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Research Paper

The impact of greening schoolyards on the appreciation, and physical, cognitive and social-emotional well-being of schoolchildren: A prospective intervention study

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ABSTRACT

Greening schoolyards is an initiative to reconnect children with nature and afford meaningful experiences that foster children's well-being. To strengthen the empirical basis for greening schoolyards, we conducted a longitudinal prospective intervention study with a two-year follow-up, to investigate the impact of greening schoolyards on schoolchildren's (age 7–11) appreciation of the schoolyard, and their physical, cognitive, and social-emotional well-being. Data were collected amongst nine elementary schools in moderate-to-high-urbanized areas in The Netherlands with approximately 700 children at each measurement. At baseline, all nine schoolyards were paved. Five schools greened their schoolyard between baseline and first-follow-up. Objective measurements included accelero-based measurements of physical activity during recess, attentional tests (Digit Letter Substitution Test, Natu & Argwal, 1995; Sky Search Task, Manly et al., 2001) and a social orientation test (Social Orientation Choice Card, Knight, 1981). Self-report questionnaires included children's appreciation of the schoolyard (naturalness, likability, attractiveness and perceived restoration), and their social- and emotional well-being (Strength and Difficulties Questionnaire, van Widenfelt, Goedhart, Treffers & Goodman, 2003; Social Support, RIVM, 2005; Pediatric Quality of Life Inventory, Varni, Seid & Kurtin, 2001). Multilevel data analyses support our expectation that greening has a positive impact on children's appreciation of the schoolyard, their attentional restoration after recess and social well-being. Furthermore, our results indicate that greening stimulates physical activity of girls. We found no impact on emotional well-being. These findings provide some support for the relevance of greening schoolyards and may guide further development of schoolyards that facilitate the well-being of schoolchildren.

1. Introduction

Children need experiences to wonder, explore, give meaning, take risks, feel comfortable, be challenged and physically modify the world around them. These sensory-motor experiences are well-known to support children's physical, cognitive and social-emotional development and well-being (Cole & Cole, 1989). An increasing body of evidence suggests that green spaces, like gardens, parks, woods and beaches, are essential elements of healthy communities for children to immerse in these experiences (for reviews, see Chawla & Nasar, 2015; Gill, 2014).

While evidence for the importance of nearby green spaces in children's everyday lives is growing, opportunities for children to engage with natural environments continue to decrease (Ferguson, Cassells, MacAllister, & Evans, 2013; WHO, 2017). Concerned by this loss of access to green space, organizations and professionals worldwide have highlighted the importance of reconnecting children with nature to promote healthy, sustainable and livable cities (Douglas, Lennon, & Scott, 2017; WHO, 2017). One way to reconnect children with nature is through greening their schoolyards. Given that elementary schoolchildren, aged 7–11, on average spent most of their time at school, greening schoolyards could make an important contribution to their physical, cognitive and social-emotional development and well-being (Chawla & Nasar, 2015).

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2. The case for greening schoolyards

In line with Bell and Dyment (2008) we describe a green schoolyard as an outdoor school environment where natural elements (such as trees, flowers, sand, water, grass, hills and bushes) are combined to create a more appealing schoolyard and improve the quality of children's (play) experiences. Ideally, a green schoolyard should be designed and used in such a way that it invites and encourages each child to interact, play and learn in and with nature in ways that fosters all aspects of their development and well-being.

Several theories provide guidance for understanding the potential benefits of greening schoolyards on children's development and well-being. First, according to the widely noted biophilia hypothesis (Kellert & Wilson, 1995), all human beings have a genetically inherited need to affiliate and connect with life and life-like forms. Playing on a green schoolyard can fulfil this need, and thereby foster a sense of connectedness to nature which induces increased feelings of psychological well-being. Connectedness to nature has also been linked to more pro-social behavior in children (Collado, Staats, & Corraliza, 2013). Other theories focus on nature's capacity to provide restoration from stress and mental fatigue, to explain the impact of greening schoolyards on children's cognitive and emotional well-being. More specifically, Stress Recovery Theory (SRT; Ulrich, 1983) states that exposure to unthreatening natural environments elicits an initial positive affective reaction which triggers a series of positive psychophysiological responses. In a related vein, Attention Restoration Theory (ART; Kaplan, 1995) posits that unthreatening natural environments automatically draw attention in a pleasant and involuntary way, which allows depleted cognitive resources to rest and replenish and could explain a positive impact of greening schoolyards on children's attention restoration. Natural environments may further support cognitive restoration by fostering a sense of being away and extent, and because their characteristics tend to be compatible with users' needs and purposes.

According to another line of reasoning, children's (play)experiences in a natural environment are the central pathway to understand how engagement with nature fosters children's well-being. For instance, the Theory of Loose Parts (Nicholson, 1972) attributes the beneficial effects of nature to the presence of loose parts, or materials that can be moved around, designed and redesigned, like twigs, stones and sand. These loose parts create abundant opportunities for children to engage in open and flexible play experiences. Children are drawn in a creative engagement with the environment in which they experience immediate consequences of their own and other children's actions. As a result, in children's behavior there is an endless stream of transforming, exploring and modifying the environment with all their senses and abilities, and an ongoing interaction with the behavior and abilities of children surrounding them. (Chawla, Keena, Pevec, & Stanley, 2014). In a similar vein, Affordance Theory (Gibson, 1979) posits that there is an intertwined relation between people and the environment, in which affordances, the functions environmental objects can provide to people, are related to the individuals themselves. Natural settings tend to offer a rich variety of affordances, or perceived opportunities for play that tap into the child's current needs, interest and abilities. For example, a tree with low-lying branches invites children to immediately climb it, when they at least can reach the lowest branch.

Loose parts and affordances facilitate an enriched play situation through which nature fosters children's cognitive, social and emotional well-being and development by the behavior of children in these environments. Natural features are less set, children can derive their own meanings and are invited, challenged and encouraged to explore the world and their own and other children's abilities. These experiences, for instance, stimulate children's physical activity, social interaction, cooperation, skill mastering and feelings of self-resilience and competence. (Chawla et al., 2014; Dyment & Bell, 2007).

Together these theories propose an integrated framework of affective, cognitive and behavioral explanations on why greening schoolyards could foster children's physical, cognitive and social-emotional well-being. Below, we discuss empirical evidence supporting these explanations.

2.1. Appreciation of the schoolyard

Several observational and explorative studies show that schoolchildren prefer to play in natural areas at the schoolyard (Chawla et al., 2014; Jansson, Gunnarsson, Mårtensson, & Andersson, 2014; Lucas & Dyment, 2010), and that children playing on a green schoolyard show greater appreciation of their schoolyard compared to a paved schoolyard (Maas, Tauritz, van der Wal, & Hovinga, 2013; Samborski, 2010). Furthermore, a Dutch study followed 308 children aged 6 to 9 of four elementary schools before and after greening and found that on two schools children's appreciation of the schoolyard increased after greening. In addition, they found that appreciation was positively related to attentional capacity, and social-and emotional well-being (De Vries, Langers, Donders, Willeboer, & Van Den Berg, 2013).

