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Regular Article

Detecting social information processing profiles of boys with aggressive behavior problems: An interactive virtual reality approach

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Abstract

Children with aggressive behavior problems may aggress for different reasons, requiring tailored assessment and treatment. The aim of this study was to test whether it is possible to detect distinct social information processing (SIP) profiles among boys with aggressive behavior problems. We therefore conducted Latent Profile Analyses on boys' SIP patterns assessed in interactive virtual reality. Additionally, we examined the discriminant validity of these SIP profiles by comparing them on theoretically relevant child characteristics (i.e., temperament, executive functioning, aggressive belief systems, punishment insensitivity, sensation seeking). We presented boys ($N = 181$; ages 7–13) with a virtual classroom where they could play games with virtual peers. They reported on their SIP in four virtual reality scenarios, designed to assess reactive and proactive aggressive SIP. Results revealed four distinct SIP profiles: a general reactive SIP profile, a situation-specific reactive SIP profile, a mixed reactive-proactive SIP profile, and a nonaggressive SIP profile. Planned contrasts revealed that boys with these SIP profiles differed in temperament, aggressive belief systems, and punishment insensitivity, but not in executive functioning and sensation seeking. Overall, findings suggest that boys differ in the exact SIP patterns underlying their aggressive behavior, providing inroads to tailor interventions to children's individual needs.

Keywords: aggression; children; latent profile analysis; social information processing; virtual reality

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Children may engage in aggressive behavior for very different reasons. Some children may be easily angered, or prone to take revenge when they feel provoked. Other children may carefully plan their aggressive behavior, hoping to benefit instrumentally from it (for reviews, see: De Castro & Van Dijk, 2017; Dodge, 2011). It makes sense, then, to try to identify profiles of children with aggressive behavior problems, based on how they process social information. Yet, detecting distinct social information processing (SIP) profiles of children with aggressive behavior problems is difficult, especially when using conventional SIP assessment methods that ask children how they *would* think or feel in hypothetical situations (e.g., vignette-based measures). These methods may tap aggressive SIP insufficiently as such processing often occurs in vivid, emotionally-laden contexts (Anderson & Bushman, 2002; Lemerise & Arsenio, 2000), thereby underestimating individual differences in SIP patterns between children. In the current study, we therefore assessed children's aggressive SIP using an interactive virtual reality (VR) environment in which children played games with virtual peers – a context that resembles real-world interaction and evokes strong emotions in children (Verhoef, Verhulp, et al., 2021). The primary aim of our study was to distinguish SIP profiles of children with aggressive behavior problems by conducting latent profile analyses (LPA) on their aggressive SIP patterns assessed in interactive VR. Detecting distinct SIP profiles in children with aggressive behavior problems may uncover new possibilities to tailor cognitive-behavior interventions to the needs of individual children.

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Social information processing in children with aggressive behavior problems

The SIP model (Crick & Dodge, 1994) offers a useful framework to try to distinguish SIP profiles in children with aggressive behavior problems. The model postulates that children's aggressive behavior in social situations derives from deviancies in a sequence of SIP steps: (1) encoding of social cues, (2) mental representation of social cues, (3) setting interactional goals, (4) generation of behavior options, (5) evaluation of behavior options, and (6) behavior enactment. Emotional processes are often implicated in each of these SIP steps (Lemerise & Arsenio, 2000). Over the past decades, researchers have gained considerable understanding of the SIP deviancies contributing to children's aggressive behavior, such as encoding social cues in a hostile manner, making hostile intent attributions, setting interactional goals directed at revenge or instrumental gain, generating more aggressive responses, and evaluating aggressive responses and their

outcomes more positively (for reviews, see: De Castro & Van Dijk, 2017; Dodge, 2011; Verhoef et al., 2019). However, exactly which SIP steps are implicated in aggressive behavior may differ markedly between children. In the present study, we examined whether clusters of children with distinct SIP patterns can be discerned.

One relevant dimension to distinguish SIP profiles of children with aggressive behavior problems may be the well-known distinction between reactive and proactive aggression (e.g., Dodge, 1991; Hubbard et al., 2010; Kempes et al., 2005). Reactive aggression refers to hot-blooded, defensive, uncontrolled aggressive behavior triggered by perceived threat, provocation, or frustration. Proactive aggression, in contrast, refers to cold-blooded, offensive, controlled aggressive behavior driven by a desired goal such as acquiring material gain or social dominance. Children may differ in which type of aggression they display most. Research typically has identified predominantly reactive subgroups and mixed reactive-proactive subgroups of children, and sometimes also a predominantly proactive subgroup (Carroll et al., 2018; Euler et al., 2017; Marsee et al., 2014; Muñoz et al., 2008; Smeets et al., 2017; Thomson & Centifanti, 2018; Van Dijk et al., 2021). Although the evidence for a proactive subgroup is not conclusive, a recent study using a questionnaire with improved ability to discriminate between reactive and proactive motives did support the existence of such a group (Van Dijk et al., 2021), suggesting its relevance for further exploration. Moreover, scholars have suggested that children displaying predominantly reactive versus proactive aggression may show deviancies in different SIP steps (for reviews, see: De Castro & Van Dijk, 2017; Hubbard et al., 2010; Merk et al., 2005; Vitaro et al., 2006). That is, reactively aggressive children may experience anger, attribute hostile intent, and set revenge goals. In contrast, proactively aggressive children may set instrumental goals, expect positive outcomes of their aggressive behavior, and evaluate the use of aggression positively.

The empirical evidence thus far for distinct SIP profiles, however, is not conclusive. First, only a part of the available studies has found that children's SIP steps are associated differentially with reactive versus proactive aggressive behavior, suggesting that it may be possible to detect distinct SIP profiles of children with aggressive behavior problems based on their reactive and proactive SIP patterns (e.g., Arsenio et al., 2009; De Castro et al., 2005; Dodge et al., 1997; Hubbard et al., 2001). Yet other studies did not replicate such findings (e.g., Crick & Dodge, 1996; Dodge et al., 1997; Oostermeijer et al., 2016; Stoltz et al., 2013). These inconsistencies may have occurred because previous studies used conventional vignette-based measures, which do not tap into vivid, emotionally-laden SIP, and may therefore be limited in their ability to detect individual differences in children's aggressive SIP (Verhoef et al., 2019). Second, to our knowledge, all previous SIP research used a variable-based approach, studying associations between SIP variables instead of clustering children into distinct groups based on their SIP patterns. Hence, even if our understanding of the SIP deviancies that underlie children's aggression is substantial, we do not yet know whether children with aggressive behavior problems cluster systematically in terms of their SIP characteristics. Thus, research is needed that uses (1) emotional, engaged interactions to assess substantial variance in SIP and (2) person-based analytical methods to cluster this variance within children.

A person-based interactive VR approach to detect distinct SIP profiles

To address these issues, we used a person-based analytical approach to examine children's SIP patterns in the context of emotionally engaging interactive VR. Interactive VR allows the assessment of SIP in a vivid, emotionally arousing context – a context in which individual differences in aggressive SIP tend to become salient (Anderson & Bushman, 2002; Lemerise & Arsenio, 2000). Indeed, a meta-analysis showed that children's aggressive behavior is better predicted by SIP assessed in actual social interactions, as compared to hypothetical social interactions described in vignettes (Verhoef et al., 2019). Interactive VR provides a context in which children are immersed in actual social interactions with virtual peers – but then in a standardized manner, allowing for more accurate assessment of individual differences in children's aggressive SIP.

