Journal of Environmental Psychology 35 (2013) 110–120

Contents lists available at SciVerse ScienceDirect

Journal of Environmental Psychology

journal homepage: www.elsevier.com/locate/jep

Child-friendly urban structures: Bullerby revisited

Anna Broberg [a,*], Marketta Kyttä [a,1], Nora Fagerholm [b,2]

[a] Department of Surveying and Planning, Aalto University, P.O. Box 12200, 00076 Aalto, Finland
[b] Section of Geography, Department of Geography and Geology, University of Turku, 20014 Turku, Finland

ARTICLE INFO

Article history:
Available online 20 June 2013

Keywords:
Child friendliness
Built environment
Affordance
Independent mobility
GIS

ABSTRACT

Definitions of environmental child friendliness offer broad criteria that are not easy to study or assess. We suggest that due to this broadness, these definitions have produced surprisingly few attempts to evaluate how child-friendly various types of physical environments are. The purpose of this study is to analyse how the structure of the built environment contributes to environmental child friendliness. We define child friendliness by two central criteria: children's possibilities for independent mobility and their opportunities to actualize environmental affordances.

We study how built environment qualities condition environmental child friendliness in place-based ways by asking children and youth in Turku, Finland, to tell about their meaningful places and their mobility to these. The data consists of over 12,000 affordances, localized by the respondents. This experiential and behavioural place-based knowledge is combined with objectively measured data on residential and building density, and quantity of green structures.

Moderate urban density seems to have child-friendly characteristics such as an ability to promote independent access to meaningful places and the diversity of affordances. We find that affordances situated on residential areas are likely to be reached alone, whereas access to affordances situated in densely built urban cores is less independent. The proportion of green structures is not associated with independent access. The diversity of affordances is highest in areas that are densely populated and not very green. Green areas are important settings for doing things, and green structures around emotional affordances increase the likelihood of liking the place significantly.

Combining children's place-based experiences with information derived from objective measurable qualities of the physical environment provides a valuable methodological contribution to studies on environmental child friendliness, and the two proposed criteria of child friendliness are supported by this study. There is no one environment that is child-friendly, but different environments have different uses and meanings.

1. Introduction

The research literature offers an abundance of definitions concerning environmental child friendliness, where the criteria for child friendliness are often relatively broad and not easy to study and assess (see Chatterjee, 2005; Horelli, 2007; Schulze & Moneti, 2007). These different definitions of environmental child friendliness have produced surprisingly few attempts to evaluate the child friendliness of various types of physical environments or to study the structural variables of the urban fabric that contribute to this matter. We argue that it may – at least partly – be due to the abstractness, broadness and vagueness of these definitions.

To deepen the understanding of urban characteristics promoting environmental child friendliness, a more focused and operationalizable definition of environmental child friendliness is needed. The Bullerby model by Kyttä (2008) is one candidate for such an approach. According to this assessment model, environmental child friendliness can be defined by two central criteria: children's possibilities for independent mobility and their opportunities to actualize diverse environmental affordances.

The Bullerby model is a theoretical tool for assessing the child friendliness of various settings. In this article, we propose an approach where the model is used to study how specific, built environment qualities condition environmental child friendliness in place-based ways. Our target in this paper is to combine both children's experiential and behavioural place-based knowledge

* Corresponding author. Tel.: +358 505124554; fax: +358 947024071.
E-mail addresses: anna.broberg@aalto.fi (A. Broberg), marketta.kytta@aalto.fi (M. Kyttä), ncfage@utu.fi (N. Fagerholm).
[1] Tel.: +358 505124554; fax: +358 947024071.
[2] Tel.: +358 2 333 5596; fax: +358 2 333 5896.

0272-4944/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jenvp.2013.06.001

with objectively measurable, place-based characteristics of specific settings.

