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Outdoor environmental assessment of attention promoting settings for preschool children

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ABSTRACT

The restorative potential of green outdoor environments for children in preschool settings was investigated by measuring the attention of children playing in settings with different environmental features. Eleven preschools with outdoor environments typical for the Stockholm area were assessed using the outdoor play environment categories (OPEC) and the fraction of visible sky from play structures (sky view factor), and 198 children, aged 4.5–6.5 years, were rated by the staff for inattentive, hyperactive and impulsive behaviors with the ECADDES tool. Children playing in large and integrated outdoor areas containing large areas of trees, shrubbery and a hilly terrain showed less often behaviors of inattention ($p<.05$). The choice of tool for assessment of attention is discussed in relation to outdoor stay and play characteristics in Swedish preschool settings. The results indicate that the restorative potential of green outdoor environments applies also to preschool children and that environmental assessment tools as OPEC can be useful when to locate and develop health-promoting land adjacent to preschools.

1. Introduction

Green outdoor environment may be important to young children's health and development, as indicated by studies in the Scandinavian countries. Children in preschools with a green outdoor environment get higher levels of physical activity and more optimal levels of UV radiation (Boldeman et al., 2004; Söderström et al, 2004; Boldmann et al., 2006), improved motor development (Fjörtoft, 2001) and are absent fewer days due to illness (Söderström and Blennow, 1998; Grahn et al., 1997), compared to children in preschools with a more barren environment. The quality of physical environments at day care centers, renamed preschools in Sweden, is important for 86% of the children 1–5 years old who spend a majority of their waking hours at a preschool (National Agency for Education, 2007). Some preschools have outdoor stay all day or the major part of it, making them extremely dependent on the quality of preschool yard and public spaces such as playgrounds, parks and urban forests.

The green structure is continuously exploited in urban areas and the relative importance of density and green areas for a sustainable development, is subject to dispute. In an overview of how the quality of outdoor environments at preschools is safeguarded in the Nordic countries it was concluded that there is a lack of planning incentives in the area (Nordic Council of Ministers, 2007). The standard of outdoor environments varies widely and depends on local policies. Research can contribute by investigating the health potentials of staying in different types of outdoor environments and to develop tools for environmental assessment.

The development of the outdoor play environment categories (OPEC) is based on data from the video-tracking of children in different preschool settings (Mårtensson, 2004). The environmental features of the tool are motivated by characteristics found to be typical for agile outdoor play sequences (Mårtensson and Boldemann, 2008). The OPEC tool suggests that the play potential of large and integrated spaces with plentiful greenery and varied topography is higher, than that of small areas with open spaces, vegetation and play structures located in separate parts of the environment.

The sky view factor is another plausible tool for the evaluation of children's outdoor environments. The sky view factor defines the fraction of sky from a given position on the ground, i.e. sky

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that is uncovered by objects such as trees, buildings, etc. In this study the sky view factor is calculated from defined play areas (as play structures) to get an overall measure of the proximity between greenery and the children playing in the setting. Greenery is considered of major importance to promote outdoor play in preschool settings (Cosco, 2006; Grahn et al., 1997; Herrington and Studtmann, 1998; Mårtensson, 2004).

The attention restoration theory (Kaplan, 1995) defines two types of attention, (1) directed attention and (2) involuntary attention, sometimes called soft fascination. During directed attention the cognitive capacity to pursuit tasks and goals involves the inhibition of potentially distracting factors such as noise or the suppression of more immediate wishes and impulses. Directed attention is a demanding activity and a limited cognitive resource. When this resource is depleted, a state of directed attention fatigue may develop. Typical for this mental state is distractibility, restlessness, and forgetfulness. It is then important to create a situation in which the person can rely on involuntary attention that is a more effortless and interest driven form of attention. Natural environments contain many elements and characteristics that promote soft fascination and facilitate the recovery of directed attention, according to the attention restoration theory. In a dense social and physical environment with many tasks to fulfill it may be difficult to withdraw sufficiently to get the sleep or the rest required for recovery in a less severe state of attention fatigue. Green surroundings can make restoration possible as part of ongoing events in everyday life. For adults, even a glimpse out of the window can be restorative (Kaplan, 2001). It has been suggested that preschools belong to those potentially stressful settings in which very young children may take advantage of restorative environment as well (Kuo and Faber Taylor, 2004).

Several studies on adults demonstrate a correlation between the experience of nature and the improvement of the cognitive capacity required for directed attention (Hartig et al., 2003, 1991; Kuo, 2001; Ottosson and Grahn, 2005). For school age children the attention restoration theory has generated studies on the relation between greenery in everyday environment and different aspects of mental wellbeing. Green surroundings to dwellings have been positively related to impulse control in 7–12-year-old girls (Faber Taylor et al., 2001a). In studies on children having been diagnosed for behaviors of impulsivity, hyperactivity and attention deficit, these behaviors were experienced as less severe when after-school and weekend activities took place in green outdoor settings (Faber Taylor et al., 2001b; Kuo and Faber Taylor, 2004). For a group of children 7–12 years old the relocation to a more green dwelling environment was correlated to improved cognitive functioning (Wells, 2000). Direct effects on attention after a 20 min walk in a park versus a built setting, have also been demonstrated for a group of children with attention deficit hyperactive syndrome, 7–12-year old (Faber Taylor and Kuo, 2009).