Another advantage of interactive VR is that it allows for creating distinct, theoretically relevant contexts of interaction. For example, to assess reactive SIP, children can be presented with provocation contexts that may elicit anger or frustration (e.g., being excluded from a game, or being hindered by a peer; Hubbard et al., 2010). To assess proactive SIP, children can be presented with instrumental gain contexts that may elicit envy and desire (e.g., competing against a peer, or having an opportunity to steal; Hubbard et al., 2010). In interactive VR, children actually enact these scenarios, making it likely that both provocation and instrumental gain contexts can be truly engaging for children. We thus expected that interactive VR would enable us to detect distinct reactive and proactive SIP profiles. Based on the literature, we hypothesized four SIP profiles: a reactive SIP profile, a proactive SIP, a mixed reactive-proactive SIP profile, and a nonaggressive SIP profile (see Table 1 for our hypotheses on specific SIP patterns within each SIP profile).

Table 1. Hypothesized scores on SIP variables for boys in each SIP profile

	SIP profile			
SIP variables	Reactive	Proactive	Mixed	Nonaggressive
Anger	High	Low	High	Low
Hostile intent attributions	High	Low	High	Low
Revenge goals	High	Low	High	Low
Instrumental goals	Low	High	High	Low
Positive outcomes of aggression	Low	High	High	Low
Positive evaluations of aggression	Low	High	High	Low
Aggressive responding	High	High	High	Low

Discriminant validity of SIP profiles

A secondary aim of this study was to provide further validation for distinct SIP profiles in children with aggressive behavior problems. We therefore examined whether children with different SIP profiles differed on (1) teachers' impressions of children's reactive and proactive aggression, and (2) theoretically relevant child characteristics (i.e., temperament, executive functioning, aggressive belief systems, punishment insensitivity, and sensation seeking; De Castro & Van Dijk, 2017; Dodge & Pettit, 2003; Frick & Morris, 2004; Hubbard et al., 2010; Merk et al., 2005; Verhoef et al., 2022). We expected each SIP profile to stand out on unique characteristics.

Children with a reactive SIP profile may be characterized by a highly emotionally reactive temperament, which predisposes them

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Table 2. Theoretically relevant child characteristics that boys in the reactive, mixed, and proactive SIP profiles are expected to stand out for

	Reactive & mixed SIP profile	Proactive & mixed SIP profile
Teachers' impression	Reactive motives	Proactive motives
Child characteristics	Anger-frustration temperament	Callous & unemotional traits
	Hostile beliefs	Justification of violence beliefs
	Working memory deficits	Sensation seeking
	Inhibition deficits	Punishment insensitivity

Note. We used planned contrasts to test if scores were higher for the two expected profiles (e.g., reactive and mixed) versus the other two profiles (e.g., proactive and nonaggressive).

to experience excessive anger or frustration in social interactions (for reviews, see: Bookhout et al., 2018; Moore et al., 2018). Moreover, these children may be prone to attribute hostile intent, which may stem from hostile memory structures and limited working memory capacities impeding their accurate processing of social events (for reviews, see: De Castro & Van Dijk, 2017; Dodge, 2006; Verhoef et al., 2022). Last, these children's tendency to promptly seek revenge may be rooted in inhibition deficits (Ellis et al., 2009; Thomson & Centifanti, 2018).

In contrast, children with a proactive SIP profile may be characterized by callous and unemotional (CU) traits. These traits may predispose them to value aggression as a useful strategy to obtain instrumental gain (for reviews, see: 2014b, Frick et al., 2014a; Frick & Morris, 2004). Moreover, these children may be prone to pursue instrumental goals and hold positive outcome expectancies of aggressive behavior, stemming from a moral belief system that justifies the use of aggression (Calvete & Orue, 2010; Zelli et al., 1999). Last, these children's positive expectations and evaluations of aggression may be rooted in their sensation seeking tendencies and insensitivity to punishment. They seek for thrills (for a review, see: Matthys et al., 2013), and are relatively unaffected by negative consequences of their behavior (for a review, see: Branje & Koot, 2018).

Last, as this would be the first study to identify a subgroup of children with a mixed reactive-proactive SIP profile, we chose the most straightforward hypothesis: that they would display characteristics of both groups. For children with a nonaggressive SIP profile, we expected that they would share none of these characteristics (see Table 2 for an overview of the expected differences between SIP profiles).

The present study

Our study goals were to (1) detect distinct SIP profiles underlying children's aggressive behavior, and (2) validate these profiles against teachers' impressions and theoretically relevant child characteristics. We used interactive VR to assess emotionally-engaged SIP, presenting participants with an interactive VR classroom where they played games with virtual peers. To assess participants' reactive and proactive SIP patterns, we presented them with both provocation and instrumental gain contexts. To validate the obtained SIP profiles, we asked teachers to rate participants' reactive and proactive aggression at school, parents to rate their children's temperament, and children themselves to complete questionnaires and tasks assessing their traits, beliefs, and executive functioning. Our study included only boys for pragmatic reasons (i.e., the development of VR scenarios is quite costly, and assessing aggressive SIP in girls would have required us to develop additional VR scenarios relevant for girls' aggression; Ostrov & Godleski, 2010). We expected to find four distinct SIP profiles of boys with aggressive behavior problems (i.e., reactive, proactive, mixed, and nonaggressive; Table 1), differing on teachers' impressions and theoretically relevant child characteristics (Table 2).

Method

Participants

Participants were $N = 181$ boys ages 7–13 ($M = 10.23$; $SD = 1.27$), recruited from 18 Dutch primary schools. Schools were from neighborhoods representative of the Dutch population, with on average mostly native Dutch middle class inhabitants, and a minority of inhabitants with a migration background (Western: 8.6%, $SD = 2.5\%$; non-Western: 13.1%, $SD = 9.5\%$), a lower educational level (20.8%, $SD = 4.2\%$), or a low income (7.5% of households, $SD = 3.06\%$) (Statistics Netherlands, 2018, 2019). To maximize variance in aggressive behavior, we included boys from special education for children with disruptive behavior problems ($n = 115$ boys), in addition to boys randomly selected from regular education ($n = 66$ boys). In the Netherlands, special education for children with disruptive behavior problems and/or psychiatric problems is offered to children whose problems are so severe that they require extra support. Our study included boys from special education who were nominated by their teachers for frequently showing aggressive behavior problems. Boys were excluded if they had an IQ below 80 or an autism spectrum disorder according to their casefiles, or showed autism spectrum disorder symptomatology within the clinical range on the Social Emotional Questionnaire, which teachers filled out for all participants (Scholte & Van der Ploeg, 2007). Parents gave their written informed consent, boys themselves gave verbal assent. The study was conducted in accordance with the 2013 Helsinki Declaration and approved by the Medical Ethics Committee of University Medical Center Utrecht.

Procedure

Participants were tested individually in a silent room at their school by trained research assistants (i.e., undergraduate psychology students) or the first author. We tested participants in two 45-min sessions, spaced about a week apart. Boys completed questionnaires and executive functioning tasks on a computer tablet in Session 1, and the VR-based SIP assessment in Session 2. Parents (95.0%) and teachers (98.3%) completed the questionnaires online, in their own time.

