarom de behandeling beter zou worden door virtual reality. Aangezien virtual reality een kostbaar instrument is, moet integratie in interventies gebaseerd zijn op zorgvuldige theoretische en praktische redeneringen. Daarbij is het essentieel om studies met meerdere groepen (multi-armed trials) uit te voeren die virtual reality direct vergelijken met een andere methode, zoals rollenspellen (Lindner, 2021). Hiermee kan de toegevoegde waarde

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van virtual reality ten opzichte van minder kostbare instrumenten vastgesteld worden. Ook is het belangrijk om de kosten en baten van verschillende typen virtual reality af te wegen. Zo biedt interactieve virtual reality een dynamische omgeving die realistische interacties in de virtuele wereld mogelijk maakt, maar daardoor is dit ook een kostbare methode. Dit terwijl bijvoorbeeld 360 graden virtual reality een meer eenvoudige, goedkopere statische video- of foto-omgeving biedt. Dit kan volstaan wanneer alleen blootstelling aan een sociale stimulus vereist is, maar niet geschikt lijkt om kinderen te laten ervaren hoe anderen op hun gedrag reageren. Het is dus belangrijk om de kosten af te wegen tegen de voor- en nadelen van verschillende virtual reality mogelijkheden.

De belangrijkste implicatie voor de klinische praktijk is dat behandelaren de YourSkills interventie kunnen inzetten om agressieve gedragsproblemen van kinderen te behandelen. Beide oefenmethoden kunnen gebruikt worden in de praktijk, doordat ons onderzoek aantoonde dat YourSkills met zowel virtual reality als rollenspellen effectiever was dan standaardzorg. Clinici kunnen voor virtual reality kiezen wanneer de behandelmotivatie van kinderen laag is, of wanneer ze realistischer willen oefenen of sterkere emoties willen oproepen. Wij hopen dat YourSkills breder kan worden toegepast in de klinische praktijk en kan fungeren als voorbeeld van hoe virtual reality effectief kan worden geïntegreerd in interventies voor kinderen.

Daarnaast lieten cijfers uit dit proefschrift zien dat veel kinderen met agressieve gedragsproblemen ook comorbide angstproblemen hadden (42%). Deze hoge comorbiditeit benadrukt de noodzaak om agressie en angst tegelijkertijd te behandelen, wellicht door behandeling te richten op transdiagnostische factoren. Door behandelingen meer af te stemmen op de behoeften en problemen van individuele kinderen (in plaats van op één stoornis), kunnen interventies verkort worden, wat op de lange termijn kosten bespaart (Lucassen et al., 2015). Ook vonden we in dit proefschrift bewijs voor boosheidsregulatie en vijandige intentie attributies als behandelmechanismen voor agressieve gedragsproblemen van kinderen. Clinici kunnen behandelingen focussen op deze elementen, wanneer zij denken dat deze ten grondslag liggen aan de agressieve gedragsproblemen van kinderen (Collins e.a., 2004; Kazdin & Nock, 2003). Clinici kunnen dus nagaan of hun cliënten tekorten vertonen in deze mechanismen, als basis om hun behandelingen op maat te maken.

Ten slotte hebben we een korte wekelijkse vragenlijst ontwikkeld die in de klinische praktijk kan worden gebruikt om boosheidsregulatie, vijandige intentie attributies en agressie van kinderen te meten. Onze wekelijkse metingen bleken bruikbaar op zowel school als in de klinische praktijk. Hierdoor kunnen ze gebruikt

worden om de voortgang van een behandeling eenvoudig te volgen en om de kwaliteit van gezamenlijke besluitvorming te verhogen tijdens de behandeling (Campbell & Hemsley, 2009).