1.1. Definitions of child-friendly environments

The research literature offers an abundance of definitions concerning environmental child friendliness. Themes like safety, available green space, variety of activity settings, independent mobility possibilities, active socialization or "neighbourliness", and integration of children into decision-making processes are often included as essential criteria of environmental child friendliness (Freeman & Tranter, 2011; Haider, 2007; McAllister, 2009). These kinds of broad, extensive criteria are also the basis of the work of the international network of Child Friendly Cities promoted by UNICEF. The Child Friendly City Initiative (CFCI) encourages local governments to make decisions that are in the best interests of children and promote children's rights to a healthy, caring, protective, educative, stimulating, non-discriminatory, inclusive and culturally rich environment (Malone, 2001; Riggio, 2002; Schulze & Moneti, 2007).

An example of a more systematic definition of environmental child friendliness embedded in both substantive and procedural theories of a good environment is produced by Horelli (2007). The resulting definition includes 10 normative dimensions: (1) Housing and dwelling, (2) Basic services, (3) Participation, (4) Safety and security, (5) Family, peers and community, (6) Urban and environmental qualities, (7) Provision and distribution of resources and poverty reduction, (8) Ecology, (9) Sense of belonging and continuity, and (10) Good governance. When children in different countries were questioned about their thoughts on the dimensions in the definition of environmental child friendliness by Horelli (2007), only a few of these themes were brought up by the children themselves. Safety and security, urban and environmental qualities, and basic services were among the sets of criteria relevant to children in Finland (Haikkola, Pacilli, Horelli, & Prezza, 2007) and in Sweden (Nordström, 2010). When queried about these same dimensions, Italian children mentioned urban and environmental qualities and basic services in accordance with the Finnish and Swedish children, but they did not mention environmental safety (Haikkola et al., 2007). These findings resonate interestingly with the earlier results of the *Growing Up In Cities* project (Chawla, 2002), where the provision of basic services, the variety of activity settings, and the freedom from physical dangers were also among the factors that children from six continents and eight different countries indicated as primary indicators for a child-friendly environment. In addition to these three themes, green areas, freedom of movement, and peer gathering places were also important positive physical qualities of a child-friendly environment.

Chatterjee (2005, 2006) also finds the definitions of child friendliness to be too broad and suggests that a child-friendly city can only be studied as a disaggregation, made up of a number of child-friendly places that children have a friendly relationship with. She proposes a new theoretical concept of place-friendship that she bases on a review of the literature on childhood friendship. Based on the six dimensions of place-friendship, Chatterjee offers a working definition of child-friendly places in a child's everyday environment, where these places:

1. provide opportunities for children to develop an attitude of care for places that children love and respect;
2. promote a meaningful exchange between child and place through affordance actualization in places;
3. offer opportunities for environmental learning and developing environmental competence through direct experience in places;
4. allow children to create and control territories and protect these territories from harm;
5. provide privacy experiences and nurture childhood secrets; and
6. allow children to express themselves freely in place.

While we find Chatterjee's conceptualization interesting, it still seems to be relatively difficult to operationalize. In her dissertation, Chatterjee (2006) questioned children in New Delhi about their important places. Based on the data acquired from children, she concludes that rather than having three separate dimensions concerning activities of children in relatively constraint-free places, dimensions number four and six ('creating and controlling territories' and 'freedom of expression in place') could be included under the higher level construct of 'meaningful exchange with places', which introduces children to the affordances outdoors. She thus proposes limiting the dimensions to four. Similarly, in their recent study on Iranian children, Ramezani & Said (2012) interviewed children about their important places using the place-friendship framework and investigated whether the dimensions can be reduced in number based on the data obtained on children's relations to different places. Their finding was that the six dimensions of place friendship could be reduced to the following three: meaningful exchange with place, learning and gaining competence through place experience, and having a secret place. Meaningful exchange with place was seen as in parallel with the actualization of affordances in place (Ramezani & Said, 2012) and also represented the dimensions concerning the freedom of expression, care and respect for the place, and creating territories. What we find interesting in these two projects using Chatterjee's definition of child-friendly places is that the actualization of various affordances seems to be central criteria for children's friendly relationship with a place when defined by children themselves.