Interactive virtual reality environment to assess aggressive SIP

Setting

The VR environment was built as a virtual school classroom. Participants could walk around freely, talk with virtual peers, and play games in the virtual classroom setting (see: Verhoef, Van Dijk, et al., 2021). Participants played two games: (1) building a block tower, and (2) throwing cans from a table with a ball. We chose games to enhance emotional engagement, and augmented these games with high scores and bonuses to have experimental control over gain and losses. The games were created to allow participants to engage in aggression directed at the virtual peer (e.g.,

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hitting, name calling) or the peer's property (e.g., knocking over the peer's tower). We provided the instructions, game rules, and score count within the VR, using a voice-over and a digital whiteboard. Before entering the VR environment, the experimenter explained participants that they would enter a classroom where specific behavior rules applied (i.e., be friendly to other children, have respect for others). We also told them that they would interact and play games in the VR environment with actual boys from other schools who simultaneously took part in the study. In reality, the experimenter controlled the virtual peers by activating default movements and standardized verbal responses.

VR scenarios

Participants were presented with six VR scenarios in fixed order: (1) practice scenario, (2) neutral scenario, (3) object acquisition scenario, (4) competition scenario, (5) social provocation scenario, and (6) object provocation scenario. The practice scenario allowed participants to familiarize themselves with the VR environment, practice the games, and learn the classroom rules. The neutral scenario consisted of a brief interaction with an avatar, and was included to familiarize boys with answering our SIP questions. The next two scenarios (i.e., object acquisition, competition) covered the instrumental gain context. In the object acquisition scenario, participants could choose to steal a block or ball from the virtual peer, which would earn them additional points. In the competition scenario, participants could win the game by engaging in unfair play (i.e., setting back the virtual peer's score). The last two scenarios (i.e., social and object provocation) covered the provocation context. In the social provocation scenario, participants were refused to join a game by two virtual peers. In the object provocation scenario, the game of the participant was ruined by a virtual peer (e.g., participants' tower was knocked over by a peer). We presented the provocation scenarios last because we anticipated that these could elicit relatively strong emotion, potentially leading to carry-over effects if they would be presented first. Participants completed all six scenarios for the same game (i.e., tower or cans). Games were assigned randomly to participants.

SIP assessment using interactive VR

At the end of each VR scenario, we assessed participants' anger, intent attributions, goals, outcome expectancies, evaluations of behavior, and behavioral responses. Because we wanted to keep the total number of questions limited, we decided to use single questions for most SIP variables. We derived these questions from the literature to cover both reactive SIP (i.e., anger, hostile intent attribution, revenge goals) and proactive SIP (i.e., instrumental goals, outcome expectancies and evaluations of aggression; De Castro et al., 2005, 2012; Verhoef et al., 2019). We used open-ended questions to assess participants' spontaneous goals and outcome expectancies of their actual behavior in VR, without prompting them with response options. We emphasized that there were no wrong answers and that all responses would remain confidential. We analyzed participants' SIP for each scenario separately, and so we did not calculate aggregate scores (as is often done in vignette-based SIP research; Crick & Dodge, 1996; De Castro et al., 2005; Verhoef et al., 2019).

Anger. We assessed anger using a single item: "The other boy did [behavior other boy]. How angry did this make you feel on a scale from 1-10 (*not at all-very)*?"

Hostile intent attribution. We assessed intent attribution using two items: "The other boy did [behavior other boy]. To what extent was he trying to be mean, on a scale from 1-10 (*not at all-very*)?" and "To what extent was he trying to hinder you, on a scale from 1-10 (*not at all-very*)?" Within each VR scenario, the two items were highly correlated ($M = .83$, $Mdn = .87$, range = .67–.90). We averaged the items to create a single hostile intent attribution score for each VR scenario.

Goals. We assessed goals using a single open-ended question following each VR scenario: "When the other boy did [behavior other boy], you did [behavior participant]. What was the reason you did this?" Following existing guidelines (De Castro et al., 2012), we coded answers as *revenge-anger goals* (e.g., "because I was angry," "to retaliate," "to defend myself"), *instrumental goals* (e.g., "to win the game," "to show him who's boss"), *goals underlying nonaggressive behavior* (e.g., "to become friends," "to avoid problems"), or *no goals* (e.g., "I don't know," "I had no goal"). To test the inter-rater reliability of the scoring system, 35.4% of transcriptions were coded by a second rater. Inter-rater reliability was excellent, with κ ranging from .85 to .96 ($M = .91$, $Mdn = .91$). Scores for revenge-anger goals were created by assigning 1 to *revenge-anger* codes and 0 to other codes. Similarly, scores for instrumental goals were created by assigning 1 to *instrumental* codes and 0 to other codes.

Behavioral responses. We assessed behavioral responses in VR by observing participants' behavior in each VR scenario. We coded behavior afterwards using a well-established procedure (De Castro et al., 2005). We coded responses as *nonaggressive behavior* (e.g., prosocial, solution-focused, avoidance), *mild aggressive behavior* (e.g., coercion, verbal aggression), or *severe aggressive behavior* (e.g., physical aggression, destructive aggression). To test the inter-rater reliability of the scoring system, 35.4% of transcriptions were coded by a second rater. Inter-rater reliability was excellent, with κ ranging from .92 to 1.00 ($M = .97$, $Mdn = .98$). Because frequencies of *mild aggressive behavior* were low or even absent in all scenarios (i.e., 0.0 to 2.2%, $Mdn = 0.6\%$), we created a dichotomous variable for aggressive responding by scoring *mild* and *severe aggressive behavior* as 1 and *nonaggressive behavior* as 0.

Outcome expectancies. We assessed outcome expectancies for aggression with a single item: "What did you expect would happen when you [behavior participant]?" Each answer was coded as: *positive instrumental outcomes of aggression* (e.g., "I would win the game") or *no positive instrumental outcomes of aggression* (e.g., "I would not receive bonus points"). To test the inter-rater reliability of the scoring system, 35.4% of transcriptions were coded by a second rater. Inter-rater reliability was excellent, with κ being 1.00. Scores for each outcome were created by assigning 1 to the specific outcome and 0 to other codes. Because we were interested in participants' outcome expectancies of *aggression*, we coded data of participants who displayed no aggression as missing.

Response evaluations. We assessed positive evaluations of aggression using a single item: "When the other boy did [behavior other boy], you did [behavior participant]. To what extent do you approve your own behavior on a scale from 1-10 (*not at all-very)*?" Again, we coded data of participants who displayed no aggression as missing.

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Measures used for validation purposes

Questionnaires

Teachers' impressions of reactive and proactive motives. We used the Instrument for Reactive and Proactive Aggression to assess teachers' impressions of boys' reactive and proactive motives (Polman et al., 2009). Teachers rated the frequency of seven distinct forms of aggressive behavior (i.e., kicking, pushing, hitting, name calling, arguing, gossiping, and doing sneaky things) in the previous month on a 5-point Likert scale (0 = *never,* 1 = *once,* 2 = *weekly,* 3 = *multiple times a week,* 4 = *daily*). For aggression items rated above 0, teachers rated 6 items about the motives underlying boys' aggression on a 5-point Likert scale (0 = *never,* 1 = *rarely,* 2 = *sometimes,* 3 = *often,* 4 = *always*). For aggression frequency items rated 0, motives scores were missing by design. Three items described reactive motives (e.g., "because someone teased or upset him/her") and three items described proactive motives (e.g., "to hurt someone or to be mean"). We calculated reactive and proactive motive scores by averaging across all reactive motive items (i.e., three items for seven forms of aggression; $\alpha = .81$) and all proactive motive items ($\alpha = .83$). Thus, high scores for reactive or proactive motive indicated that *if* children engaged in aggressive behavior, they often had reactive or proactive motives. The correlation between reactive and proactive motives was nonsignificant ($r = .12$, $p = .146$).