For children of preschool ages there has not been any systematic study of green outdoor environments as a restorative environment. In a pilot study on children (4–6 years) 1991–1992 it was found that extended periods of play in a green outdoor environment were related to a higher degree of attention, compared to children spending shorter time outdoors in a well equipped but more barren environment (Grahn et al., 1997). It was a small study in which children in an urban area were compared with children living in the countryside, which might well explain the differences. An adapted version of an instrument originally developed for attention assessment in schoolchildren (ADDES) was used, as the tool adapted to children of preschool age (ECADDES), was not yet developed then.

This study investigates if green outdoor environments promoting children's physical activity, as previously analyzed (Boldemann et al., 2006), have effect on children's attention, as suggested by the attention restoration theory. The study could contribute to the development of tools for assessing health-promoting outdoor environments from the perspective of children. The primary aims of this study were to investigate:

(1) If the attention of preschool children is related to outdoor environments with different play potential, as assessed by the OPEC instrument.
(2) If the attention of preschool children is related to outdoor environments with different degree of proximity between natural elements and play structures, as assessed by the sky view factor.

2. Methods

2.1. Study population and preschool sites

Eleven preschools in the Stockholm area were selected to include a variation in outdoor environment characteristics and socio-economic status (Boldemann et al., 2006). Permission for the study was obtained from the Ethics Committee, the involved local authorities, the preschools and the parents. Data collection was carried out from the end of April to the beginning of June 2004.

In a letter the parents were informed about the study, and that it concerned the role of the outdoor environment for children's health, and its uniqueness in measuring attention behavior, physical activity and UV exposure at the same time. After written informed consent from the parents, 200/268 of the attending children aged $4\frac{1}{2}-6\frac{1}{2}$ years participated in the study (74%). The parents of 54 children (20 percent) did not respond (three reminders) and the parents of the remaining preschools (6 percent) declined participation. Drop-out was non-selective. Two children were excluded from final analysis due to missing data on physical activity and UV exposure. The number of participating children at each preschool varied between 9 and 30 (Table 2).

The total number of children at each preschool varied between 34 and 95, divided into units of 12–22 children. All preschools were staffed according to the recommendations of the National Agency of Education, i.e. one full time workforce per five to six children. The size of indoor spaces at the units varied between approximately 80 and 450 m^2 (median 100 m^2).

At three of the preschools the children spent 91–97% of the preschool day outdoors during the period. All of these had a yard adjacent to the building, but spent most of the time at a specific place in the woods with agreed upon borders defined by elements in the environment as a specific stone, tree, biking lane, etc. These places (each $>12{,}000\,m^2$) had a mixture of spruce and pine woods typical for the eastern lowlands of the Scandinavian Peninsula. The children at the remaining eight preschools stayed outdoors during 22–52% of the day (average 41%). The size of their respective outdoor environments were 11,000, 4638, 3848, 3307, 3059, 1587, 1270 and 1200 m^2. Outdoor stay was scheduled and the outdoor environments simultaneously used by children from different units.

2.2. Environment features (independent variable)

The outdoor environments were assessed using two separate tools previously used to investigate the health-promoting role of preschool outdoor environment (Boldemann et al., 2006), (1) the outdoor play environment categories (OPEC) based on studies of

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Figs. 1 and 2. Sky View by fish eye photography left column sky view factor <50%, right column sky view factor ≥50%, 100 cm (39.37 in.) above the ground 360° around the horizon. Adapted by Katarina Yuen and Ulf Wester (former Swedish Radiation Protection Authority), Stockholm, 2004.

outdoor play (Mårtensson, 2004; Mårtensson and Boldemann, 2008) and (2) the sky view factor measuring visible sky above play areas in preschool outdoor environments (Boldemann et al., 2006; Boldeman et al., 2004) as an overall measure of children's contact with greenery. Originally the calculations of sky view factors were developed for various environmental assessments from the sun in urban environments (Grimmond et al., 2001; Holmer et al., 2001).

2.3. OPEC

The outdoor environments were scored 1, 2 or 3 along three different variables. The three scores of each environment were summed up and divided by 3, yielding an average score for each environment ranging from 1 to 3.

The following three variables were assessed (A–C):

A. The total outdoor area accessible to the children.
   1 = small (<2000 m^2), 2 = medium (2000–6000 m^2), 3 = large (>6000 m^2)
B. The proportion of the area containing shrubbery, trees or hilly terrain:
   1 = little/nonexistent, 2 = <half of the area, 3 = ≥half of the area
C. The degree of integration between vegetation, open areas and play structures:
   1 = no integration. Most vegetation along edges and scanty vegetation adjacent to play structures.
   2 = either of the following characteristics
   (a) Play structures adjacent to trees and shrubbery or integrated into areas with the character of wild nature.
   (b) The open spaces are located in between play-areas and not in separate parts of the environment.
   3 = environments fulfilling both 2a and 2b above.

Aerial photos were used to assess the size and the layout and proportion of the outdoor areas with different content. Ocular assessment in situ was made to check children's access to different parts of the environment, the position of play structures and other content in areas that were covered, e.g. by trees on the photos. OPEC scores for the three preschools where the children stayed outdoors the major part of the day and used both an adjacent yard and a play area in the woods were calculated as an average of both settings. The outdoor settings of each preschool were dichotomized into "high-score" and "low-score" environments in analysis (statistical cut-off: 2,0). The values for high- and low-score OPEC environments were 2,3; 2,6; 2,6; 2,6; 2,6, and 1,6; 1,6; 1,6; 1,6; 1,8; 2,0, respectively. All preschools were included in the overall analysis. A separate analysis was also made for preschools with regular length of outdoor stay periods by excluding the three preschools in which children stay outdoors the major part of the day.