CONCLUSIE

Het huidige proefschrift had als doel om behandeleffecten voor agressieve gedragsproblemen bij kinderen te vergroten en beter te begrijpen. Interactieve virtual reality is een effectieve methode gebleken om de behandeleffecten van een CGT interventie te vergroten. Oefenen in een emotioneel geladen, realistische omgeving levert niet alleen verbeteringen op in de effectiviteit van de behandeling, maar ook meer waardering van kinderen voor de behandeling. Daarbij hebben we ons begrip van behandelmechanismen vergroot door bewijs te leveren voor boosheidsregulatie en vijandige intentie attributie als behandelmechanismen om agressieve gedragsproblemen te verminderen. Wij hopen dat dit proefschrift wetenschappers en behandelaren kan inspireren om virtual reality zorgvuldig te gebruiken en te onderzoeken in interventies om behandeleffecten te vergroten en kinderen te helpen hun vaardigheden te verbeteren.

Een kort promofilmpje zien over YourSkills? Scan de QR code!

Meer lezen over YourSkills? Neem een kijkje op onze website!

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DANKWOORD

" **Wat ik wil gaan doen weet ik nog niet,
maar ik weet wel zeker dat ik niet wil promoveren** "

Sophie Alsem (2016)

Ja **Bram**, mede dankzij jouw aanstekelijke enthousiasme is dat toch even anders gelopen! Vanaf het begin liet je merken dat jij oneindig veel vertrouwen in mij had, waardoor ik me heel vrij en gestimuleerd heb gevoeld. Ik weet dat dat niet vanzelfsprekend is tijdens een promotie en voel me dan ook echt bevoorrecht om samen met jou aan zo'n mooi project te hebben mogen werken. Jouw grenzeloze optimisme is daarbij een grote inspiratie voor mij. Als ik tijdens een meeting met een hele waslijst van dingen kwam die misliepen, kon jij de minst slechte oplossing als een nieuwe nobelprijs uitvinding bejubelen zodat ik toch met een gerust gevoel naar buiten liep. Jij bent daarbij de enige persoon die ik ken die daadwerkelijk kan multitasken door tijdens meetings mails te beantwoorden en ondertussen hele slimme opmerkingen te maken. Ik ben heel blij dat we bij de UvA samen de wereld kunnen veroveren met virtual reality.

Esmée, wat een mijlpaal! Bedankt dat ik je kamer duizend keer mocht binnenvallen met een hele korte vraag (lees: een kletspraatje van minstens een uur). Ik vind het heel bijzonder dat jij altijd met mij kan en wilt meedenken en we heerlijk vaak op één lijn zitten. Jouw fantastische oplossingsgerichtheid was voor mij (en de duur van dit project) echt van onschatbare waarde. Ik waardeer jouw oog voor mijn welzijn enorm, waarbij jij bij elke keuze in het project benadrukte wat de invloed van de verschillende opties op mij zouden zijn (terwijl ik enkel voor de meest efficiënte of optimale oplossing probeerde te gaan). En ons hoogtepunt was denk ik toch echt onze 'congresdag' in Stockholm, ondanks dat het de hele dag regende, jij een doorweekte broek had door een kapotte step en we een uur moesten omlopen omdat er geen trap was ('waarom staan hoge rotswanden niet op google maps?').

Anouk, wat was het fijn om jou als 'mentor' en sparringpartner te hebben. Jij weet de theoretische kant in mij te stimuleren (blijkbaar zit die toch ergens verstopt). Bedankt dat je binnen ons clubje de ondankbare taak van 'maar, wat nou als…' op je hebt genomen. Hoe graag ik jouw positief kritische opmerkingen soms niet wilde horen, hoe nuttig deze eigenlijk altijd waren. En niet te vergeten: jouw ultieme schrijftips en feedback heb ik zo goed geautomatiseerd dat ik zelfs bij het schrijven van mijn dankwoord tekstuele aanpassingen maak omdat ik mezelf hoor denken 'oh nee, hier zou Anouk … zeggen'. Ik weet je te vinden op de UvA!

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* Omcirkel wat van toepassing is gebleken na 17 maart.