Another critical view towards the abstractness of definitions of child-friendliness has been aired by Whitzman, Worthington, and Mizrachi (2010). They analysed how different Child-Friendly City (CFC) initiatives in Australia have supported physical and social transformations towards the institutionalization of children's right to the city. They see children's independent mobility (in other words, children's possibility to autonomously explore the public space) as children's right to the city. In seven governments, they reviewed plans on a general level and on lower level policies that deal with young people. They revised these plans and policies in regard to six elements: whether the plan (1) recognized children as an interest group; (2) recognized children's right to all public space, not only those designed for children; (3) provided achievable targets, strategies and implementation mechanisms; (4) was integrated into health and land-use planning; (5) included training for administrators in child rights; and (6) had planners trained in interacting with children. Interestingly, their policy scan showed the narrow extent to which land-use planning policies were integrated with CFC initiatives. The language or concepts of CFC were not in use in the high-level plans governing land use and development. Children were not mentioned as a specific group, but rather in many implicit examples, they were assumed to belong in specific places designed for children. Whitzman et al. (2010) concluded that even if Child-Friendly Cities are a promising practice in its focus on the children's right to independently roam the public space, there are still difficulties in moving from the social and health planning perspective that has informed these initiatives towards impacts on land-use planning policies and practices.

1.2. Bringing the physical environment into the discussion

There are a few studies that evaluate environmental child friendliness empirically, either on the neighbourhood, community or city level. Among them are comparative studies by Kyttä (2002,

2004) in Finland and Belarus, and work analysing the degree of independent mobility of children in various settings (Fyhri & Hjorthol, 2009; Fyhri, Hjorthol, Mackett, Fotel, & Kyttä, 2011; Hillman, Adams, & Whitelegg, 1990; Tranter & Pawson, 2001). Interviews with families living in the city centre of Auckland, New Zealand, revealed that the central location was seen as convenient and less dependent on cars, while play spaces were insufficient, apartments were not designed for family use, and fears for children's safety were prominent (Carroll, Witten, & Kearns, 2011). These neighbourhood- or city-level studies do not offer a detailed enough analysis of the physical characteristics contributing to a child-friendly environment.

More information should be gathered on the environment's features that motivate everyday activity that are defined by children themselves. This kind of information has so far been mostly from small, qualitative studies (Veitch, Salmon, & Ball, 2007). Among the few previous studies simultaneously studying children's own perceptions of their neighbourhood and the actual potential for activity in specific physical settings is Wridt's (2010) research utilizing a qualitative GIS approach. She found significant gender differences in patterns of use of the physical environment among U.S. children, and interesting differences between the perceived places of danger and actual reported crime. This intriguing study was, however, a small-scale project in one neighbourhood with a very limited number of participants.

This is not to say that only perceived information provided by children themselves is valid when the child friendliness of different environments is studied. In fact, an interesting study from London, Ontario, examined whether publicly provided recreational opportunities for children and youth are distributed unequally in the spatial continuum (Gilliland, Holmes, Irwin, & Tucker, 2006). This study looked at the spatial distribution of possibilities for recreation in relation to neighbourhood characteristics solely from register-based data. In contrast, the structural qualities of the environment are often approached solely from a subjective perspective. For example, in a UK study, children told about their perceptions of different elements of their physical environment in connection with their independent mobility and participation in play (Page, Cooper, Griew, & Jago, 2010). Studies of environmental child friendliness that would look at more objectively measured characteristics of the physical environment are still rare, and studies that would combine children's subjective experiences with objective characteristics are almost non-existent. This is a gap the current study hopes to fill.

In contrast to the few empirical studies concerning environmental child friendliness as a whole, research about the mobility-promoting qualities of the urban structure has yielded a large empirical base on connections between an active, healthy lifestyle for children and characteristics of the physical environment. (For a recent review, see van Loon & Frank, 2011.) Residential density, the proportion of green structure, a traffic environment that favours pedestrian and light traffic, as well as accessibility to recreation areas and versatile services are among the structural features of a community that seem to support children's active lifestyle and independent mobility (Carver, Timperio, & Crawford, 2008; De Vries, Bakker, Van Mechelen, & Hopman-Rock, 2007; Frank, Kerr, Chapman, & Sallis, 2007).