2.4. Sky view factor

The sky view factor, i.e. the fraction of free sky above play structures, was imaged by fish eye photography 100 cm above the ground, i.e. the height below which 3–5-year-old children usually play (Boldemann et al., 2006). The selected positions were all play structures and other play areas of frequent use as estimated from physical traces of environmental use and confirmed by the staff. Fish eye photos were taken from the center of each play area (10–12 per preschool) and dichotomized into <50% and ≥50% of free sky in analysis (Figs. 1 and 2).

2.5. Attention (dependent variable)

The Early Childhood Attention Deficit Disorders Evaluation Scale (ECADDES, School version) (McCarney, 1995) was applied to measure attention. The tool was developed for the detection of behavior characteristics typical for attention-deficit/hyperactivity disorder with two main domains of attention being evaluated: inattention and hyperactivity/impulsivity. Inattention items are, e.g. "Requires eye contact in order to listen successfully", "Forgets", "Fails to remember sequences, e.g. in daily routines". The second dimension contains a mix of hyperactivity items as, e.g. "Moves about while seated" and "Becomes overexcited", and impulsivity items, e.g. "Intrudes on others" and "Blurts out answers without being called on".

The tools developed by McCarney (1995, 1989) to measure children's attention were evaluated as high in standardization, validity and reliability and recommended as a part of intervention in school settings (Demaray et al., 2003; Kohli, 1998). The similarities between statements describing hyperactive, impulsive and inattentive behaviors in these tools, to those behaviors described as typical for attention fatigue by Kaplan (1995) in the attention restoration theory, have made the instruments

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appraised as useful in research on restorative environments for children. The Attention Deficit Disorders Evaluation Scale (ADDES) developed for children (4–18 years) has been used on children 7–12 years (Wells, 2000) and in an adapted version on preschool children as well (Grahn et al., 1997). The Early Childhood Attention Deficit Disorders Evaluation Scale (ECADDES, School version) (McCarney, 1995) was later developed to measure attention functioning in children 2–6 years and 11 months.

The ECADDES tool is based on normative observation data for American children aged 2–6 years old and is standardized for age and sex. It contains 56 items of descriptive statements on the child's behavior in preschool settings which cluster around the dimension of inattention (32 items) and the dimension of hyperactivity/impulsivity (24 items). Each child was rated by two members of the staff who according to the instructions, meet the child on a regular basis in preschool and are familiar with its behavior. The ratings should be based on how the child's behavior is acknowledged during the everyday course of life. Each child is rated independently using separate forms and without conferring with each other. The time for completing the questionnaire for one child could take several days and according to the manual there is no definite time limit.

Each behavior item of the ECADDES form was rated from 0 to 4, with a lower score indicating a lower occurrence and a higher score indicating a higher occurrence of a specific negative behavior, 0 = child does not engage in the behavior at all, 1 = behavior occurs one to several times per month, 2 = behavior occurs one to several times per week, 3 = behavior occurs one to several times per day, and 4 = behavior occurs one to several times per hour. The ratings were tested in factor analysis (Table 1).

The sum of the ratings per child on each dimension, *raw scores*, was converted into *standard scores* taking into account sex and age based on a normally distributed sample according to the McCarney (1995) manual. For the age group under study the standard scores were in the range 1–13. Standard scores ≥ 7 are in the normal range (<1 standard deviation from the mean for a normally distributed sample of children). Standard scores 4–6 indicate a cluster of behaviors of "concern" (>1 standard deviation from the mean) and standard scores below 4 indicate behaviors of "serious concern" (>2 standard deviations from the mean). The standard scores were divided into five classes of standard scores called *graded scores* along McCarney, and labeled as follows (standard scores↔ graded scores): 1–3↔5, 4–6↔4, 7–8↔3, 9–10↔2, 11–13↔1. For greater clarity in the figures the standard scores were regrouped into three classes of standard scores: Class 1 contains standard scores >10 (graded score 1), class 2 standard scores 7–10 (graded scores 2 and 3), and class 3 standard scores ≤ 6 (graded scores 4 and 5).

2.6. Control variables

Variables plausibly related to attention were measured. Data on parent's socio-economic status and mother's education (Statistic Sweden, 1995), and parents' estimated hours of the child's sleep per night, the child's physical leisure activities and if the child was content with preschool stay, were collected by a questionnaire to the parents. The children's body mass indexes were assessed and calculated by the investigators and time spent outdoors was recorded by the staff, converted into percentage of the whole preschool day ("outdoor fraction"). Physical activity measured by pedometry and expressed as steps per minute, was included as well (for further details on data collection see Boldemann et al., 2006).

Table 1
Factor analysis.