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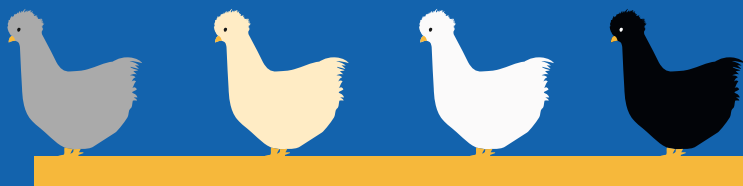
ABOUT THE

AUTHOR
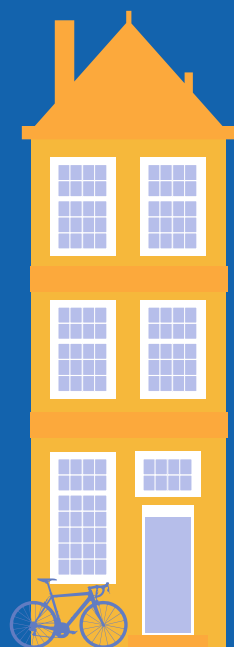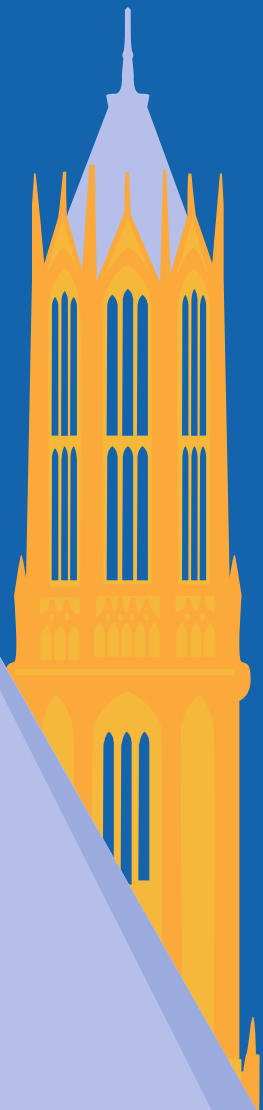
BIOGRAPHY

Sophie Alsem (1991) completed her bachelor's degree in Child and Youth Psychology (2014) with honors at Utrecht University. She continued her studies in Utrecht and obtained two master degrees: Development and Socialization in Childhood and Adolescence (research master, 2016) and Child & Youth Psychology (clinical master, 2017, cum laude). During the clinical master, Sophie completed a ten-month internship at Altrecht Youth Psychiatry and obtained a certificate of psychological assessment (BAPD). Parallel to her studies, Sophie worked as a student-assistant at the department of Developmental Psychology. Here, she also got the chance to start as a junior researcher in her final study year. She worked on the NWO Vici project 'Using virtual reality to understand and treat aggressive behavior problems in children' and co-authored a meta-analysis on hostile intent attribution and aggression in children.

After finishing her studies, Sophie started as PhD candidate on a project investigating the added value of virtual reality in interventions to reduce aggression in children. She collaborated with her supervision team and clinicians to develop a new cognitive behavioral therapy: YourSkills. Together with the technical company CleVR, Sophie created anger-eliciting virtual environments and situations for children to practice newly learned skills. Sophie coordinated a large-scale randomized controlled trial conducted over fifteen clinical centers across the Netherlands to examine the effectiveness of YourSkills.

During her PhD project, Sophie completed courses on cognitive behavioral therapy, Bayesian statistics, and scientific skills. She gained teaching experience by supervising bachelor and master students in writing their thesis, lecturing small-group sessions, and co-tutoring students in the research master. Throughout her PhD, Sophie shared her findings with researchers and clinicians on conferences, such as the World Congress of Cognitive and Behavioural Therapies and the Workshop on Aggression. In the last phase of her PhD, Sophie worked on a one-year post-doc project at Utrecht University, focusing on the effectiveness and implementation of a teacher intervention in special education.