On a more detailed level, features that promote traffic on foot or by bike include sidewalks and bikeways, traffic light-controlled junctions, cul-de-sacs and well-functioning public transportation. Children's free and active movement is impeded by heavy traffic, difficult junctions and a long distance to school (Bringolf-Isler et al., 2008). In addition to structural features of the community, several social, cultural and experiential features have been recognized that are related to children's activity possibilities in different kinds of communities. For example, a large number of children and a strong sense of community in the neighbourhood promote children's active mobility (Carver et al., 2005; Timperio et al., 2006).

Also in these studies concerning the mobility-promoting qualities of the urban structure, the analysis of the environment's features has often been based on subjective observations made by experts or children's parents, whereas we suggest that the objective features of the physical environment should rather be analysed by using Geographic Information Systems (GIS). We agree with McMillan (2005) and Woolcock, Gleeson, and Randolph (2010) that questions concerning children's active lifestyle and urban form cannot be fully answered without a more thorough analysis of micro-scale data on urban form and the social and ecological variation that occur throughout cities. Nevertheless, more detailed information is also needed on individual and household lifestyles and place-based environmental experiences and perceptions. There is also little debate about the relationship between more broad definitions of child-friendly environments and more focused aspects of the environment that motivate children to create an inspired and individual relationship to their surroundings. The next chapter offers one possible approach to this problem.

1.3. Environmental child friendliness in the light of the Bullerby model

To deepen an understanding of characteristics of the urban structure that promote environmental child friendliness, a more focused and operational definition of environmental child friendliness is needed. The Bullerby model by Kyttä (2008) is one candidate for such an approach. According to the assessment model by Kyttä (2008), environmental child friendliness can be defined by two central criteria: children's possibilities for independent mobility and their opportunities to actualize environmental affordances. According to Moore (1986), "Access to and diversity [of resources] emerge as the most important themes in child-environment policy" (p 234).

The Bullerby model is built on the idea that the covariation of independent mobility and the actualization of environmental affordances (Gibson, 1986; Heft, 2001) define four qualitatively different types of children's environments (see Fig. 1). A child-

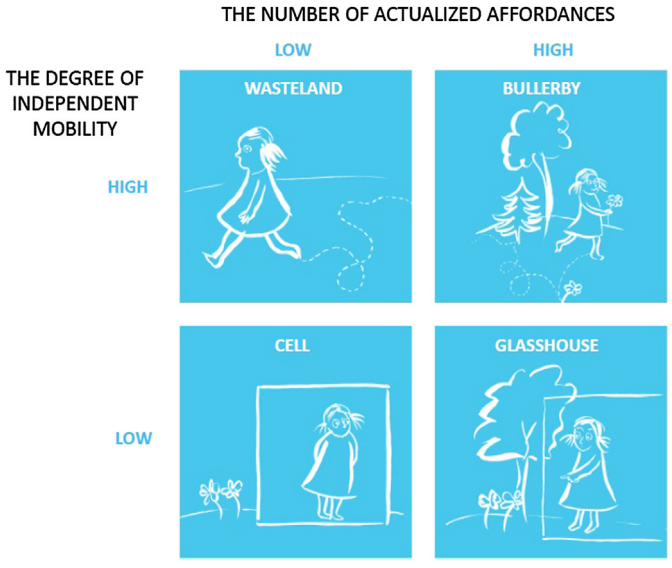

Fig. 1. The Bullerby model for describing four hypothetical types and levels of child-friendly environments (Kyttä, 2008).