	Data Stockholm		Data McCarney	
	Factor 1	Factor 2	Factor 1	Factor 2
Inattention				
ec1	.43	.67	.48	.64
ec2	.33	.72	.49	.67
ec3	.41	.64	.44	.71
ec4	.41	.75	.40	.76
ec5	.31	.88	.42	.76
ec6	.37	.83	.41	.79
ec7	.31	.82	.41	.77
ec8	.33	.81	.40	.71
ec9		.79	.41	.75
ec10		.83		.83
ec11	.31	.69		.80
ec12		.85	.39	.81
ec13	.36	.63	.33	.75
ec14	.45	.53	.39	.76
ec15	.36	.68	.30	.76
ec16		.74	.38	.78
ec17	.41	.75	.48	.73
ec18	.40	.65	.69	.39
ec19		.86	.42	.70
ec20	.48	.65	.48	.72
ec21	.35	.72	.41	.77
ec22	.50	.60	.41	.70
ec23	.41	.69	.39	.75
ec24	.43	.71	.50	.66
Hyperactivity				
ec25	.71	.37	.68	.51
ec26	.76	.37	.69	.39
ec27	.53	.58	.78	
ec28	.63	.34	.79	.31
ec29	.61	.47	.81	.34
ec30	.65		.77	.32
ec31	.77		.70	.51
ec32	.68		.69	.53
ec33	.73	.31	.76	.46
ec34	.62	.40	.80	.32
ec35	.64	.47	.72	.50
ec36	.76	.39	.66	.52
ec37	.60		.72	.49
ec38	.67	.43	.75	.46
ec39	.66	.48	.57	.64
ec40	.76	.39	.66	.45
ec41	.63		.57	.66
ec42	.50	.61	.56	.65
ec43	.35	.65	.54	.66
ec44	.73		.66	.54
ec45	.67	.42	.59	.64
ec46	.60	.38	.71	.37
ec47	.34	.44	.67	.44
ec48	.68	.43	.78	.37
ec49	.49	.68	.71	.52
ec50	.63		.75	.43
ec51	.67	.47	.78	.38
ec52	.65	.48	.75	.47
ec53	.60		.70	.50
ec54	.72	.38	.67	.36
ec55	.65	.38	.77	.37
ec56	.45	.66	.73	.45

Loadings of each of the scored items, motivating the scores for inattention and hyperactivity based on ec1–ec24 and ec25 and ec56, respectively (loadings between −.3 and +.3 not shown). Factor loadings for Factor 1 (hyperactivity/impulsivity) and Factor 2 (inattention) after varimax rotation. Preschool children of Stockholm County, 2004 ($N = 198$), compared with McCarney data.

2.7. Statistical analysis

The obtained original ratings of ECADDES (raw scores, not adjusted for age and gender) were tested for validity by factor

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analysis along the procedures applied to the original sample of American children (McCarney, 1995). The first two factors were chosen, describing 62.6% of the variation. A varimax rotation was done to compare loadings (Table 1). Most items related to inattention had a final factor loading similar to, or higher than the results presented by McCarney. The pattern for the items related to hyperactivity/impulsivity score presents some items with lower loadings than presented by McCarney (Table 1).

The correlation of OPEC and sky view factor for the 11 preschools was tested by Pearson correlation.

To test the correlation of OPEC and the sky view factor to hyperactivity/impulsivity and inattention, respectively, a nested mixed model with preschool as random factor was applied (procedure Mixed in SAS). To find the relevant covariates, backward elimination was used starting with the variables body mass index, hours of sleep per night, physical activity (mean number of steps/min during the study period), leisure time activity (yes/no), if the child is content with preschool stay (yes/no), mother's education, outdoor fraction (%), hours spent outdoors on Sundays, and parent's socio-economic status. Independent variables were removed one by one to find the optimal model for each dimension of hyperactivity/impulsivity and inattention. The final models for both OPEC and sky view factor contained the variables leisure time activity, if the child was content with preschool stay, mother's education, outdoor fraction, hours spent outdoors on Sundays and parent's socio-economic status. To enable a comparison between the outcomes of high and low OPEC and low and high sky view factor, the least-squares means were calculated. One analysis included all preschools and the other excluded preschools with outdoor stay the major part of the day.

For analysis SAS Release 8.2 was used and the significance level .05 was used.

3. Results

The correlation between the values of OPEC and the values of sky view factor for the eleven preschools was $r = -.69$ ($p < .05$). The 198 children were evenly distributed between environments with high- and low-score OPEC and high- and low-sky view factor. More boys participated in the study than girls (115/83) (Table 2). The percentage of time spent outdoors during preschool stay (outdoor fraction) and physical activity (steps/min) were higher among children attending preschools with high-score environment and low-sky view factors (Table 2).

The distribution of graded scores of hyperactivity/impulsivity and inattention dimensions versus OPEC and the sky view factor, respectively, are shown in Figs. 3 and 4. The graded scores (1–5) are classes of standard scores used in analyses but regrouped into three classes of standard scores in the tables. Only a few percent of the children had behaviors of concern according to the McCarney (1995) manual.

In the tests of effects using a nested mixed model with random effect of preschools, OPEC was significantly related to the inattention dimension ($p < .05$). It was also close to significant in relation to the hyperactivity/impulsivity dimension ($p = .069$) (Table 3). One out of six control variables had a significant relation to the hyperactivity/impulsivity dimension (Children's outdoor time on Sundays) and three out of six on the inattention dimension (Mother's education, Children's outdoor time on Sundays, and Outdoor fraction). The difference in least-squares means values was at large the same for both dimensions (Table 3).