Anger-frustration temperament. We assessed anger-frustration temperament using the Dutch translation of the Anger-Frustration subscale of the Temperament for Middle Childhood Questionnaire (Simonds & Rothbart, 2004). Parents rated the extent to which seven items applied to their child on a five-point Likert scale from 1 (*almost never true for my child*) to 5 (*almost always true for my child*), with "*does not apply*" as an additional option. A sample item is: "Has anger outbursts when he/she does not get what he/she wants." We calculated anger-frustration temperament scores as the average across items ($\alpha = .84$).

Hostile beliefs. To assess hostile beliefs, we used 10 items derived from the Hostility subscale of the Child Automatic Thoughts Scale (Schniering & Rapee, 2002) and the Mistrust/Abuse subscale of the Schema Inventory for Children (Rijkeboer & de Boo, 2010). Boys rated these items on a five-point Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*). A sample item is: "You can never trust someone." We calculated hostile belief scores as the average across items ($\alpha = .85$).

CU traits. We assessed CU traits with the Callous & Unemotional Subscale of the Youth Psychopathic Inventory Child Version (Van Baardewijk et al., 2010). Boys rated 15 items on a four-point Likert scale from 1 (*does not apply at all*) to 5 (*applies very well*). A sample item is: "When I have hurt other people's feelings, it doesn't really bother me." We calculated CU trait scores as the average across items ($\alpha = .78$).

Justification of violence. We assessed justification of violence with 14 items derived from the How I Think Scale (Nas et al., 2008) and The Irrational Beliefs Scale for Adolescents (Cardeñoso & Calvete, 2004). Boys rated these items on a five-point Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*). A sample item is: "Sometimes you need to hurt or threaten someone to get what you want." We calculated justification of violence scores as the average across items ($\alpha = .91$).

Sensation seeking. We assessed sensation seeking using the Brief Sensation Seeking Scale (Dekkers et al., 2018). Boys rated 14 items on a five-point Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*). A sample item is: "If someone dares me to do something, I will do it." We calculated sensation seeking scores as the average across items ($\alpha = .66$).

Executive functioning tasks

Executive functioning tasks were presented in a game-based format on a tablet computer. The tasks were developed to be appealing for children (Van Rest et al., 2019).

Working memory deficits. We assessed visual working memory using a task based on the Klingberg principles for working memory (Klingberg et al., 2005; Klingberg, 2010). The task assesses boys' capacity to temporarily store and manipulate patterns of visual stimuli. The task consists of sequential trials in which participants are asked to replicate a visual pattern presented as a monkey or crocodile moving on a 4 × 4 check-like board. Participants listened to an instruction and conducted a sequence of four practice trials, before starting the test trials. These trials started easy (i.e., only two attached spaces) and increased stepwise in length (i.e., more spaces) and visual difficulty (i.e., detached spaces further apart). The monkey was presented for 1000 ms and disappeared for 750 ms before appearing in another space. Participants were asked to replicate the monkey's movement pattern immediately after the monkey stopped moving. The test trials ended if boys had two consecutive incorrect responses on trials with the same length and difficulty level. Boys completed 12 trials, on average (range: 1–21). Next, boys took part in another round of trials, but this time they were asked to replicate the movement pattern of a crocodile in reversed order (i.e., starting with the last step of the crocodile, ending with the first step). Boys completed nine of these trials, on average (range: 0–21). The number of correct trials was reverse-scored for each child so that higher scores represented more working memory deficits. We standardized and averaged scores on the backward and forward trials ($r = .54$) to create a single working memory deficits score.

Inhibition deficits. We assessed response inhibition using a task based on the Go/No-go principle (Nigg, 1999). The task assesses children's ability to inhibit action tendencies, asking them to press a button as fast as they can when a stimulus is presented on screen. The task consists of two phases that each include an instruction and a sequence of practice trials. In the first (i.e., learning) phase, participants were asked to press an apple-shaped button as fast as they could when an elephant appeared on the screen. Participants were presented 52 trials where an elephant appeared on screen for a maximum of 800 ms, until they responded. Each trial started with a fixation symbol that was presented for 1000 ms before the elephant emerged. Participants were instructed to not press the button during the presentation of the fixation symbol, but only when the elephant appeared on screen, requiring them to inhibit their response. The duration between each trial was 1000 ms. In the second (i.e., inhibition) phase, participants were again presented with 52 trials and instructed to respond as fast as they could when the elephant appeared on the screen. However, this time, they were instructed not to respond when the elephant was presented with a red cross through it. There were 39 trials including the elephant without a red cross (i.e., Go-trials) and 13 trials including the elephant with a red cross (i.e., No-go trials). Again, elephants (with or without the red cross) were presented on screen for 800 ms,

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preceded by the fixation symbol. Presentation order of Go and No-go trials was fixed. We used the number of premature responses in the first (i.e., learning) phase and second (i.e., inhibition) phase, as well as the number of incorrect responses (i.e., pressing the button while the elephant was presented with a red cross through it) the second phase, as indicators of participants' inhibition abilities. These three scores were standardized and averaged (r ranging from .48 to .49) to create a single inhibition deficits score.

Punishment insensitivity. We assessed punishment insensitivity using a door-opening task used in previous studies (e.g., Matthys et al., 1998, Matthys et al., 2004), which is based on the card-playing task (Newman et al., 1987). Participants were asked to open doors by pressing a button. With each door, participants could earn or lose 10 cents. Participants started with 0 cents and the task included 110 trials. The probability of winning decreased gradually by 10% with each 10 trials (i.e., from 100% in trials 1–10 to 0% in trials 100–110). Participants were instructed to win as much money as they could and were told they could stop playing at each trial by pressing a stop button. The order of winning and losing doors was fixed across participants. We used the elapsed time between a losing door and opening a next as indicator of participant's punishment insensitivity. We standardized and reverse-scored children's scores so that higher scores indicated more punishment insensitivity.

Statistical analysis

Our primary aim was to detect SIP profiles of boys with aggressive behavior problems. Before we conducted our main analyses, we inspected multicollinearity between SIP variables. We found high correlations of aggressive responding with instrumental goals in the object acquisition (Pearson's $\pi = .98$) and competition scenario (Pearson's $\pi = .91$), and with revenge goals in the social provocation (Pearson's $\pi = .80$) and object provocation scenario (Pearson's $\pi = .86$). Thus, almost all children who responded aggressively, also pursued instrumental goals (in the object acquisition and competition scenario) or revenge goals (in the social and object provocation scenario). To avoid multicollinearity, we excluded the aggressive responding variables, and kept the revenge and instrumental goal variables in our analyses to discriminate between reactive and proactive SIP.