2.2. Physical activity

Although the evidence is somewhat mixed and inconclusive, the idea that that greening schoolyards can support children's physical activity is supported by several studies (Ferguson et al., 2013; Sharma-Brymer & Bland, 2016). For instance, 105 teachers, parents and administrators of 59 Canadian elementary schools consistently reported that greening their schoolyard created opportunities for children to be more physically active (Dyment & Bell, 2008). Furthermore, Fjortoft (2004) showed that playing on a green schoolyard every day for one or two hours led to significant improvement of motor ability in children aged 5–7 in Norway, compared to children who played on a traditional schoolyard. However, other studies do not support the assumption of increased physical activity in green areas. For instance, Mårtensson et al. (2014) showed that although environments with more diverse features support a greater variety in play experiences, school children aged 10–13 on two schools in Sweden, were not more physically active on green schoolyards compared to paved schoolyards. This may be explained by the fact that paved open spaces and flat surfaces promote and invite locomotion in high speed – which may even result in higher level of physical activity compared to natural spaces, especially in boys (Fjørtoft, Kristoffersen, & Sageie, 2009).

2.3. Cognitive and social-emotional well-being

Empirical research on the impact of greening schoolyard on attentional capacity and social-emotional well-being of children is relatively scarce. One study among 14 elementary schools in a large Australian city showed that children's perceptions of the restorative qualities of their schoolyard were positively related to vegetation volume and self-reported positive affect (Bagot, Allen, & Toukhsati, 2015). Furthermore, based on parent and teacher's observations, alumni memories and ethnographic observations, Chawla et al. (2014) report that playing on a green schoolyard enables children aged 6–12 to escape from stress and supports social relationships. Furthermore, two Dutch studies showed that children playing on a green schoolyard reported that they had more friends and experienced less bullying behavior than children playing on a paved schoolyard (De Vries et al., 2013; Maas et al., 2013).

The available empirical knowledge partly supports the theoretical framework that greening schoolyards indeed provides opportunities for children to immerse in meaningful play experiences, and that these experiences can positively influence children's appreciation of the school ground, their physical activity, and cognitive, and social-emotional well-being. However, the available empirical evidence for school children is still limited and in some cases mixed or inconclusive. Moreover, most of the studies suffer from limitations such as a lack of

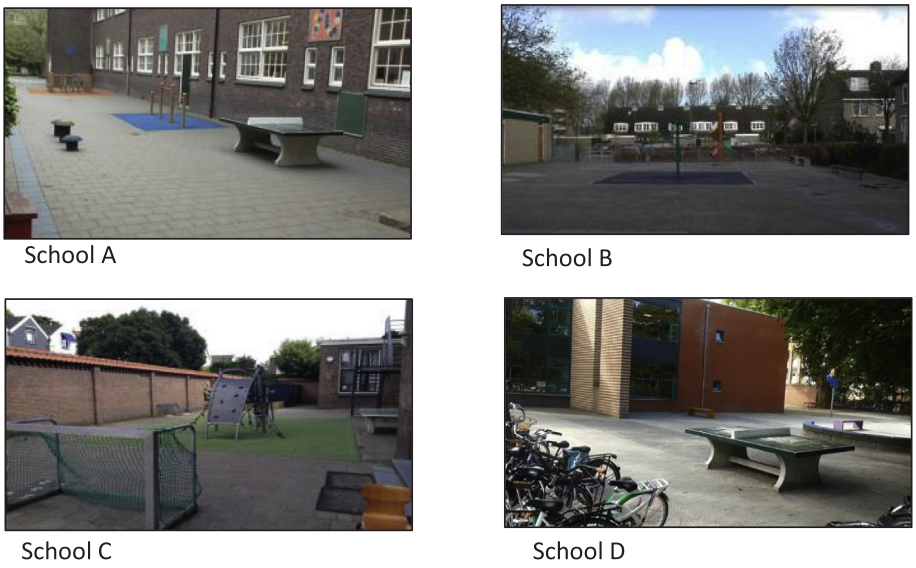

Fig. 1. Impressions of the paved schoolyards of the four control schools.

pre-measurements or control groups. As yet, there are also no longitudinal studies that have measured the more long-term effects of greening schoolyards.

2.4. The present research and hypotheses

We conducted a prospective intervention study with a two-year follow-up to further understand the impacts of greening schoolyards on the well-being of schoolchildren. In particular we focus on the impacts of greening on children's physical, cognitive, and social-emotional well-being. We hypothesized that at first and second follow-up, after their schoolyard had been greened, children at the intervention schools display (1) more positive appreciation of the schoolyard (2) increased levels of physical activity during recess (3) more attentional restoration after recess, and (4), improved (pro)social behavior and (5) better emotional functioning. While these effects were expected for all children, we also explored moderating influences gender (in particular for physical activity, see Fjørtoft et al. (2009) and grade level.

3. Method

3.1. Overview and design

The data presented in this paper are part of a large, four-year research program on greening schoolyards of elementary schools in moderate-to-high-urbanized areas in The Netherlands (Wesselius, Maas, & Hovinga, 2015). Data collection took place at nine schools during three consecutive years (2014, 2015, 2016) in the period between February and June. At the baseline measurement in 2014 the schoolyards of all nine schools were paved. Five schools greened their schoolyard between pre-measurement and first follow-up in 2015. The other four schools served as control schools and did not green their schoolyards. Data collection covered a broad set of objective and self-reported measurements. Objective measurements included video observations of children's play behavior and accelerometer-based physical activity measurements at the schoolyard, classroom-based tests of children's attentional capacity and social value orientation. Self-report questionnaires were used to assess, among other things, children's perceptions of the schoolyard, and their social and emotional well-being. In addition, we collected questionnaires amongst parents and teachers, and held interviews with principals of the participating elementary schools. The current paper discusses results from the accelerometer data and classroom-based tests and questionnaires. Results of the video observations and parent- and teacher evaluations, as well as data gathered at a tenth school which already had a green schoolyard at baseline, will be reported elsewhere.

3.2. Schools

Participating schools were selected based on various inclusion criteria. A main selection criterion for the intervention schools was that they should have advanced plans for greening their schoolyards between 2014 and 2015, according to guidelines for greening schoolyards developed by Fonds1818, a Dutch foundation which has subsidized greening of 187 schoolyards in the Western part of the Netherlands (Fonds1818, 2014). Second criterion was that the schools should be located in urbanized areas with limited green play opportunities for children. Consequently, only schools in extremely high urbanized (> 2500 addresses per square kilometer, one intervention school), highly urbanized (1500–2500 addresses per square kilometer, two intervention schools) and moderately urbanized areas (1000–1500 addresses per square kilometer, two intervention schools) were included in the study. Finally, four control schools were selected to match the intervention schools with respect to their level of urbanization of the neighborhood and socioeconomic status of parents. School boards of schools that were potentially eligible for inclusion based on available data were approached directly by the research team or through the foundation for greening schoolyards. Of the 16 schools that were approached, seven declined to participate, mainly for lack of time or for not being sure that the greening could be completed within the specific period between 2014 and 2015.