The directions as presented in Table 3 show that high socio-economic status, high level of mother's education, leisure time activity and if the child was content with preschool stay, correlates with lower incidence of Hyperactive/Impulsive behavior while long outdoor stays during the preschool day (outdoor

Table 2
Distribution of variables between preschool children in environments with high-score and low-score OPEC and low and high fraction of free sky (sky view factor), respectively, Stockholm county, 2004.

		High-score OPEC preschools	Low-score OPEC preschools	*p*-value	Sky view factor <50% preschools	Sky view factor ≥50% preschools	*p*-value
Number of children assessed with ECADDES ($N = 198$)				x^2			x^2
Girls, *n* (%)	85 (43)	39 (39)	46 (47)	ns	42 (40)	43 (47)	ns
Boys, *n* (%)	113 (57)	61 (61)	52 (53)	ns	64 (60)	49 (53)	ns
Total *n* (%)	198 (100)	100 (100)	98 (100)		106 (100)	92 (100)	
				Difference, *p*-value			Difference, *p*-value
Mean age, year (SD)	5.26 (.56)	5.32 (.52)	5.21 (.58)	ns	5.29 (.55)	5.24(.57)	ns
Mean steps/min, girls (SD)	18.0 (4.0)	19.3 (4.0)	16.9 (3.6)	<.01	19.7 (3.9)	16.4 (3.4)	<.001
Mean steps/min, boys[a] (SD)	20.9 (5.4)	23.0 (4.7)	18.5 (5.3)	<0.001	22.1 (4.8)	19.3 (5.8)	<.01
Outdoor fraction % (SD)[b]	54.3 (25.7)	62.9 (26.0)	45.5 (22.3)	<.001	61.9 (25.6)	45.5 (23.0)	<.001
Mean body mass index (SD)	15.9 (1.6)	15.8 (1.6)	16.0 (1.5)	ns	15.8 (1.6)	16.0 (1.5)	ns
Mean hours of sleep per night (SD)	10.7 (.6)	10.7 (.6)	10.6 (.7)	ns	10.8 (.6)	10.6 (.7)	.05
Mean hours spent outdoors on Sundays (SD)	2.9 (1.6)	3.0 (1.6)	2.8 (1.5)	ns	3.0 (1.5)	2.8 (1.6)	ns
				x^{2b}			x^{2b}
Engaged in leisure time activity, yes: *n* (%)	81 (42.6)	52 (64.2)	29 (35.8)		54 (66.7)	27 (33.3)	
Engaged in leisure time activity, no: *n* (%)	109 (57.4)	43 (39.4)	66 (60.6)	<.01	48 (44.0)	61 (56.0)	<.01
Mother's education, high: *n* (%)[c]	55 (29)	30 (54.6)	25 (45.4)	ns	22 (40.0)	33 (60.0)	<.05
Mothers education, low: *n* (%)[c]	134 (71)	62 (46.5)	72 (53.5)		81 (60.4)	53 (39.6)	
Socioeconomic standard, high: *n* (%)	100 (54)	63 (63.0)	37 (37.0)		69 (81.2)	16 (18.8)	
Socioeconomic standard, low: *n* (%)	85 (46)	27 (31.8)	58 (68.2)	<.001	33 (33.0)	67 (67.0)	<.001

[a] Based on data delivered by 112 boys as one boy from a low-score OPEC/>50% sky view factor-site were absent during the all the days during which step counts were made.
[b] Fisher's exact test.
[c] Mother's education was dichotomized high education/low education with a cut-off at professional/white collar worker.

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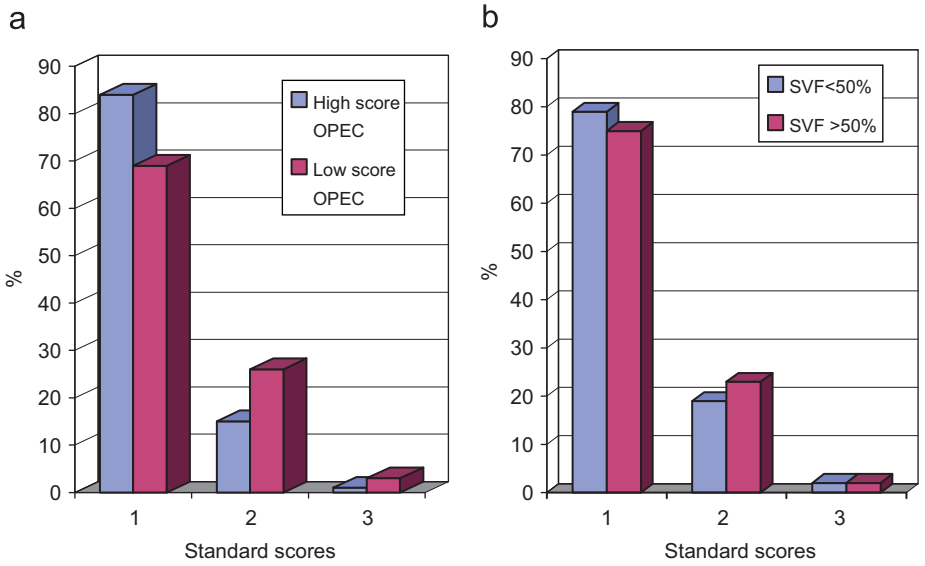

Fig. 3. (a, b) Standard score classes of hyperactivity/impulsivity of the children (%) vs. OPEC and sky view factor, in 11 preschools in Stockholm County 2004. 1 = standard scores >10 (graded score 1), behaviors in the normal range*; 2 = standard scores 7–10 (graded scores 2 and 3), behaviors in the normal range*; 3 = standard scores ≤6 (graded scores 4 and 5), behaviors indicating concern*. *According to McCarney (1995) standard scores <6 represent behavior indicating concern and ≤3 behavior of serious concern and standard scores ≥7 behaviors within the normal range.