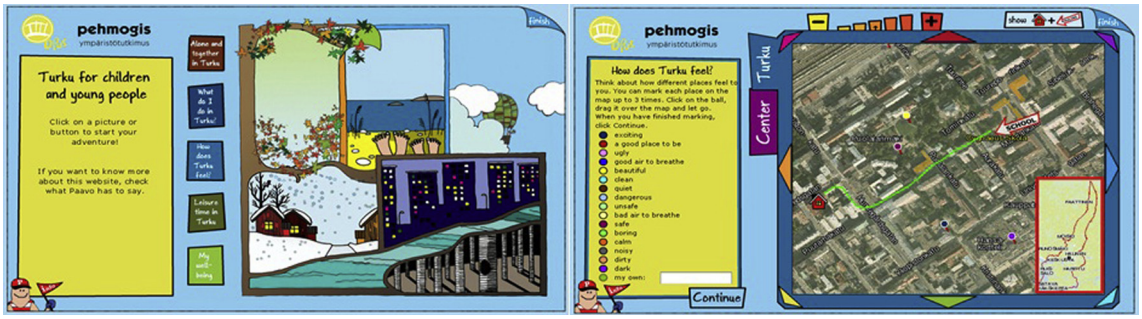

Fig. 2. Front page of the softGIS children questionnaire and page for locating emotional affordances.

friendly environment is primarily represented by the Bullerby[3] type of environment, where the abundance of mobility licenses and actualized affordances create a positive cycle: the more children can move around in the environment, the more and in richer variety the affordances will be revealed. The actualization of affordances motivates further exploration and mobility. The opposite (i.e., the negative cycle) can also take place. In the latter case, children are living in circumstances that are termed a Cell, without opportunities to form a personal relationship with the environment. In the Wasteland, possibilities for independent mobility reveal only the dullness of the environment. Finally, the child growing up in a Glasshouse lives in a condition where external affordances are present, and the child can even be aware of them but cannot actualize them autonomously. A Glasshouse situation could occur when the media and other sources of second-hand information give children the idea that the environment is a field of ample affordances, but due to mobility restrictions imposed by parents or sometimes by communities, children do not have independent access to those affordances.

While being aware that the Bullerby model does not include all the essential criteria of environmental child friendliness, we argue that the two selected dimensions are among the most crucial and the most threatened in modern Western societies. It is also noteworthy that the same physical environment might appear as a Bullerby-type environment to one child and as a Cell-type environment to another. The physical, social, and cultural environments form an inseparable entity, the adaptation to which is partly dependent on a child's individual characteristics as well as the social context (see Bronfenbrenner, 1993).

The Bullerby model is a theoretical tool for assessing the child friendliness of various settings. In this article, we test whether the model can be used to study how specific, built environment qualities condition environmental child friendliness in place-based ways. While the axis of independent mobility has been studied extensively in relation to urban structure, less is known about the axis of affordances. Our target in this paper is to combine both children's experiential and behavioural place-based knowledge with objectively measurable, place-based characteristics of specific settings. Linking the discussion of child-friendly environments to actual places can also help communicate with land-use planners of child friendliness, which has been shown to be problematic (Whitzman et al., 2010).

[3] "Bullerby" can be literally translated as meaning a noisy village. The term is used by the famous Swedish writer Astrid Lindgren (http://www.astridlindgren.se/) in a number of her children's novels where she describes the life of a group of children living in a Swedish village, taking part in the normal everyday activities of the village.

2. Methodology

2.1. Design

This cross-sectional study focused on determining the relationships between urban structure characteristics and children's environmental experiences and independent mobility. An Internet-based softGIS survey (Kahila & Kyttä, 2009; Kyttä, 2011) was used to study children's environmental experiences and independent mobility based on locality. In the softGIS survey, the respondents used the Internet interface to mark on a map places that were functionally, emotionally, or socially meaningful, and described how accessible and likeable these places were. Respondents were also asked to mark their home and daily routes to school and to answer questionnaires concerning school journeys and perceived health and well-being. Findings about active transport to school and health and well-being are reported elsewhere (Kyttä, Broberg, & Kahila, 2012).