3.3. The schoolyards: paved and greened

Paved schoolyards were mostly covered with tiles and contained some play equipment made of non-natural materials, like swings or climbing frames (Fig. 1). When vegetation was present, this served only as a fence or decoration. The greening of the five schoolyards between baseline and first follow-up, was a tailored process supported by funding from Fonds1818. This funding was allocated based on the design, quality, shape and functionality of the schoolyard greening which schools had to describe in a detailed plan. When this plan was approved, the greening was carried out in a participatory process with input from parents, teachers, children and designers.

Fig. 2 gives an impression of each schoolyard of the intervention schools before and after the greening process. All intervention schools

Fig. 2. Impressions of the schoolyards of the five intervention schools before greening at baseline (left) and after greening at second follow-up (right).

greened areas of their schoolyard and also kept some areas paved. The green areas covert mostly features as grassy hills, bushes, tree, tunnels made of tree branches, loose tree branches and garden-like parts.

3.4. Participants

After excluding children who were absent due to illness, uncompleted tasks or other circumstances, the total study population consisted of 2031 children, aged seven to eleven in group 4, 5 and 6 (as classified by the Dutch educational system). Table 1 provides a summary of characteristics of children at each time of measurement at the intervention and control schools. Depending on the group they were in at the start of the study in 2014, children participated at all three measurements (N = 238), at baseline and first-follow-up (N = 233), or at first and second follow-up (N = 201). The remaining of the children participated only at one measurement. The Research Ethics Committee of the department of social- and organizational psychology of our university approved the study and affirmed that the study would not induce negative consequences above minimal risk for the participating children. The study and study protocol were also approved by the

Table 1
Characteristics of children at each time of measurement at the intervention and control schools who participated in the classroom-based tests and questionnaires.

	Baseline (N=706)		**First follow-up** (N=682)		**Second follow-up** (N=643)	
	Intervention (N=351)	Control (N=355)	Intervention (N=360)	Control (N=322)	Intervention (N=331)	Control (N=312)
Total	49.7%	50.3%	52.8%	47.2%	51.5%	48.5%
Grade 4	121 (34.5%)	122 (34.4%)	116 (32.2%)	93 (28.9%)	106 (32.0%)	93 (29.8%)
Grade 5	125 (35.6%)	109 (30.7%)	117 (32.5%)	121 (37.6%)	106 (32.0%)	95 (30.4%)
Grade 6	105 (29.9%)	124 (34.9%)	127 (35.3%)	108 (33.5%)	119 (36.0%)	124 (39.7%)
% Boys	170 (48.6%)	181 (52.0%)	161 (44.7%)	168 (52.2%)	159 (48.0%)	175 (56.1%)
Age (in years)	8.5 (1.0)	8.6 (1.0)	8.6 (0.95)	8.6 (1.0)	8.6 (1.0)	8.7 (1.0)

Note. Children in cells with similar shading represent cohorts that participated in two or more times of measurement.

school boards. Furthermore, a passive consent procedure was conducted by sending a letter to the children's parents in which the aim of the study was explained and in which parents were informed how they could withdraw their child from participation.

3.5. Measurements

All research materials were tested prior to the baseline measurement at the first school. Based on the outcomes of these tests, some of the materials were adapted to better match the children's knowledge and abilities. Due to these adaptations, the first school is not included in both attention tasks, Social Orientation Choice Card, perceived naturalness of the school ground, and self-reported emotional functioning. At each time of measurement, the same set of objective and self-reported measurements was administrated. All self-reported measurements were designed in a child friendly manner, with colorful illustrations and easy-to-answer options, and so that they can be filled in or administered as a classroom activity. Part of the materials have also been used in a study on the impact of green walls in classrooms (Van Den Berg, Wesselius, Maas, & Tanja-Dijkstra, 2017).

3.6. Appreciation of the schoolyard

Children answered several questions to assess their appreciation of the schoolyard. First, children evaluated the ***naturalness*** of their schoolyard on a 5-point likert scale from 1 'not natural at all' to 5 'very natural'. The concept of 'naturalness' was explained as 'We would like to know whether you think your schoolyard is a natural environment with natural features, such as grass, trees, flowers, bushes, water, sand and animals', at the start of the test session, to assure that all children would interpret the concept unambiguously. Second, children rated the ***likability*** of their schoolyard with on a scale from 1 'I don't like my schoolyard at all' to 10 'My schoolyard is fantastic, it could not be better'. Third, children judged the ***attractiveness*** of the schoolyard. Eight positive and eight negative words were paired and placed as each other's opposites. The items were presented as a five point scale, for example '1 = very boring, 2 = a bit boring, 3 both as boring as adventurous, 4 = a bit adventurous, 5 = very adventurous'. Responses were combined into one average score, where higher scores indicate a more attractive schoolyard. The scale showed good reliability at all measurement times, with Cronbach's alpha ranging between 0.87 and 0.88. Lastly, children indicated their ***perceived restorative quality*** of the schoolyard on eight items derived from the Perceived Restorative Components Scale for Children (Bagot, 2004). Items were selected and amended to Dutch in collaboration with teachers. Children rated each item such as 'At the schoolyard I think about other things, not about learning in the classroom' and 'At the schoolyard I am free to choose my own activities' and 'At the schoolyard there are lots of things to discover' on a four point scale with '1 = not true, 2 = somewhat true, 3 = true, 4 = completely true'. Factor analysis confirmed a unidimensional scale (45.1% explained variance), so responses were combined into an average score, where higher scores indicate higher perceived restorative quality. The scale showed good reliability on all measurement times, with Cronbach's alpha ranging between 0.81 and 0.82.

3.7. Physical activity in the schoolyard

Physical activity in the schoolyard during morning recess was objectively measured with ***accelerometers*** (model ActiGraph GT3X). During morning recess children played at the schoolyard for approximately 15 min. At each school in each group ten children were randomly selected to wear an accelerometer during recess. After excluding children due to malware, technical problems and other circumstances, a total of 731 measurements were included in the dataset (237 at baseline, 246 at first follow-up, and 248 at second follow-up).

Activity levels were quantified by measuring change in velocity over time, within a chosen sampling interval of 15 s. This small interval fits the short, intermittent way in which children commonly perform physical activities (Trost, McIver, & Pate, 2005). To ascertain that activity levels of children would not be influenced by prior beliefs, no information was given about the true reason of wearing an accelerometer. Instead, children were told that the researchers wanted to see how they played on their schoolyard. Accelerometer activity counts were transformed into categories of minutes spent in sedentary (count cut-off ≥ 0 per 15 s), light (count cut-off ≥ 26 per 15 s), moderate (count cut-off ≥ 574 per 15 s) or vigorous (count cut-off ≥ 1003 per 15 s) physical activity intensity during recess with help of the data analysis program ActiLife (Version 6.13.1). Specific cut-offs for time spend in each category were chosen based on the study of Evenson, Catellier, Gill, Ondrak, and McMurray (2008). The cut-off points used in this study

have been found to predict activity intensity within each category in children best (Trost, Loprinzi, Moore, & Pfeiffer, 2011). For this study time spent at moderate and vigorous physical activity (MVPA) levels was summed, because time spent on a MVPA level, preferably for 60-minutes a day, is believed to be beneficial for children's health (WHO, 2015). The amount of MVPA in minutes was divided by total recess time to provide a percentage of MVPA during recess on a continuous scale.