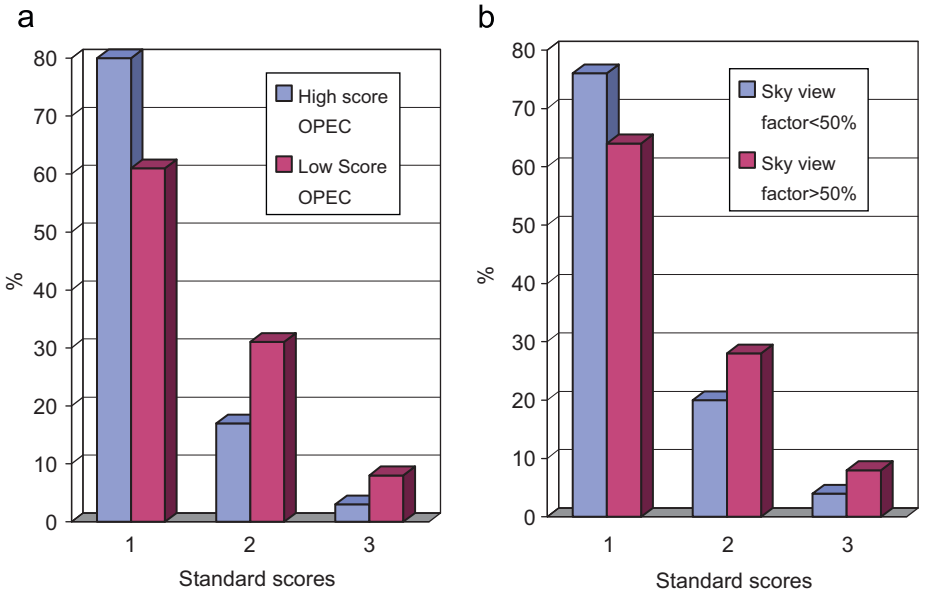

Fig. 4. (a, b) Standard score classes of inattention of the children (%) vs. OPEC and sky view factor in 11 preschools in Stockholm County 2004. 1 = standard scores >10 (graded score 1), behaviors in the normal range*; 2 = standard scores 7–10 (graded scores 2 and 3), behaviors in the normal range*; 3 = standard scores ≤6 (graded scores 4 and 5), behaviors indicating concern*. *According to McCarney (1995) standard scores <6 represent behavior indicating concern and ≤3 behavior of serious concern and standard scores ≥7 behaviors within the normal range.

fraction) and many hours spent outdoors on Sundays correlate with higher incidence of Hyperactive/Impulsive behaviors.

The sky view factor was not significantly related to either dimension of attention. One control variable (Children's outdoor time on Sundays) had a significant impact on the hyperactivity/impulsivity dimension, whereas two control variables (Mother's education and Children's outdoor time on Sundays) were significantly related to the inattention dimension. The difference in least-squares means values was at large the same for both dimensions (Table 4).

In the tests of preschools with regular length on outdoor stay periods, with preschools staying outdoors all day excluded, OPEC was significantly related to both the inattention and the hyperactivity/impulsivity dimension ($p<.05$) (Table 5). Even here, one out of six control variables had a significant relation to the hyperactivity/impulsivity dimension (Children's outdoor time on Sundays); however, two out of six on the inattention dimension (Mother's education and Children's outdoor time on Sundays). The difference in least-squares means values was at large the same for both dimensions (Table 5). The sky view factor was not significantly related to either dimension of attention (not shown in table).

4. Discussion

The main finding in this study was that green outdoor environments, as assessed by the OPEC tool, correlated to the

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Table 3
OPEC.

	Mixed model, Type III tests of fixed effects *F*-value (*p*-value)	LS means, low-score	LS means, high-score
Hyperactivity/impulsivity			
SES	(−) .60 (ns)		
Mother's education	(−) 1.40 (ns)		
Children's outdoor time on Sundays (h)	(+) 5.24 ($p<.05$)		
Leisure time activities	(−) .22 (ns)		
Outdoor fraction	(+) .53 (ns)		
Content with preschool stayt	(−) .10 (ns)		
OPEC	(−) 4.25 ($p=.069$)	1.59	1.23
Inattention			
SES	(−) 1.13 (ns)		
Mother's education	(−) 3.97 ($p<.01$)		
Children's outdoor time on Sundays (h)	(+) 7.42 ($p<.01$)		
Leisure time activities	(+) .93 (ns)		
Outdoor fraction	(+) 2.65 ($p<.05$)		
Content with preschool stay	(−) .23 (ns)		
OPEC	(−) 7.38 ($p<.05$)	1.87	1.46

The factors influencing "hyperactivity/impulsivity" and "inattention" in children attending preschools in the Stockholm County, 11 preschools (all preschools included) 2004 analyzed by Mixed model, together with the least-squares means values of graded scores for the two levels of OPEC. The direction of each relation is indicated, positive (+) and negative (−).