The softGIS method used (see Fig. 2) is specially designed for the use of children and youth. SoftGIS methods have been developed at Aalto University since 2005 and have already been applied to eleven Finnish cities, and about 9000 Finns have participated in softGIS surveys. This methodology was honoured with the webGIS innovation award in 2011 by Geospatial World Forum (Kyttä & Kahila, 2011). SoftGIS methods allow residents to produce localized experiential knowledge. As the experiences are gathered using GIS-based methods, they not only comprise a separate experiential world, but they also link to the physical environment. The localized experiential knowledge that is gathered has coordinates and can thus be analysed together with register-based or geographical data included in geographic information systems (Kahila & Kyttä, 2009; Rantanen & Kahila, 2009). The directing board of the research project, involving public servants from multiple sectors of Turku city administration, took part in designing the questionnaire items to make sure the applicability of the data to planning purposes.

2.2. Subjects and communities

The study took place in the city of Turku, the oldest city in Finland, with about 177,000 inhabitants. It is situated on the western coast of Finland and consists of different living environments. The centre of the city is relatively dense and urban, whereas the distant suburban areas are almost rural with their sparse land use and open landscape.

In the coastal areas of Finland, both Finnish and Swedish are spoken as national languages. The application was translated into Swedish and English for the non-Finnish-speaking schools and children who speak neither Finnish nor Swedish.

Data was acquired from 1837 5th-grade primary school pupils (10–12 years old) and 7th grade secondary school pupils (13–15

years old). Respondents represent 54 schools from varying geographical locations in the city of Turku. A little over half of the respondents were boys, and 52% belonged to the younger age group. Of the children's families, 37% lived in single-family houses, 33% in apartment blocks, and 30% in semi-detached or terraced houses. Most children answered to the Finnish version of the questionnaire (92%), while 8% answered the questionnaire in Swedish and only 0.3% in English.

2.3. Sample and procedure

We conducted the study in two phases. In the first phase, all elementary and secondary schools of the city of Turku were invited to participate in the study. During 4 months, only about 1000 pupils had participated from the total of about 14,000 school children in Turku. To gather more representative data, the data were collected in an organized manner and were restricted to two age groups: fifth graders (10–12 years old) and seventh graders (13–15 years old). Between January and March 2008, two research assistants visited 54 schools willing to participate in the study again. Six schools refused to participate. These schools were mainly schools with special curricula (Steiner school, special schools).

Before organized data collection at schools, written consent was obtained from children's parents. The data collection was organized in computer-equipped classrooms in the course of a normal school lesson (45–60 min, depending on school policies) and was led by a research assistant – the teacher supervising the lesson. The children responded independently but could ask for assistance from either the research assistant or the teacher. The number of children responding simultaneously varied between schools, depending on the class sizes in different schools, but was generally around 20 pupils. The quality of Internet connections varied among schools, and some schools faced technical problems.

A total of 3341 children participated during the second phase. After exclusion from the database of children not in the chosen age groups and responses received outside school hours (possible multiple and/or unorganized answering), the sample size was narrowed down to 1655 subjects. To gather as representative a sample as possible, we included data from relevant age groups gathered in the first phase from the six schools that did not participate in the second phase ($n = 182$).

The final sample size was 1837 participants (1655 + 182). The respondent rate of the second phase of data collection was 73% (1655/2280). Of the 625 children that were not reached, 23% were away from school during data collection, 24% did not obtain consent from parents, and the answers of the rest (53%) were lost either because of technical problems or because the child was unable to finish the survey.

2.4. Measures

The degree of environmental child friendliness was studied on two levels: children's environmental experiences and independent mobility, as suggested by Kyttä (2004). Children's environmental experiences were operationalized as localized affordances and their likeability and diversity, and independent mobility as whether the affordance is reached alone or in company of a friend or an adult. We use both terms, independent mobility and independent access, while discussing the independence of reaching the affordances.

2.4.1. Localized affordances

As potentially meaningful places for children, functional, social, and emotional affordances were studied. The taxonomies used were based on previous studies (see Table 1). The emotional affordance category, "How does Turku feel?", was based on Finnish

Table 1
Number of locations in the four affordance categories made by children in the softGIS application.