3.8. Attention restoration

Two attentional tests were administered before and after recess: the ***Digit Letter Substitution Test (DLST)*** to measure information processing speed (Natu & Agarwal, 1995) and the ***Sky Search task (SST)***, a subscale from the Test of Everyday Attention for Children, to measure selective attention (Manly et al., 2001). First, the DLST required children within 90 s to convert as many randomly ordered digits (1–9) as possible to letters according to a key that assigns a letter to each number. Attention restoration on the DLST was calculated as the difference between the total numbers of digits converted before and after recess, where a higher improvement score indicates better restoration of information processing speed. The DLST has shown good test-retest reliability, $r = 0.97$, as well as convergent validity with other established attentional tests, $r = 0.40$ (Pradhan, 2013). Second, the SST consists of an A4 sheet with rows of figures depicting pairs of different and pairs of identical space crafts (twins). Children were required to underline as many pairs of identical space crafts in 45 s. Attention restoration on the SST was calculated as the difference between the total correctly underlined identical pairs before and after recess, where a higher improvement score indicates better restoration of selective attention. The SST has shown good test-retest reliability, $r = 0.90$, as well as convergent validity with other established attentional tests, $r > 0.40$ (Manly et al., 2001). To reduce learning effects, at each measurement occasion two different variants of the DLST and SST were used before and after recess, and counterbalanced between children. For the DLST, different versions were constructed at the three measurement times, using the same digits but different letters. All analyses are controlled and adjusted for version effects.

3.9. Pro-social orientation

The Social Orientation Choice Card (SOCC; (Knight, 1981)) was administered after morning recess to asses children's ***prosocial orientation.*** Children were told that they would receive gifts in the afternoon and that the size of their gifts would be based on the amount of points they collected during the game. Besides collecting points for themselves, they would also collect points for another child. The size of the gifts this child received, would also be based on the amount of points that they collected during the game. We instructed that they would not get to know who this child was, not during and not after playing the game. In six turns children chose between three alternatives to divide points between themselves and the other child. The alternatives were all constructed according to the triple dominance scale: prosocial – individualistic – competitive. Children were categorized as prosocial when they chose the prosocial alternative for at least four out of six turns, and as not prosocial when they chose the individualistic or the competitive alternative at least four out of six times. Children that did not fall in these two categories were labelled ambiguous and were excluded from further analysis (23.1% at baseline, 23.2% at first follow-up, 27.7% at second follow-up).

3.10. Self-reported social behavior

Social behavior at school was assessed with the subscale ***peer problems*** (three items, for example 'Other children bully me at school'*)* and ***prosocial behavior*** (four items, for example 'I easily share things such as candy, toys and pencils with other children at school') from the validated Dutch version of the Strength and Difficulties Questionnaire (van Widenfelt, Goedhart, Treffers & Goodman, 2003) and the subscale ***social support in friendships*** (six items, for example 'My friends at school and I help each other') from a validated Dutch instrument for assessing school children's social functioning (RIVM, 2005). Children rated the items on a four point scale with '0 = not true, 1 = somewhat true, 2 = true, 3 = completely true'. Responses were combined into an average score for each subscale, with higher scores indicating less peer problems, more prosocial behavior and more social support. On all measurement times, the subscales peer problems and prosocial behavior showed acceptable reliability with Cronbach's Alpha ranging between 0.64 and 0.70 for peer problems and between 0.66 and 0.72 for prosocial behavior. The subscale social support showed good reliability with Cronbach's Alpha ranging between 0.77 and 0.82.

3.11. Emotional functioning

Children indicated their self-perceived emotional functioning on the subscale ***emotional functioning*** of the Pediatric Quality of life scale (Varni, Seid & Kurtin, 2001), which has found to be a reliable measure to asses quality of life in Dutch Children (Engelen, Haentjens, Detmar, Koopman, & Grootenhuis, 2009). In the classroom one by one five emotional problems were explained by the experimenter, for example 'I worry about what will happen to me', and children indicated to what extent they experienced difficulties with that problem on a five point scale with '1 = never, 2 = almost never, 3 = sometimes, 4 = often, 5 = almost always'. Each answer was reversed and combined an average score with 5 representing the best emotional functioning. The scale showed sufficient reliability on all measurement times, with Cronbach's Alpha ranging between 0.64 and 0.71.

3.12. Procedure

Each participating elementary school was visited for one school day at baseline and at both follow-ups. The chosen weekdays and sequence of visitation were equal for baseline and follow-up measurements. The research team visiting the schools consisted of three researchers, accompanied by ten students (teacher training, psychology, health sciences students). Prior to data collection, students were trained to ensure an adequate understanding of the method of data collection. A data collection protocol was developed to minimize nuisance due to differences in data collection and therewith increase the reliability and validity of the findings. Within this protocol, information about the order and execution of measuring and accompanying instructions were described.

3.13. Data analysis

Data were analyzed using MLwiN software for multilevel analysis to control for the (partial) clustering of measurements within children (repeated measures) and the clustering of children within schools. We estimated the effects of greening the schoolyard using a basic three-level model where time was nested within children, and children were nested within schools. Furthermore, all analyses were controlled for group and gender and in case of moderating effects analyzed separately for each grade level and gender. First, intercept-only models were fitted with separate random intercepts for the three times of measurements at child and at school level. Second, gender and group were added as covariates. Third, we estimated the main effect of time by adding the follow-up measurements to the model with baseline as reference category, and specified random coefficients for each time of measurement at the child level. Next, the main effect of condition (intervention vs control) was estimated. Lastly, effects of greening of the schoolyards at first and second follow-up were estimated by specifying interaction-terms between the follow-up measurements (time) and condition.

Table 2
Unadjusted means and standard deviations of outcome measures in control and intervention groups at three times of measurement (T0 = baseline, T1 = first follow-up, T2 = second follow-up).