Table 4
Sky view factor.

	Mixed model, Type III tests of fixed effects *F*-value (*p*-value)	LS means, high	LS means, low
Hyperactivity/impulsivity			
SES	(−) .54 (ns)		
Mother's education	(−) 1.33 (ns)		
Children's outdoor time on Sundays (h)	(+) 4.87 ($p<.05$)		
Leisure time activities	(−) .28 (ns)		
Outdoor fraction	(+) .21 (ns)		
Content with preschool stay	(−) .09 (ns)		
Sky view factor	(−) .71 (ns)	1.52	1.34
Inattention			
SES	(−) .86 (ns)		
Mother's education	(−) 3.51 ($p<.01$)		
Children's outdoor time on Sundays (h)	(+) 6.67 ($p<.05$)		
Leisure time activities	(+) .60 (ns)		
Outdoor fraction	(+) 1.13 (ns)		
Content with preschool stay	(−) .05 (ns)		
Sky view factor	(−) 1.51 (ns)	1.81	1.55

The factors influencing "hyperactivity/impulsivity" and "inattention" in children attending preschools in the Stockholm County, 11 preschools (all preschools included) 2004 analyzed by Mixed model , together with the least-squares means values of graded scores for the two levels of sky view factor. The direction of each relation is indicated, positive (+) and negative (−).

attention of preschool children. This finding supports the hypothesis that green outdoor environment has salutogenic potentials for children attending preschools (Boldemann et al., 2006; Cosco, 2006; Fjörtoft, 2001; Grahn et al., 1997; Herrington and Studtmann, 1998; Söderström and Blennow, 1998). The relation was significant versus the Attention dimension of the ECADDES tool and of borderline significance versus the hyperactivity/impulsivity dimension. Contrary to expectations there

Table 5
OPEC.

	Mixed model, Type III tests of fixed effects *F*-value (*p*-value)	LS means, low-score	LS means, high-score
Hyperactivity/impulsivity			
SES	(−) .02 (ns)		
Mother's education	(−) 2.06 (ns)		
Children's outdoor time on Sundays (h)	(+) 11.00 ($p<.01$)		
Leisure time activities	(−) .42 (ns)		
Outdoor fraction	(+) 1.37 (ns)		
Content with preschool stay	(−) 2.51 (ns)		
OPEC	(−) 10.60 ($p<.05$)	1.59	1.06
Inattention			
SES	(−) .06 (ns)		
Mother's education	(−) 5.04 ($p<.01$)		
Children's outdoor time on Sundays (h)	(+) 8.85 ($p<.01$)		
Leisure time activities	(+) .25 (ns)		
Outdoor fraction	(+) 1.15 (ns)		
Content with preschool stay	(−) 2.27 (ns)		
OPEC	(−) 10.50 ($p<.05$)	1.81	1.28

The factors influencing "hyperactivity/impulsivity" and "inattention" in children attending preschools in the Stockholm County, 8 preschools (outdoor preschools excluded) 2004 analyzed by Mixed model, together with the least-squares means values of graded scores for the two levels of OPEC. The direction of each relation is indicated, positive (+) and negative (−).

was no significant difference in attention between children using outdoor environments with different sky view factors.

Long outdoor stay during the preschool day was expected to boost attention, especially in interaction with high score OPEC environment. Contrary to expectations there was a negative correlation between children's attention and length of outdoor stay in preschool. However, an analysis excluding the preschools in which children stay outdoors the major part of the day showed that this was not the case for children in preschools with more ordinary lengths of outdoor stay. Children with long preschool days at outdoor preschools have long outdoor stay periods. Long preschool days is possibly correlated to a life situation, e.g. with parents working long hours, that is stressful. It could also make the health reasons to encourage outdoor stay at preschool all day long, as common in the Nordic countries, less convincing. As implied by the concept of "restoration" children cannot "re-store" their cognitive capacity beyond restoration. Questions are further to be raised regarding the applicability of the ECADDES tool to outdoor settings.

As expected mother's education seems to influence the child's behavior, but it is noteworthy that the socio-economic status of the child did not seem to have the same effect. Possibly the quality of the preschool environment may be of greater importance for children from lower socio-economic conditions. Fathers and their education may also be considered as fathers are much more involved in the daily life of their children today than 10 years ago (Statistics Sweden, 2008).

Another limit of the study is the variation in number of participating children between the preschools, which could have put different weights on the outdoor environments in the model. The nested mixed model was applied to minimize this effect. Also outings could have affected the results. However, the staff made notes of visits to locations outside the preschool area and areas in the woods that were used daily were included in environmental assessment. A confounder not included was the psychosocial climate among the staff, always an important factor when

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children's behavior in the everyday environment is investigated, not least at preschools where the work strain can be high due to infections, shortage of staff, quality of leadership etc. Apart from this, the working models and attitudes to children in the Swedish preschools are relatively uniform, making it likely that children meet similar strategies, e.g. in case of problematic behavior. The square meter per child is a usual indicator for crowding in preschool settings which could have been included in the model, but should be considered a more serious threat to children's restoration in more crammed preschool settings.