Next, we conducted LPA using Mplus (version 8.5). We included proactive SIP variables assessed in instrumental scenarios (i.e., instrumental goals, outcome expectancies, and response evaluation), and reactive SIP variables assessed in provocation scenarios (i.e., anger, hostile intent attribution, and revenge goals).[1] We first tested a single-profile model, and increased the number of profiles until the model no longer improved in terms of model fit, interpretability, and parsimony (McCutcheon, 2002). Regarding model fit, we aimed to select the model with the lowest Akaike information criterion, Bayesian information criterion, and sample size adjusted Bayesian information criterion; sufficient entropy (i.e., entropy >.80); a significant Vuong-Lo-Mendell-Rubin likelihood ratio test (VLMR; Lo et al., 2001) and bootstrapped likelihood ratio test (BLRT; McLachlan & Peel, 2000); and a sufficient number of observations in each profile (i.e., more than the number of parameters estimated).

[1]We began running the LPA with reactive and proactive SIP variables assessed in both provocation and instrumental gain scenarios, but this model would not identify because it included too many parameters given the study sample size.

We described how boys from the obtained SIP profiles differed in terms of their SIP using five labels (i.e., very high, high, moderate, low, and very low). We applied these labels by dividing the scale of continuous SIP variables (i.e., 1–10) and item probabilities of dichotomous SIP variables (i.e., 0–1) by 5. Although arbitrary, these labels may help interpret differences between the SIP profiles in terms of aggressive SIP.

Our secondary aim was to validate the obtained SIP profiles, using boys' most likely profile membership as independent variable. First, we compared the SIP profiles of the best-fitting model on teachers' impressions of boys' reactive and proactive motives for aggression. Second, we compared the SIP profiles of the best-fitting model on theoretically relevant child characteristics. We conducted planned contrasts to test our a priori hypotheses (Table 2). In addition, if we found that the ANOVA of SIP profile membership on a variable was significant, we explored all possible contrasts. Given the non-normal distribution of our variables, we conducted these analyses using bootstrapped bias-corrected accelerated (BCa) 95% confidence intervals based on 5000 resamples. We used pairwise deletion to deal with missing data (4.2% of which 2.3% missing by design on the Instrument for Reactive and Proactive Aggression).

Results

Descriptive statistics

Interactive VR evoked aggressive responses in 38.3%–58.3% of boys for the provocation scenarios, but only in 23.2%–23.8% of boys for the instrumental gain scenarios (see Table S1 in the supplementary materials for descriptive statistics of SIP variables for each VR scenario separately). This frequency of aggression was lower than anticipated, and implied substantial missing data for those SIP variables that could only be assessed in the context of an aggressive response (i.e., positive outcome expectancies and positive evaluations of aggression). Accordingly, we excluded these variables from the LPA, and report descriptive statistics of these variables in the supplementary materials (Table S2).

Distinct SIP profiles of boys with aggressive behavior problems

Table 3 shows the fit indices for the Latent Profile analyses. We selected the 4-profile model as the best-fitting model. This model showed a better fit than the 3-profile model according to all three information criteria, entropy, and BLRT, although not according to VLMR, which was (marginally) nonsignificant. Although the 5-profile model fitted slightly better than the 4-profile model according to Akaike information criterion and adjusted Bayesian information criterion, entropy, and BLRT, it added little conceptually. That is, it showed a similar pattern as the 4-profile solution, with two profiles only slightly differing in mean scores and item probabilities of SIP variables. Thus, the 4-profile model provided a more parsimonious, and well-fitting solution.

Figure 1 shows a visual representation of the four SIP profiles based on their reactive and proactive SIP patterns per scenario (for descriptive statistics, see Table S2 in the supplementary materials). As predicted, we found evidence for a reactive SIP profile, mixed reactive-proactive SIP profile, and a nonaggressive SIP profile. Contrary to our predictions, we did not find a proactive SIP profile, and detected an additional situation-specific profile.

As expected, we found one "general reactive SIP" profile of $n = 47$ boys (26.0%), characterized by reactive SIP in both

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Table 3. Fit indices for the LPA models

	Akaike information criterion	Bayesian information criterion	Adjusted Bayesian information criterion	Entropy	VLMR *p*	BLRT *p*	*n* of smallest profile
1-profile model	4420.289	4458.671	4420.666				181
2-profile model	4137.596	4204.764	4138.256	0.866	<0.001	<0.001	67
3-profile model	4084.447	4180.402	4085.390	0.808	0.182	<0.001	48
4-profile model	4045.023	4169.764	4046.249	0.823	0.080	<0.001	27
5-profile model	4031.748	4185.276	4033.257	0.835	0.524	<0.001	21
6-profile model[a]	4012.371	4194.686	4014.163	0.863	0.148	<0.001	6

[a]The 6-profile solution yielded profiles that were too small ($n = 6$) given the number of free parameters to be estimated ($q = 12$).

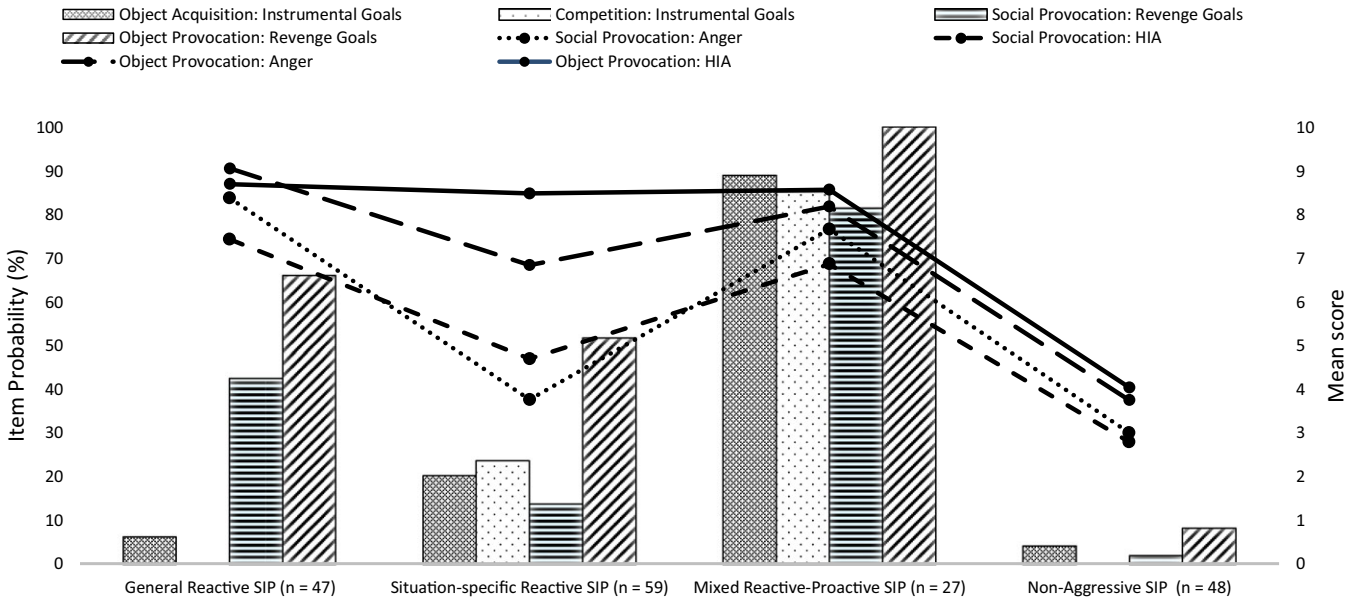

Figure 1. Latent SIP profiles based on boys' reactive and proactive SIP in each virtual reality scenario.
Note. Bars refer to dichotomous SIP variables (i.e., instrumental goals, revenge goals) and correspond with item probabilities (%) displayed on the left vertical axis; lines refer to continuous SIP variables (i.e., anger, hostile intent attributions) and correspond mean scores displayed on the right vertical axis.