Category, affordance	No. of locations
Alone and together in Turku	
I meet my friends	1108
I am in peace and quiet	651
I can be myself	412
Allowed place	317
I spend time with animals	309
I'm on my own	273
I meet new people	211
I am with grown-ups	200
Nobody is watching me	193
Forbidden place	158
Scary people	87
Place of bullying	78
I am lonely	56
Total	**4053**
What do I do in Turku?	
I ride my bicycle	414
I play ball games	381
I run	324
Own category	321
I go swimming	292
I skate/ski	253
I go on the swings	192
I go sledding	127
I hide	99
I hang/dangle	95
I climb	91
I jump	79
I ride a skateboard	72
I play water games	70
I dig holes in the ground	54
I build things	49
Total	**2913**
Leisure time in Turku	
I'm at my computer	469
I go shopping	301
I do sports	300
I just hang out	256
I have hobbies	234
I go to the library	179
I have fun	140
I go on adventures	133
I go to the cinema	130
I play	112
I eat out	112
I have nothing to do	97
Own category	67
I go to sports events	54
I go to a concert	18
I visit a museum	14
I go to see a show	11
Total	**2627**
How does Turku feel?	
Safe	323
A good place to be	256
Peaceful, calm	224
Beautiful	208
Good air to breathe	207
Noisy	204
Boring	199
Dirty	188
Clean	160
Dangerous	125
Bad air to breathe	120
Ugly	106
Rowdy, rough	97
Quiet	88
Exciting	86
Own category	83
Dark	76
Total	**2750**

qualitative research on children's emotionally meaningful places (Miettinen, 2006). Some examples of the 17 different emotional affordances questioned were peaceful or dangerous places. For the social affordance category, an empirical study in Britain among the same age groups (Clark & Uzzell, 2002) was applied. In total, 14 social affordances were queried under the heading "Alone and together in Turku", and included, for instance, places to be with friends or forbidden places. The functional affordances were studied on a more general (activity) level, "Leisure time in Turku", and on a more specific level (action, operation), "What do I do in Turku?" (Leontjev, 1978). The taxonomy for functional affordances by Heft (1988), as interpreted by Kyttä (2002), was applied to study the action-level functional affordances. Examples of activity-level affordances included visiting the library and playing sports. The action-level affordances were, for example, bicycling or climbing. The former items represented the interests of the multisectorial partners of our project from the city of Turku. In each category, the order of the appearance of individual affordances in the survey application was randomized. However, the order of the main categories on the front page of the application was stable. The survey application allowed the respondent to map up to three localizations for each affordance. This limitation was due to complexities the programmers faced in storing variable amounts of data for each respondent back in the year 2007.

2.4.2. Independent mobility

With each affordance marked on the map, the respondents were asked how they reached the place. The options were alone, with friends, and accompanied by an adult. Due to a mistake in the application, this information was missing in all the localizations of emotional affordances (22.3% of localizations). And because respondents were not forced to answer the question, this data is missing from further a 24% of other affordance localizations, in all from 41% of the places.

2.4.3. Likeability index

Environmental likeability was addressed after the localization of each meaningful place. The children responded on a sliding scale from unpleasant to pleasant. The middle of the scale was marked. The responses were stored as 0–100, with 50 representing neutral. Unfortunately, the default value in the program was 50, and genuine neutral responses were indistinguishable from the missing responses. Therefore any responses of exactly 50 were discarded. In further analysis, we used a dichotomous variable, where the value '1' represented positive likeability (over 50) and the value '0' represented negative likeability (below 50).