When studying restorative environments based on the attention restoration theory (Kaplan and Kaplan, 1989; Kaplan, 1995), the rationale for studying hyperactive and impulsive behavior cannot be taken for granted. At face value these behaviors are distinct from those associated to the concept of attention. In a study by Wells (2000) only the inattention variable of the ADDES tool was used to test if green outdoor environments were restorative for children, but in a Swedish case study both dimensions of the tool were included (Grahn et al., 1997). A recent study (Faber Taylor and Kuo, 2009) on attention promoting greenery included both children with symptoms of attention deficit and children with symptoms of hyperactive/impulsivity, as part of ADHD. This was based on the experience of inattentive and hyperactive behaviors being interrelated with and aggravated by attention fatigue, e.g. of symptoms being more troublesome in a tired child. To guide future research the theoretical construct of these behaviors in children needs to be further scrutinized in relation to the construct of attention fatigue.

In this study, the OPEC instrument measured qualities of outdoor environment that had an influence on the attention of children attending preschools. The tool was easy to use but could be criticized for being a blunt measure as the calculation yields few values. The application of the tool to other regions with outdoor environments that are, e.g. smaller or contain less greenery needs consideration of the range and weight for each environmental dimension. The values for sky view factor are defined by objective measurements and could be a more differentiating variable. In this study in the Stockholm area it was not significantly related to the dependent variables, but could turn out to be in climates with stronger UV radiation where children seek the shade for thermal comfort or where play structures make up more of the overall play potential. If children use woodland, lawns or other natural features extensively, a behavior mapping procedure could be used to find the actual play areas from where to measure the sky view factor.

The ECADDES tool used to measure attention seems to be well adapted to children in Sweden. In factor analysis the congruence of the items was generally high between the Swedish and the original sample from the US. However, the loadings of several items in the dimension of "hyperactivity/impulsivity" were lower. This could possibly be explained by the way Swedish preschool teachers tend to apprehend a child's failure to follow instructions or comply with routines. Such behaviors could be acknowledged as natural components of children's exploration and "free play", cherished forms of activity in Swedish preschools. Some preschool teachers even expressed discomfort in applying the tool due to its wording on what the child was unable instead of able to do, which may have hampered validity. The results indicate that the inattention items were simpler for the staff to identify and rate, possibly making this part of the tool more valid for the study of restorative environments in a Swedish preschool context.

A complication using ECADDES in the study of restorative environments for children is that behaviors appraised as inattentive are more common in outdoor settings in general, and in high OPEC outdoor environments particularly. This could be an alternative explanation for length of outdoor time being negatively related to attention for children staying the major part of the day in high OPEC outdoor environments. The situated and very concrete character of playing, typical for the youngest children (Evaldsson and Corsaro, 1998), is characteristic for children of all ages when playing outdoors in green environments (Mårtensson, 2004). The typical outdoor play structure is open and flexible, creating a situation easy to influence for the individual child and promoting play sequences in which rapid sequences easily alternate with calmer sequences of more intimate interaction with place and peers. Such outdoor play of "flux and transformation" could very well be evaluated as containing plenty of inattentive, hyperactive and impulsive behaviors. The ECADDES tool does not distinguish between indoor and outdoor settings, but many of the items apply to situations related to rules set by adults and supported by cues in the indoor environment, making it more applicable to indoor settings. In preschools staying outdoors the major part of the day, there are no or very few opportunities to assess children's indoor behavior.

It would be an improvement to develop a tool more neutral to the setting than the ECADDES tool, i.e., a tool focusing on the child's contact with peers and the physical environment, rather than the child–adult interaction in attention assessment. Using a cognitive test adapted to the age group is another option, as has been done in research on restorative environments for adults (Ottosson and Grahn, 2005; Kuo, 1992, 2001), and for school children (Taylor and Kuo, 2009). A third option is to include outdoor play as a mediating factor in the research design, combining the tracking of play sequences with concurrent measurements of psycho-physiological states (e.g. cortisol in salvia and pulse rate). Integrating the perspective of psycho-physiological stress reduction (Ottosson and Grahn, 2005; Korpela et al., 2007; Ulrich, 1984) with the attention restoration theory (Kaplan and Kaplan, 1989; Kaplan, 1995) into a more general theoretical framework on mental restoration (Hartig, 2004) can be especially helpful when studying restorative environments for children. Children perceive the physical environment with their bodies and are less subordinated to visual perceptions than adults (Nordström, 1993). In adapting the experiential values described as restorative for adults (Kaplan et al., 1998; Kaplan and Kaplan, 1989) to preschool children, the experiences they make while moving around in the environment, must be considered. If an outdoor environment scored high on OPEC is likely to afford those experiential values described as restorative (fascination, being away, extent and compatibility), and if these values of adult have any correspondence to children's way of experiencing the environment, is far beyond the scope of this study but further investigation is well motivated by its results.

To conclude, the study shows that children in preschools with green, spacious and well-integrated outdoor environments have higher attention. The OPEC tool, a descriptive environmental assessment tool based on children's actual play behavior in outdoor settings, was useful. Added to previous findings the study show that high score OPEC environments that promote physical activity in terms of step count and spontaneous sun protective behavior resulting in low UV exposure, can also promote attention in preschool children. Handy assessment tools as OPEC may serve to locate health-promoting land for inclusion in child care settings and in guiding the development of new green areas adjacent to preschools, a task of common interest in architectural design, city planning, early childhood education and health promotion.

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