provocation scenarios. Boys with this profile showed very high levels of anger ($M = 8.38$, $SD = 1.48$; $M = 9.06$, $SD = 1.51$), high levels of hostile intent attributions ($M = 7.43$, $SD = 2.63$; $M = 8.70$, $SD = 1.88$), and a moderate-to-high probability of displaying revenge goals ($\rho = .426$; $\rho = .660$) in the social provocation and object provocation scenario, respectively. Moreover, these boys showed very low-to-zero probabilities of displaying instrumental goals in the object acquisition ($\rho = .064$) and competition scenario ($\rho < .001$).

Unexpectedly, we found a second reactive SIP profile of $n = 59$ boys (32.6%) who displayed reactive SIP only in the object provocation scenario. We refer to this group as the "situation-specific reactive SIP" profile. Boys with this profile showed high levels of anger ($M = 6.84$, $SD = 2.20$), very high levels of hostile intent attributions ($M = 8.49$, $SD = 1.46$), and a moderate probability of displaying revenge goals in the object provocation scenario ($\rho = .517$). They showed low levels of anger ($M = 3.76$, $SD = 1.64$), moderate levels of hostile intent attributions ($M = 4.70$, $SD = 2.49$) and a very low probability of displaying revenge goals ($\rho = .138$) in the social provocation scenario, as well as low probabilities of displaying instrumental goals in the object acquisition ($\rho = .203$) and competition scenario ($\rho = .237$).

We also found the predicted "mixed reactive-proactive SIP" profile, consisting of $n = 27$ boys (14.9%) displaying reactive SIP in both provocation scenarios and proactive SIP in both instrumental gain scenarios. Boys with this profile showed high levels of anger ($M = 7.67$, $SD = 2.08$) and hostile intent attributions ($M = 6.87$, $SD = 3.08$), and a very high probability of displaying revenge goals in the social provocation scenario ($\rho = .815$). Moreover, they showed very high levels of anger ($M = 8.19$, $SD = 2.19$) and hostile intent attributions ($M = 8.57$, $SD = 2.62$), and a very high probability of displaying revenge goals ($\rho = 1.00$) in the object provocation scenario, as well as very high probabilities of displaying instrumental goals in the object acquisition ($\rho = .889$) and competition scenario ($\rho = .852$).

The remaining 26.5% of boys ($n = 48$) showed a "nonaggressive SIP" profile, characterized by nonaggressive SIP in all scenarios. Boys with this profile showed low levels anger ($M = 3.00$, $SD = 1.62$; $M = 3.75$, $SD = 1.55$), very low-to-low levels of hostile intent attributions ($M = 2.79$, $SD = 1.86$; $M = 4.04$, $SD = 2.02$),

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and a very low probability of displaying revenge goals ($\rho = .021$; $\rho = .083$) in the social and object provocation scenario, respectively. They also showed very low-to-zero probabilities of displaying instrumental goals in the object acquisition ($\rho = .042$) and competition scenario ($\rho < .001$).

Taken together, the 4-profile solution indicated distinct profiles of reactive SIP (i.e., general and situation-specific), mixed reactive-proactive SIP, and nonaggressive SIP. We hypothesized but did not find a proactive SIP profile. We explored the data for children who displayed instrumental goals but no revenge goals, and found only 6 boys who potentially could fit this profile – a group too small to be detected by LPA.

Discriminant validity of SIP profiles

Next, to validate the obtained SIP profiles, we compared them on (1) teacher's impression of boys' reactive and proactive motives for aggression and (2) theoretically relevant child characteristics. Table 4 shows descriptive statistics of the four SIP profiles on these variables and bootstrap 95% confidence intervals of the mean difference between SIP profiles of the planned contrasts, based on 5000 resamples. Bivariate correlations between these variables are reported in the supplementary materials (see Table S3).

Teacher-reported reactive and proactive motives for boys' aggression

Planned contrasts revealed that boys with a mixed reactive-proactive SIP profile showed more reactive motives for their teacher-reported aggression than those with a nonaggressive profile ($d = 0.60$) and more proactive motives than boys with a general reactive SIP profile ($d = 0.70$), situation-specific SIP profile ($d = 0.53$) and nonaggressive SIP profile ($d = 0.75$). However, we found no significant differences in reactive motives between the reactive versus nonaggressive profiles.

Theoretically relevant child characteristics

Planned contrasts yielded partial support for the distinctiveness of the reactive SIP profiles. Boys with a general reactive SIP profile displayed higher levels of anger-frustration temperament ($d = 0.68$) and hostile beliefs ($d = 0.73$) than boys with a nonaggressive SIP profile. Boys with a situation-specific reactive SIP profile reported more hostile beliefs ($d = 0.40$), but not more anger-frustration temperament, than those with a nonaggressive SIP profile. We found no significant differences in working memory and inhibition deficits between the reactive versus other SIP profiles.

We also found partial support for the distinctiveness of the mixed reactive-proactive SIP profile. Boys with this profile showed higher levels of hostile beliefs ($d = 0.65$), CU traits ($d = 0.54$), and justification of violence beliefs ($d = 0.91$) than those with a nonaggressive SIP profile. They also displayed higher levels of justification of violence beliefs than those with a situation-specific reactive SIP profile ($d = 0.55$), but not than those with a general reactive SIP profile. Furthermore, they showed higher levels of punishment insensitivity than those with a general reactive SIP profile ($d = 0.50$), but not than those with a situation-specific reactive or nonaggressive SIP profile. Contrary to our hypotheses, we found no differences between the mixed versus reactive SIP profiles on CU traits, nor any differences between SIP profiles in sensation seeking, working memory, or inhibition.

Last, exploratory analyses revealed significant group differences for the variables anger-frustration temperament, $F(3,171) = 4.37$, $p = 005$, and justification of violence beliefs, $F(3, 180) = 5.29$, $p = 002$. Bootstrapped pairwise comparisons showed that boys with a general reactive SIP profile displayed higher levels of anger-frustration temperament than those with a mixed reactive-proactive SIP profile ($d = 0.52$) and a situation-specific reactive SIP profile ($d = 0.53$), and more justification of violence beliefs than those with a nonaggressive SIP profile ($d = 0.64$).

Discussion

The present study used interactive VR methods to detect distinct SIP profiles of boys with aggressive behavior problems. Improved understanding of such profiles should help tailor cognitive-behavioral interventions to the needs of individual children. We found two reactive SIP profiles (i.e., a "general" and "situation-specific" reactive SIP profile), a mixed reactive-proactive SIP profile, and a nonaggressive SIP profile. We found no evidence for a proactive SIP profile. These findings demonstrate how different SIP patterns may underlie children's aggressive behavior problems. As such, our study extends previous work not only by showing that children's aggression may stem from deviations in distinct steps of the SIP model (De Castro & Van Dijk, 2017; Dodge, 2011), but also by demonstrating that these deviations can be used to demarcate subgroups of children with aggressive behavior problems.