Currently, Sophie combines her research interests with working in clinical practice as a youth psychologist at RIOzorg. At the University of Amsterdam, she continues her research on the use of virtual reality as a post-doctoral researcher, aiming to enhance intervention effects for children. Outside work, Sophie likes to relax by doing sports like ice skating, cycling, and hockey. When at home in Utrecht, she enjoys spending time with her friends, family, boyfriend, and pets.

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AUTHOR'S PUBLICATIONS

Published articles

*Alsem, S. C., van Dijk, A., Verhulp, E. E., & de Castro, B. O. (2020). Using virtual reality to treat aggressive behavior problems in children: A feasibility study. *Clinical Child Psychology and Psychiatry, 26*(4), 1062-1075. http://doi:.org/10.1177/13591045211026160.

Alsem, S. C., Menting, A. T., de Castro, B. O., & Matthys, W. (2021). Follow-up effects in a parent-training trial for mothers being released from incarceration and their children. *Psychology, Public Policy, and Law, 27*(3), 421-431. https://doi.org/10.1037/law0000305

*Alsem, S. C., Keulen, J., Verhulp, E. E., van Dijk, A., & de Castro, B. O. (2022). Capturing mechanisms of change: Weekly covariation in anger regulation, hostile intent attribution, and children's aggression. *Aggressive Behavior, 48*, 232-240. http://doi:.org/ 10.1002/ab.22019.

Verhoef, R. E. J., Alsem, S. C., Verhulp, E. E., & de Castro, B. O. (2019). Hostile intent attribution and aggressive behavior in children revisited: A meta-analysis. *Child Development, 90*(5), 525−547. https://doi.org/10.1111/cdev.13255
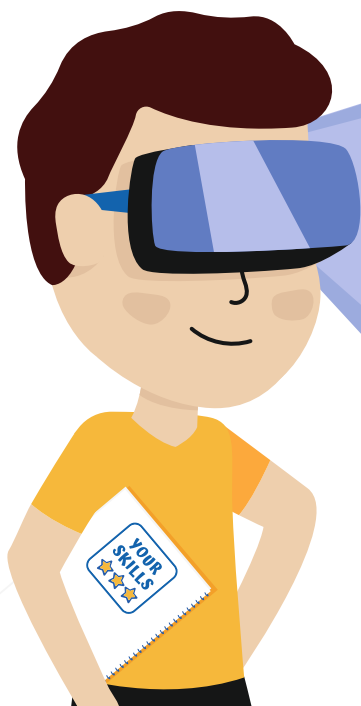
Articles submitted for publication

*Alsem, S. C., van Dijk, A., Verhulp, E. E., Dekkers, T. J., & de Castro, B. O. Treating children's aggressive behavior problems using cognitive behavioral therapy with virtual reality: A multicenter randomized controlled trial. *Revision submitted for publication.*

*Alsem, S. C., Verhulp, E. E., van Dijk, A., & de Castro, B. O. Within intervention change: Anger regulation and hostile intent attribution as mechanisms reducing children's aggressive behavior. *Submitted for publication.*

*Alsem, S. C., van Dijk, A., Verhulp, E. E., & de Castro, B. O. Hostile interpretation as a transdiagnostic factor for cooccurring anxiety in children with aggressive behavior problems. *Revision submitted for publication.*

Alsem, S. C., van den Brink, F., Hoogendijk, C., Tick, N. T. Teacher-student relationship types in children with special educational needs. *Submitted for publication.*

Other manuscripts

Alsem, S. C., van Dijk, A., Verhulp, E. E., & de Castro, B. O. (2019) *YourSkills Handleiding* [YourSkills Treatment Manual]. Universiteit Utrecht.

Tick, N. T., Hoogendijk, C., van den Brink, F., Alsem, S.C., van Veen, A. F. D. (2022). *Key2Teach Handleiding* [Key2Teach Treatment Manual]. Universiteit Utrecht.

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* The manuscripts noted with an asterisk are included in this dissertation.

THE END!