	Baseline		Follow-up 1		Follow-up 2	
Outcome measure	Control	Intervention	Control	Intervention	Control	Intervention
Perception Schoolyard						
Naturalness	2.80 (1.21)	2.89 (1.23)	2.80 (1.23)	3.74***††† (1.19)	2.93 (1.16)	3.76***††† (1.21)
Likability	7.01 (2.15)	6.40* (2.46)	6.72 (2.09)	7.15††† (2.32)	7.01 (1.94)	7.13††† (2.40)
Attractiveness	3.65 (0.79)	3.54 (0.89)	3.59 (0.78)	3.77††† (0.88)	3.66 (0.73)	3.73†† (0.83)
Restorative quality	2.55 (0.67)	2.58 (0.69)	2.50 (0.66)	2.59 (0.71)	2.60 (0.60)	2.60 (0.73)
Attention						
DLST	2.44 (5.24)	2.11 (5.93)	2.54 (5.76)	2.70 (5.92)	1.71 (6.04)	2.95* (6.02)
SST	1.48 (3.03)	1.73 (2.95)	1.23 (2.69)	1.36 (2.78)	1.35 (2.80)	2.22* (2.76)
Physical activity						
Time spent in MVPA (%)	28.33 (15.61)	27.80 (16.97)	32.00 (16.22)	34.76††† (18.16)	30.08 (15.43)	31.46†† (17.37)
Social Behavior						
SOCC: Prosocial orientation (%)	37.22	41.88	32.04[1]	44.17†	45.20†	48.37†
Prosocial	2.23 (0.54)	2.24 (0.60)	2.23 (0.56)	2.26 (0.61)	2.33 (0.49)	2.23 (0.57)
Peer problems	0.50 (0.66)	0.63 (0.72)	0.46 (0.62)	0.46† (0.63)	0.37† (0.57)	0.49† (0.68)
Social support	2.30 (0.61)	1.85* (0.96)	2.19† (0.58)	2.18† (0.65)	2.29 (0.51)	2.27† (0.54)
Emotional well-being						
	3.75 (0.82)	3.77 (0.81)	3.64 (0.73)	3.58 (0.82)	3.59 (0.75)	3.56 (0.76)

Means indicated with an asterisk differ significantly from the mean in the control group at the same time of measurement, after controlling for gender and grade level, $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$; means indicated with an obelisk differ significantly from baseline within the same condition after controlling for gender and grade level, $^{\dagger}p < .05$; $^{\dagger\dagger}p < .01$; $^{\dagger\dagger\dagger}p < .001$.

During each step overall effects as well as individual effects of the parameters were estimated. In addition, we checked for moderating effects of gender and group by adding 2 and 3-way interaction terms of gender/grade level with condition and time.

4. Results

Table 2 provides an overview of unadjusted mean values for all outcome measures. Table 3 gives a summary of overall as well as

Table 3
Overview of overall (Chi^2) as well as individual (Z) outcomes of multilevel analyses of the follow-up scores with time (T0, T1, T2) as a within-subjects factor and condition (control, intervention) as a between-subjects factor, and gender and grade level as covariates.

Outcome measure		Condition(df = 1)	Time (df = 7)		Interaction condition * time (df = 2)	
			Follow-up 1 (T1)	Follow-up 2 (T2)	Condition * T1	Condition * T2
Perception schoolyard						
Naturalness	*Z*	0.30	0.00	1.69	8.40***	7.52***
	Chi^2	6.33*	94.12***		77.97***	
Likability	*Z*	−2.02	−1.75	−0.23	4.53***	3.59***
	Chi^2	0.02	38.46***		21.06***	
Attractiveness	*Z*	−1.09	−1.18	−0.26	3.76***	3.45***
	Chi^2	0.03	21.78***		15.93***	
Restorative quality	*Z*	0.14	−1.20	0.67	1.09	0.55
	Chi^2	0.45	12.78		1.22	
Attention restoration						
DLST	*Z*	−0.55	0.16	−1.42	0.72	2.07*
	Chi^2	0.27	7.06		4.29	
SST	*Z*	0.91	−1.03	−0.48	−0.38	1.75
	Chi^2	3.57	9.828		6.15*	
Physical activity						
MVPA	*Z*	−0.27	1.52	0.72	1.37	0.81
	Chi^2	0.34	19.45**		1.90	
Social Behavior						
SOCC (% prosocial)	*Z*	1.00	−1.32	1.76	1.12	−0.48
	Chi^2					
Prosocial	*Z*	−0.54	−0.54	2.43*	0.88	−1.35
	Chi^2	1.23	19.20*		5.50	
Peer problems	*Z*	1.60	−0.82	−2.33**	−1.98*	−0.43
	Chi^2	1.10	30.90***		4.76	
Social support	*Z*	−4.58***	−2.29*	0.12	6.42***	5.79***
	Chi^2	2.29	137.15***		42.21***	
Emotional well-being						
Emotional functioning	*Z*	0.40	−2.30*	−3.00**	−0.83	−0.25
	Chi^2	0.04	32.00***		0.79	

$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001^{*}$.

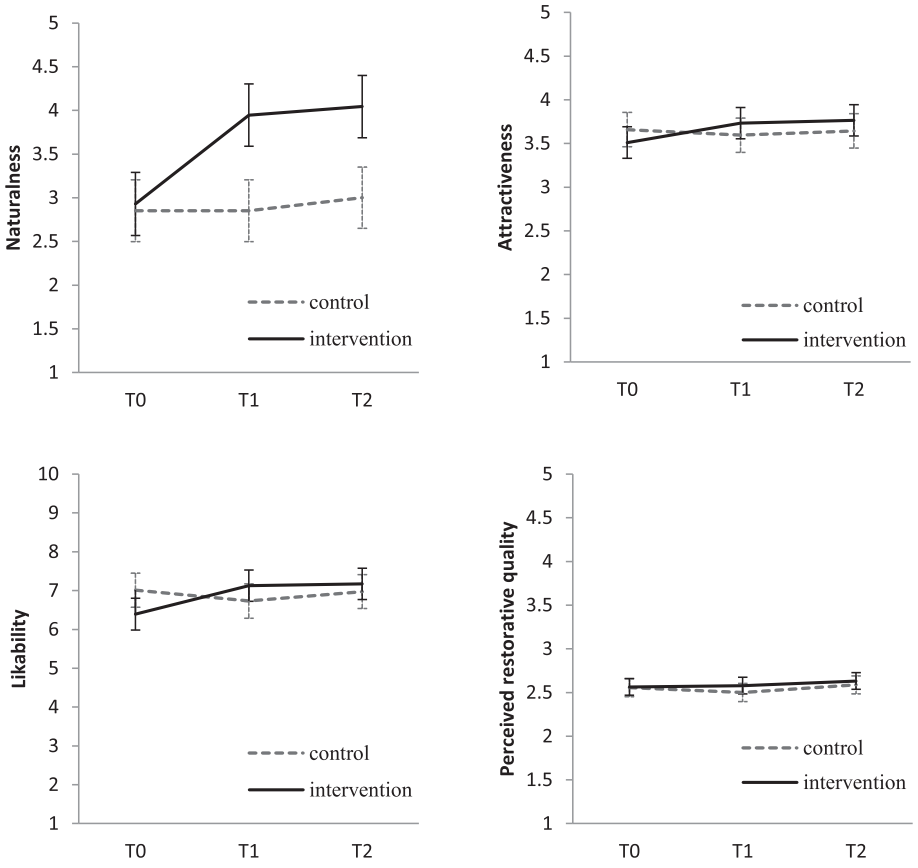

Fig. 3. Scores on the Naturalness, Attractiveness, Likability and Perceived Restorative Quality of the schoolyard in the control and intervention groups at baseline (T0), first follow-up (T1) and second follow-up (T2), with higher scores indicating a more positive appreciation of the schoolyard. Error bars represent the 95% CI. All scores are adjusted for gender and grade level.

individual main effects of condition and time, and interaction effects between time and condition.