Some of our findings were unexpected. First, although we did not anticipate finding two distinct reactive SIP profiles, this finding aligns with learning theory and research indicating that children's SIP may depend on conditioning of situational cues (De Castro & Van Dijk, 2017; Dodge et al., 1985; Matthys et al., 2001). Some children may be sensitized to specific situations, perhaps through past experience (Dodge, 2006; Matthys et al., 2001). For example, children whose properties have been damaged by peers in the past will likely show aggressive SIP in similar situations (e.g., when their game is ruined by a peer), but less so in other situations (e.g., when being excluded from a game by peers). An alternative explanation for the emergence of a situation-specific profile lies in the fixed presentation order of the VR scenarios: it is possible that some children managed to regulate their anger up to a certain point in the first (social) provocation scenario, but were unable to regulate their anger in the face of yet another (object) provocation scenario, leading them to display aggressive SIP and behavior in this last scenario specifically (Kempes et al., 2008). However, such spill-over of anger seems unlikely, given that boys showed relatively low mean scores on anger in the first (social) provocation scenario.

Second, we did not find support for a proactive SIP profile. Prior research aiming to identify subgroups of children based on their reactive versus proactive motives for aggression has found mixed evidence for the existence of a predominantly proactive aggressive group, with some studies finding such a group (Carroll et al., 2018; Van Dijk et al., 2021), but not others (e.g., Euler et al., 2017; Marsee et al., 2014; Munoz et al., 2008; Smeets et al., 2017; Thomson & Centifanti, 2018). As previously detected proactive aggressive groups have been proportionally small (e.g., Van Dijk et al., 2021), it also is possible that our study failed to detect such a group due to limited variance in proactive SIP (we used one dichotomous proactive SIP indicator only: instrumental goals). It is also possible that proactively aggressive boys in our sample displayed aggressive SIP in the provocation scenarios (meant to assess reactive SIP) because of a carry-over effect, leading to a classification in the mixed reactive-proactive SIP profile. Indeed, the instrumental gain scenarios (meant to assess proactive SIP) that were presented first may have activated boys' aggressive responses, and perhaps facilitated the accessibility of aggressive response options in the

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Table 4. Descriptive statistics of theoretically relevant child characteristics for each SIP profile and bootstrap 95% confidence intervals of the mean difference between planned contrasts (based on 5000 resamples)

	SIP profiles				Contrasts					
	General reactive (GR-SIP)	Situation-specific reactive (SR-SIP)	Mixed Re- & proactive (M-SIP)	Nonaggressive (NA-SIP)	GR-SIP vs. SR-SIP	GR-SIP vs. M-SIP	GR-SIP vs. NA-SIP	SR-SIP vs. M-SIP	SR-SIP vs. NA-SIP	M-SIP vs. NA-SIP
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	95% CI	95% CI	95% CI	95% CI	95% CI	95% CI
Anger-frustration temperament	3.43 (0.84)[a]	3.00 (0.79)[b]	3.01 (0.71)[b]	2.81 (0.94)[b]	[.10, .76]	[.04, .79]	[.25, .98]	[−.38, .33]	[−.15, .51]	[−.18, .61]
Hostile beliefs	2.41 (0.87)[a]	2.12 (0.71)[a]	2.27 (0.66)[a]	1.85 (0.66)[b]	[−.02, .58]	[−.22, .48]	[.26, .86]	[−.49, .15]	[.01, .54]	[.12, .75]
Working Memory deficits	0.13 (0.95)[a]	0.05 (0.98)[a]	−0.04 (0.81)[a]	−0.17 (0.68)[a]	[−.31, .45]	[−.24, .60]	[−.08, .65]	[−.32, .49]	[−.12, .55]	[−.23, .50]
Inhibition deficits	0.10 (0.99)[a]	−0.08 (0.65)[a]	0.04 (1.04)[a]	−0.03 (0.64)[a]	[−.12, .51]	[−.47, .55]	[−.18, .45]	[−.63, .28]	[−.30, .19]	[−.31, .51]
Callous & Unemotional traits	2.03 (0.51)[ab]	1.95 (0.48)[ab]	2.09 (0.49)[a]	1.85 (0.41)[b]	[−.12, .26]	[−.32, .17]	[−.01, .37]	[−.37, .08]	[−.07, .27]	[.02, .45]
Justification of violence beliefs	2.15 (0.95)[ab]	1.88 (0.78)[ac]	2.34 (1.01)[b]	1.65 (0.57)[c]	[−.05, .59]	[−.67, .26]	[.19, .80]	[−.92, −.04]	[−.03, .48]	[.30, 1.09]
Sensation seeking tendencies	3.27 (0.57)[a]	3.47 (0.51)[a]	3.33 (0.44)[a]	3.24 (0.56)[a]	[−.41, .02]	[−.29, .16]	[−.19, .25]	[−.07, .35]	[.02, .42]	[−.14, .31]
Punishment insensitivity	−0.30 (1.41)[a]	−0.01 (0.89)[ab]	0.31 (0.85)[b]	0.14 (0.51)[b]	[−.85, .16]	[−1.16, −.11]	[−.97, −.02]	[−.72, .10]	[−.45, .14]	[−.20, .52]
Teacher-rated reactive motives	2.81 (1.02)[ab]	2.74 (0.89)[ab]	3.03 (0.83)[b]	2.49 (0.94)[a]	[−.32, .47]	[−.69, .24]	[−.11, .74]	[−.70, .12]	[−.12, .61]	[.11, .95]
Teacher-rated proactive motives	1.91 (0.80)[a]	2.02 (0.88)[a]	2.48 (0.89)[b]	1.90 (0.69)[a]	[−.44, .21]	[−.98, −.16]	[−.30, .32]	[−.88, −.05]	[−.21, .45]	[.18, 1.00]

Note. Hypotheses for underlined variables were at least partly supported. SIP Profiles with different superscripts had a significant mean difference (i.e., the 95% CI does not include zero).

subsequent provocation scenarios. Hence, although our findings did not identify a proactive SIP profile, further scrutiny is needed.

Discriminant validity of SIP profiles

Our secondary aim was to provide further validation for the existence of distinct SIP profiles in boys with aggressive behavior problems by comparing them on (1) teachers' impressions of boys' reactive and proactive motives for aggression and (2) theoretically relevant child characteristics.

Teacher-reported reactive and proactive motives for boys' aggression

Teachers' impressions partly corresponded with the obtained SIP profiles. They reported that boys with a mixed reactive-proactive profile displayed more reactive motives for their aggression than those with a nonaggressive profile, and more proactive motives than those with any other SIP profile. However, they did not report more reactive motives in boys with reactive versus other SIP profiles. One possible explanation is that, because boys with a mixed reactive-proactive SIP profile displayed the highest levels of aggressive SIP across all VR scenarios, their aggressive behavior and underlying motives also were observed more often by their teachers.