4.1. Appreciation of the schoolyard

There were no baseline differences between the control and intervention schools in perceived naturalness, perceived attractiveness and perceived restorative quality of the schoolyard, *ps* > 0.3. However, children in the intervention condition gave a significant lower average likability score to their paved schoolyard than children in the control condition, mean adjusted difference = −0.62, 95% CI [−1.22, −0.017], $p < .05$. *ps* > 8. Across the two follow-up measurements, there were significant main effects of time and condition for naturalness, attractiveness and likability, with scores at follow-up being generally higher than scores at baseline, and scores in the intervention conditions higher than in the control conditions. These main effects were qualified by significant interactions between time and condition. As illustrated in Fig. 3, at first and second follow-up children in the intervention condition perceived their schoolyard as more natural, gave a higher likability score and perceived it to be a bit more attractive, compared to baseline. By contrast, scores of children in the control condition remained approximately the same across times of measurements. Furthermore, the baseline difference between control and intervention schools in averaged perceived likability was no longer present at both follow-up measurements, *ps* > 0.2. Greening the schoolyard did not affect the perceived restorative quality of the schoolyard, *ps* > 0.2, nor were there any significant main effects of condition or time on perceived restorative quality, *ps* > 0.1.

Impacts of schoolyard greening on children's appreciation were moderated by grade and gender. At first follow-up, there was a significant three-way interaction between group 5, condition and time for attractiveness, z = −2.00, $p < .05$, and likability, z = −2.62, $p < .01$. At second follow-up, there was a significant three-way interaction between group 6, condition and time for attractiveness, z = −1.98, $p < .05$, likability, z = −3.01, $p < .01$, and restorative quality, z = 1.06, $p < .001$. Exploration of these moderating effects reveals that at first follow-up, effects of greening schoolyards on perceived attractiveness and likability were stronger for groups 4 and 6 than for group 5, *ps* < 0.05, while at second follow-up effects of greening schoolyards on perceived attractiveness and likability of the schoolyard were generally stronger for groups 4 and 5 than for group 6, *ps* < 0.05. Children in grade 4 and 5 in the intervention school also perceived their schoolyard to be somewhat more restorative at second follow-up, compared to baseline. Grade level did not moderate the influence of greening schoolyards on perceived naturalness of the schoolyard. At first follow-up there was also a significant interaction between gender, condition and time on attractiveness of the schoolyard, z = 2.69, $p < .01$, and at second follow-up there was a trend for this three-way interaction, z = 1.83, $p = .07$. Exploration of these moderating effects showed that the impact of greening schoolyards on perceived attractiveness was on average stronger for girls than for boys. Gender did not moderate impacts of greening on perceived naturalness, likability and restorative quality, *ps* > 0.1.

Overall, the results support the hypothesis that children show greater appreciation of the schoolyard after their schoolyard has been greened, this holds in particular for younger children and for girls.

4.2. Attention restoration

In general, children's scores on the two attentional tasks improved after recess, which may be due to a learning effect, or a general impact of having a break. At baseline, there were no significant differences in the attention-improving effect of recess between intervention and control schools, neither for the DLST nor the SST, *ps* > 0.4. At second follow-up, there was a significant interaction between time and condition for the improvement in DLST after recess and a trend for this

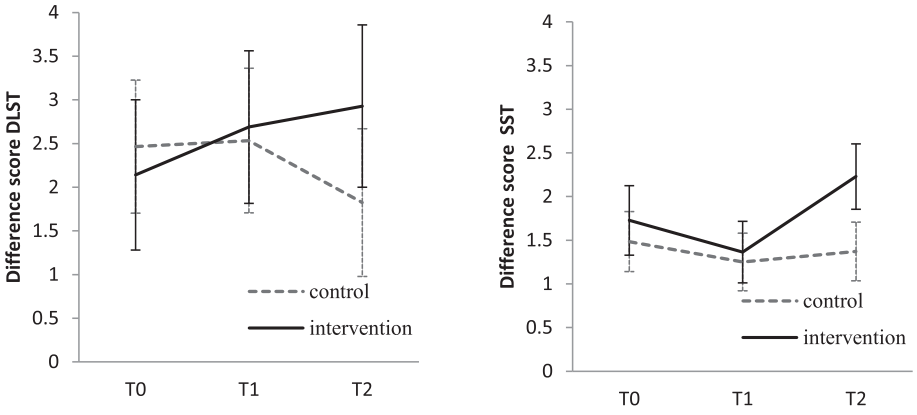

Fig. 4. Difference scores between before and after recess on the DLST (left) and SST (right) task in the control and intervention groups at baseline (T0), first follow-up (T1) and second follow-up (T2). Higher scores represent greater improvement in attentional functioning after recess. Error bars represent the 95% CI. All scores are adjusted for gender and grade level.

interaction for the improvement in SST, $p = .08$. As illustrated in Fig. 4, at second follow-up children in the intervention condition show on average greater improvement in scores on the DLST and SST than children in the control condition. For both attentional tasks, there were no significant interactions at first follow-up, nor did gender and grade moderate the effects, $ps > 0.1$. Taken together, the results support the hypothesis that greening a schoolyard improves children's attention restoration during recess, this holds for both attentional tasks, but only after the schoolyard had already been greened for a longer period.

4.3. Physical activity

At baseline, there was no significant difference between children in the control and intervention condition in percentage of time spent in MVPA during recess, $p < 1$. There was an overall increase in percentage of time children spent in MVPA during recess at both follow-up measurements, as indicated by a significant main effect of time across the two-follow-ups. There was no significant main effect of condition. However, as illustrated in Fig. 5, the overall trend for impact of greening on physical activity was positive, no significant interactions between time and condition were found, $ps > 0.2$, but the effects of greening the schoolyard were moderated by gender. At first follow-up there was a significant three-way interaction between gender, condition and time, $z = 2.15$, $p < .05$. As illustrated in Fig. 5, at baseline, girls in the intervention condition spent on average a significant lower percentage of time in MVPA during recess than girls in the control condition. During first follow-up, the percentage of time girls at the intervention schools spent in MVPA during recess increased, compared to baseline. Whereas, the percentage of time girls in the control condition spent in MVPA at first follow-up remained similar to baseline. As a result, the baseline difference is no longer present at first follow-up. At second follow-up, although the baseline difference is still no longer present, the three-way interaction is not significant, $p = .16$. No significant impact of greening schoolyards on physical activity was found for boys, $ps > 0.6$. There were also no significant moderating effects of grade on the impacts of greening schoolyards on physical activity.

Overall, the results show some support for the hypothesis that greening a schoolyard stimulates physical activity, but only in girls and in particular shortly after the schoolyard has been greened.

4.4. Prosocial orientation

At baseline, there was no significant difference between the control and the intervention condition in percentage of children with a prosocial orientation, as measured by the Social Orientation Choice Card, $p = .32$. There was a significant main effect of time at second follow-up, indicating a higher percentage of children with a prosocial orientation at both the intervention and the control schools. There were no significant interactions between time and condition at both follow-ups, $ps > 0.25$.

Grade moderated the impacts of greening on prosocial orientation at first follow-up as indicated by a trend for the three-way interaction between grade 5, condition and time, $z = 1.66$, $p = .097$, and a significant interaction between grade 6, condition, and time, $z = -2.53$, $p < .05$. As can be seen in Fig. 6, percentages of children with prosocial behavior in grades 4 and 5 of the intervention schools, in comparison to control schools, increased more from baseline to first follow-up, while in grade 6, there was a significant decrease in the percentage of children with a prosocial orientation. At second follow-up, there were no significant differences in percentages of children with a prosocial orientation between the control and intervention schools in all grades, $ps > 0.1$. These results provide some support for a positive short-term impact of greening the schoolyard on younger and a negative impact on older children's prosocial orientation.

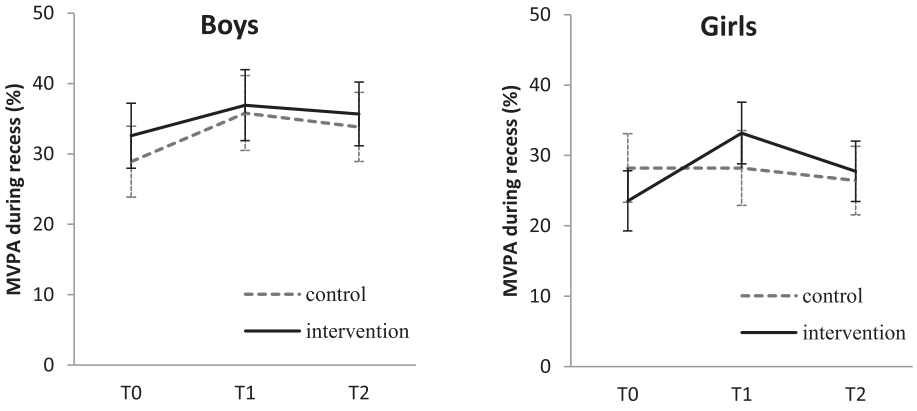

Fig. 5. Percentage of time spent in Moderate to Vigorous Physical Activity (MVPA) during recess in control and intervention groups at the three times of measurement, baseline (T0), first follow-up (T1) and second follow-up (T2), for boys (left) and girls (right). Error bars represent the 95% CI. All scores are adjusted for grade level.

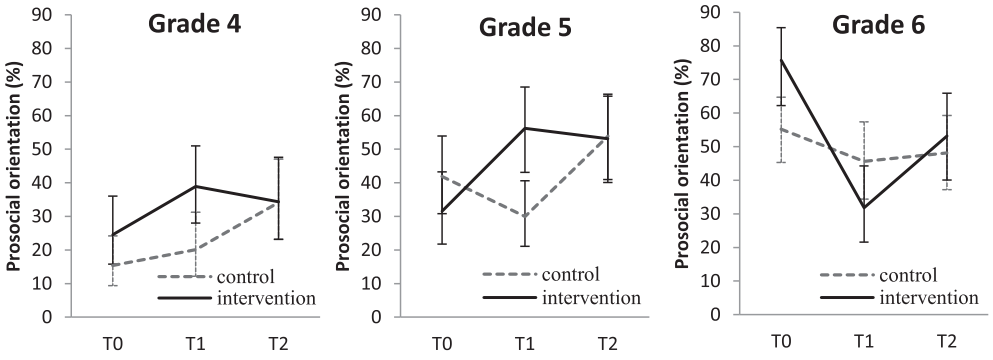

Fig. 6. Percentage of children with a prosocial orientation on the Social Orientation Choice Card in control and intervention groups at the three times of measurement, baseline (T0), first follow-up (T1) and second follow-up (T2), for children in grade 4 (left), grade 5 (middle) and grade 6 (right). Error bars represent the 95% CI. All scores are adjusted for gender.

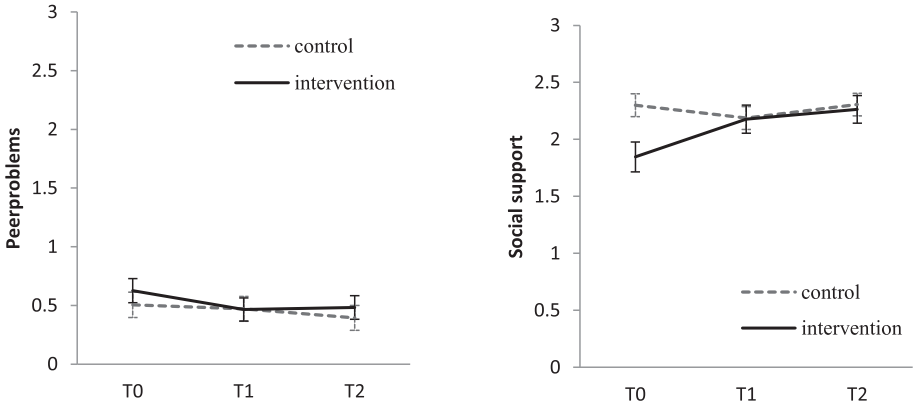

Fig. 7. Scores on the self-reported peer problems and support in control and intervention groups at the three times of measurement, baseline (T0), first follow-up (T1) and second follow-up (T2). Error bars represent the 95% CI. All scores are adjusted for gender and grade level.

4.5. Self-reported social behavior

There were no significant baseline differences between children in the control and intervention schools in self-reported prosocial behavior and peer problems, *ps* > 0.1. Children in the intervention condition did, however, experience less social support in their friendships than children in the control condition, $p < .0001$. There were significant main effects of time at both follow-ups for self-reported peer problems and social-support, and a significant main effect of time only at second follow-up for social support. There were no significant main effects of condition. Main effects of time were qualified by significant interactions between time and condition for peer problems only at first follow-up, and for social support at both first and second follow-up. As illustrated in Fig. 7, children in the intervention condition reported significantly fewer peer problems at first follow-up, compared to baseline. At second follow-up, both children in intervention and control schools report significantly fewer peer problems, compared to baseline. Furthermore, children in the intervention condition significantly reported more social support during both first and second follow-up, compared to baseline, whereas, children in the control condition experienced significantly less social support at first follow-up. As a result, the baseline difference between control and intervention schools in social support was no longer present at both follow-up measurements, *ps* > 0.7. No significant interactions between time and condition were found for self-reported prosocial behavior, *ps* > 0.2.

At first follow-up there were significant interactions with condition and time for grade 5, $z = 2.55$, $p < .05$, and for grade 6, $z = 2.88$, $p < .05$, indicating that the positive effect of greening schoolyards on social support was only present in grade 5 and 6. At second follow-up grade did not moderate the effect, the positive effect was present in all three grades. Grade did not moderate the results on self-reported prosocial behavior and peer problems, nor did gender moderated the results on any of the three outcome measures, *ps* > 0.09.