Theoretically relevant child characteristics

For the general reactive SIP profile, we found partial support for unique child characteristics. Boys who showed this profile displayed higher levels of anger-frustration temperament and hostile beliefs than those with a nonaggressive SIP profile (Frick & Morris, 2004; Hubbard et al., 2010; Merk et al., 2005). Furthermore, exploratory analyses showed that boys with a general reactive SIP profile also displayed higher levels of anger-frustration temperament than those with a mixed reactive-proactive SIP profile or a situation-specific reactive SIP profile. These findings correspond with research indicating that children with an emotionally reactive temperament are prone to show reactive, but not proactive, SIP and aggression (Frick & Morris, 2004).

Unexpectedly, we found that boys who showed a general reactive SIP profile also reported more justification of violence beliefs than those with a nonaggressive SIP profile. It is possible that children displaying reactive SIP and aggression across provocation contexts view aggression as an acceptable strategy to defend themselves or retaliate. Indeed, further analysis[2] revealed that boys with the general reactive SIP profile were particularly likely to endorse justification of violence items directly related to reactive aggression (e.g., "When somebody provokes you, it is normal to hit or threaten that person"). This finding aligns with studies showing that justification of violence beliefs are associated positively with reactive SIP and aggression (Calvete & Orue, 2010; Shu & Luo, 2021). In addition, we found that boys with a general reactive SIP profile were more sensitive to punishment than boys with a nonaggressive SIP profile and mixed reactive-proactive SIP profile. Although this finding was unexpected, it aligns with previous work suggesting that children who engage in reactive aggression may be sensitized to negative stimuli (e.g., punishment and threat), possibly due to the harsh and punitive environments they often grow up in (Bubier & Drabick, 2009; Pederson et al., 2018).

[2]We identified items directly related to the justification of reactive ($k = 3$) and proactive aggression ($k = 3$), calculated an average score for each, and tested them against each other using a dependent t test, $t(46) = 3.38$, $p = .001$, $d = 0.49$.

The child characteristics of boys who showed a situation-specific profile were less pronounced than those of boys who showed a general reactive SIP profile. They displayed higher levels of hostile beliefs than boys with a nonaggressive SIP profile, but similar levels of anger-frustration temperament, inhibition and working memory. This may imply that boys with a situation-specific profile do not respond aggressively due to temperamental or inhibitory dispositions, but because of hostile schemas that are activated only in certain situations and predispose them to display reactive SIP in those situations (e.g., object provocations) but not others (e.g., social provocations; Verhoef et al., 2022).

For the mixed reactive-proactive SIP profile, we again found partial support for unique child characteristics. As predicted, boys with this profile more strongly justified violent beliefs than boys with a situation-specific reactive SIP and nonaggressive SIP profile. They also displayed CU traits more than boys with a nonaggressive SIP profile, but not more than boys with reactive SIP profiles. This last finding contradicts earlier work demonstrating that children who engage in both reactive and proactive aggression display higher levels of CU traits than children who solely engage in reactive aggression (Thomson & Centifanti, 2018). Moreover, we found that boys with a mixed reactive-proactive SIP profile were not less sensitive to punishment than those with a nonaggressive SIP profile. This contradicts earlier work suggesting that children who engage in proactive aggression may be less sensitive to punishment (Branje & Koot, 2018).

Last, we did not find any differences between SIP profiles for working memory and inhibition. This may be due to our measures. To match the emotionally engaging nature of interactive VR, we used standard executive functioning tasks presented in a game-based format designed to engage children. Nevertheless, these tasks may have evoked substantially less emotional arousal than our interactive VR assessment of SIP. It is possible that children's executive functioning assessed using "cool" tasks do not predict children's "hot" SIP assessed in emotionally engaging social interactions using interactive VR.

Strengths and Limitations

To our knowledge, our research is the first person-based study to distinguish between SIP profiles of children with aggressive behavior problems. We examined children's SIP patterns using interactive VR, which seems particularly suited to detect individual differences in children's SIP because it evokes relatively strong emotions in children, triggering aggressive SIP patterns that less likely occur when children are calm (Anderson & Bushman, 2002; Lemerise & Arsenio, 2000). We maximized clinically meaningful variance in children's SIP by recruiting boys from the entire spectrum of aggressive behavior problems, including children with severe aggressive behavior problems. This allowed us to detect four distinct SIP profiles, suggesting that different SIP patterns may underlie aggressive behavior in different children.

We acknowledge several limitations. First, the relatively small sample size of our study may have limited statistical power to find proportionally small SIP profiles, such as a proactive SIP profile. Relatedly, we were not able to identify enough children who displayed aggressive responses in instrumental gain scenarios. As such, we were not able to include children's positive outcome expectancies and response evaluations of aggression in the LPA. Because our LPA was thus based on one proactive SIP indicator only (i.e., instrumental goals), the chance of finding a proactive SIP profile was further reduced. Future research could aim to

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recruit larger samples of children, perhaps oversampling children predisposed to engage in proactive aggression, and have them report in greater detail on their interactional goals and outcome expectancies (e.g., differentiating between obtaining material versus social gain, or expecting instrumental versus relational outcomes).

Second, as interactive VR is relatively time-consuming and costly to develop, we were able to include four scenarios only. Although we carefully chose the scenarios based on the literature and pilot work (Verhoef, Van Dijk, et al. 2021), they do not cover the broad range of social situations known to trigger aggressive SIP and behavior in children. Moreover, all participants completed both the VR scenarios and the SIP questions in the same order. We tried to limit carry-over effects by presenting the provocation scenarios last, as these may arouse the strongest emotions, and by asking the SIP questions in the order that children's spontaneous SIP is thought to occur (Crick & Dodge, 1994). Nevertheless, we cannot rule out the possibility that order-effects affected some of our findings. Future work could use more VR scenarios, counterbalance their order (perhaps across different sessions), counterbalance SIP questions, or assess children's SIP by asking children to speak freely during scenarios and code their SIP afterwards (Milch-Reich et al., 1999).

Third, our study included a relatively homogeneous sample of boys, with limited diversity in ethnic/cultural and socio-economic backgrounds. Future work is needed to test generalization to other subgroups of children.

Conclusion

This study shows, for the first time, that it is possible to detect distinct SIP profiles among children with aggressive behavior problems using interactive VR. Our findings advance our understanding of the SIP patterns contributing to children's aggressive behavior, and inform efforts to tailor cognitive-behavior interventions to individual children. For instance, for children displaying situation-specific reactive SIP, cognitive-behavioral interventions could focus on anger exposure and challenging hostile cognitions in only those situations that are most problematic to them. For children displaying both reactive and proactive SIP, interventions may include a wider range of techniques (e.g., practicing prosocial strategies to attain social goals). We hope our findings will spur further work to delineate unique SIP profiles more precisely and to scrutinize the effects of profile-tailored cognitive-behavioral interventions.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0954579422000505

Author contributions. The study was designed by all authors. Material preparation was performed by all authors. Data collection was performed by Rogier E.J. Verhoef and trained graduate students. Analyses were performed by Rogier E.J. Verhoef. The first draft of the manuscript was written by Rogier E.J. Verhoef and edited by all authors. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Conflicts of interest. None.

Ethical standards. The study was approved by the Dutch Medical-Ethical Testing Committee Utrecht (METC-Utrecht) and conducted in accordance with the 2013 Helsinki Declaration.

Availability of code. The data that support the findings of this study are available through the Open Science Framework at https://osf.io/ja9uw. The syntax of the analyses run for this study are available through the Open Science Framework (see link above).

Consent to participate. Written informed consent the study was obtained from parents and children provided verbal assent.

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