Taken together, the results partly confirm the hypothesis that greening a schoolyard is beneficial for children's social functioning. In particular for social support and self-reported peer problems, but not for self-reported prosocial behavior.

4.6. Emotional functioning

At baseline, there was no significant difference between children in the control and the intervention condition in their emotional functioning, $p = .69$. There were no significant main effects of time or condition, *ps* > 0.5, nor did there emerge significant interactions between time and condition, $p > .41$. Gender and group do not moderate the results, $p > .30$. Thus, the results do not support a positive impact of greening schoolyards on children's emotional functioning.

5. Discussion

We conducted a prospective intervention study with a two-year follow-up to investigate the impact of greening schoolyards on schoolchildren's (aged 7–11) appreciation of the schoolyard, and their physical, cognitive, and social-emotional well-being. Results showed that, in line with the hypotheses, after their schoolyard was greened, children perceived it to be more natural compared to their previously paved schoolyard and to children whose schoolyard stayed paved. Furthermore, also consistent with our expectations, greening schoolyards had a positive impact on children's appreciation of the schoolyard, attentional restoration after recess and social well-being. The hypothesized positive effect of greening schoolyards on physical activity was partially confirmed only for girls.

Contrary to the expectations, greening had no impact on children's perceived restorative quality of the schoolyard. However, the greater improvements in their performance on attentional tasks from pre- to post-recess are in line with Attention Restoration Theory (Kaplan,

1995) which predicts that contact with green space can help to replenish depleted cognitive resources. The finding that restorative effects of greening only occurred after the schoolyards had already been greened for a longer period, is along the lines proposed by Collado and Staats (2016) that attention restoration is related to children's familiarity with and interpersonal relation to natural places.

The finding that in particular girls became more active after greening their schoolyard is consistent with previous studies that also showed a differential impact of greening schoolyards for boys and girls (Fjørtoft et al., 2009; Pagels et al., 2014). In the light of Affordance Theory (Gibson, 1979), these findings could be explained by Fjørtoft et al. (2009) who found that boys tend to be more attracted to paved areas in schoolyards that afford high speed activities as running and soccer playing. Girls on the other hand showed more interest than boys in green areas, where they engaged in more physically active behaviors. Further, the overall, but not significant, results could be explained by the assumption that green schoolyards in general could afford physical activity at lower speed, but more physically intense through motor activities as climbing a hill or tree. In the present study, the positive impact of greening on girls' activity levels was only found at first follow-up. However, at second follow-up girls at the schools with greened schoolyards remained at least equally active as girls at the control schools, whereas they were less active at baseline.

The finding that children reported fewer peer problems and more social support after the greening, supports previous studies, as well as the Theory of Loose Parts (Nicholson, 1972) and Affordance Theory (Gibson, 1979), that greening schoolyards affords more cooperative and prosocial play, and thereby fosters children's social well-being (Chawla et al., 2014; De Vries et al., 2013; Maas et al., 2013). Measurements of children's prosocial orientation provided further objective evidence for these notions, but only for younger children and only shortly after greening.

Although the biophilia hypothesis (Kellert & Wilson, 1995) and Stress Recovery Theory (Ulrich, 1983) suggest that engagement with nature has beneficial effects for children's emotional well-being, our results do not support this claim. One explanation for this could be that children reported relatively little emotional problems at baseline, which could indicate that there was not much room for the intervention to foster emotional well-being. Also, emotional well-being is influenced by a variety of factors and our methodology could be too limited to capture the full impact of greening schoolyards on schoolchildren's emotional well-being. The finding that greening schoolyards was especially beneficial for girls and younger children suggests that the greening may not have been compatible with the needs and abilities of boys and older children. This suggests that schoolyards in the current project could be further developed and used in ways that make them inclusive and support the well-being of all children, regardless of their gender and age.

5.1. Strengths and limitations

The present study addressed many of the shortcomings of previous research on greening schoolyards by employing a design with matched control groups and several follow-up measurements. We also combined self-report measurements with objective tests. However, the research is not without limitations.

First, we followed a quasi-experimental design, as it was not possible to randomly assign schools to intervention or control conditions. This may have led to a selection bias, as schools made a conscious choice to redesign their schoolyards. However, intervention and control schools were carefully matched on aspects such as socio-economic status and level of urbanization. Furthermore, random assignment of greening would seem inappropriate, because greening schoolyards requires long-term investments of teachers and parents. Without these investments, chances are that the greening will be unsuccessful and not lead to a positive impact on children's well-being (Maas, Muller, & Hovinga, 2014).

Second, the project only included schools from moderate-to highly urbanized areas. The question remains whether our results can be generalized to children living in more rural, green areas. Generalizability can be increased by expanding the sample with elementary schools varying in level of urbanization, as well as socio-demographic aspects.

Third, the quantity and quality of greening possibly influenced our results, leading to an underestimation of the impact of greening schoolyards for children's well-being. Although, all intervention schools had plans to substantially green their schoolyards, the actual greening was modest in some cases and all greened schoolyards still contained some paved areas. As a result, potential benefits of the greening may not have been fully realized because the greening did not allow children to really immerse themselves in nature and engage in the meaningful experiences as described by several theories. It is also possible that children still predominantly played at the paved areas. Mårtensson et al. (2014) for example found that although most children mark natural areas as their most favorite, this was not the area where they mostly played. The video observations of children's behavior in the schoolyards, which are still under analysis, may provide more insight in these issues. However, after two years at second follow-up the schoolyards of the intervention schools were still green and well-maintained. During the data collection, on every intervention school the principal and teachers talked about ideas to further green their schoolyard and increase the use of the schoolyard as a learning environment. In this light, the present study could be a first positive indicator of the impact of greening schoolyards with more promising future results.

Fourth, we used a between-subjects design which enabled us to eliminate noise in the data related to children's maturation and unrelated events occurring between the measurements. However, this design does not allow any conclusions about the impact of greening schoolyards on children's individual development over time. For such a study a within-subject design would be more suitable.

Lastly, data collection was limited to one day a year at each school over three consecutive years. This could have led to random errors, such as coincidence of time, weather conditions, novelty effects, or something out of the ordinary happening during recess or in the classroom. However, data collection on each school each year was scheduled in approximately the same period, researchers followed a strict protocol, and special occasions were avoided.

5.2. Conclusion and implications

In this longitudinal project we obtained support for a positive impact of greening schoolyards on children's appreciation of the schoolyards, and their cognitive and social well-being. Furthermore, we found some indications that greening schoolyards is a promising intervention to stimulate in particular girls to become physically active and that it can support pro-social behavior amongst younger children. To our knowledge, this is the first study on the impact of greening schoolyards that employed both a longitudinal design and proper control groups. In future research, our approach could be replicated and extended by, for instance, selecting schools from various socio-economic contexts and by including multiple days of data collection. Furthermore, we would advise researchers and schools to co-design green schoolyards, as to further understand how certain green areas in schoolyards afford children's experiences and thereby foster their well-being. This could stimulate designing inclusive green schoolyards that foster the well-being of all children.

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