2.4.4. Bullerby grid

To test Kyttä's (2004) Bullerby model of child friendliness on the landscape scale, the original point data of the affordances set was aggregated into a grid format using a 250-m cell size. The points fell into a total of 1427 cells, but to obtain a valid result, cells having less than three affordances were removed from further analysis ($N = 779$). In each grid cell, the percentage of affordances reached alone was calculated. (Emotional affordances were excluded from this calculation because of the missing data on independent mobility.) The overall diversity and the relative occurrence of the different affordances were analysed with the Shannon diversity index, which is a popular measure of species diversity in ecology but has also been used to study social data (Krebs, 1989; Reed & Brown, 2003). Shannon's index is based on information theory. It is a measure of uncertainty (disorder in a system) in predicting what species a random individual from a collection of species S and individuals N belongs to (Ludwig & Reynolds, 1988). The Shannon diversity index was calculated for every grid cell based on the relative number of affordance points of each of the 64 themes in the grid cell.[4] A two-base logarithm was used in the analysis (Krebs, 1989).

The grid cells were categorized into four environment types of the Bullerby model according to the percentage of the affordances reached alone (mean = 35, SD = 28) and to the Shannon diversity index (mean = 2.8, SD = 0.9). The means were used to divide the grid cells into the four categories. Thus, the axis of independent mobility was

1. 35% or more of affordances within a cell reached alone, and
2. less than 35% of affordances reached alone;

and the axis of actualized affordances was

1. Shannon diversity index 2.8 or more, and
2. less than 2.8.

Using the share of affordances reached alone, rather than without adult supervision, is a debatable choice. Children's mobility is predominantly social and, as has been noted among Danish children (Mikkelsen & Christensen, 2009), independence of mobility is not necessarily moving alone, but moving without adults, among peers. Nevertheless, we've found that independent mobility is a problematic variable in the Finnish context, where children report very few restrictions on their mobility. To be able to get some variation in the axis of independent mobility in the Bullerby model, we use the narrow definition of reaching the affordance alone as a measure of independence.

2.4.5. Mapping and GIS-based measures

The analysis of the structural characteristics of children's meaningful places was based on the geographical localizations that children themselves gave while using the softGIS application. To increase the reliability of the localizations, the softGIS application helped children to orient themselves on the map. After the name of a child's school was given, the map automatically centred on it.

GIS-based measures of the urban structure were calculated within a 50-m buffer of each affordance marked on the map and into the 250-m grid cells of the Bullerby model. The urban structure measures were:

- Proportion of green structure: the proportion of fields, forests, parks, and water of the total buffer or grid cell area. These were calculated from the citywide cartographic data obtained from the surveying department of Turku.
- Residential density: housing units per hectare (hu/ha) within the buffer or grid cell. The centroids for each building in Turku, containing the information on housing units, floor areas and population demographics for the building, were obtained from the city.
- Floor area ratio (FAR): calculated as the combined floor area of the buildings within the buffer or grid cell divided by the area not classified as green. In the buffer data, ratios over 10 were dismissed as outliers (1.3% of buffers). These outliers were supposedly due to incongruence in the geographical datasets gathered on different scales.
- Number of population within buffer or grid cell, calculated from the above-mentioned building centroid data.

[4] The Shannon index does not have a specific range but is dependent on the richness and occurrence of the themes and the affordance points representing them. Thus, a high diversity value indicates there are several of the 64 themes with a large number of affordances marked in different themes present in the specific grid cell.

2.5. Analysis

The research data were saved in a database from which the children's responses were written out in a table format, either so that each respondent created one record or so that the record was created by a single location (i.e., an affordance located by a respondent). When a single respondent was the basic unit of analysis, the respondent-based material was provided with locality-based summaries from the data, such as the number of different locations, information about the respondent's home environment, or the average distance to meaningful places. This article covers the affordance-based material. The person-based material has been reported upon separately (Kyttä et al., 2012).

The data were statistically analysed with PASW Statistics 18 software. The significances in the differences of means between genders and the two age groups were studied using *t*-tests or the Mann–Whitney *U* test, and the differences in frequencies using the χ^2 test. Analysis of variance (ANOVA) was used to study the significances in difference between different categories of affordances and the grid cells in the Bullerby model. The ANOVA results were further analysed using Tukey's test. The connections between the urban structure characteristics and children's environmental experiences were studied with logistic regression analyses, as few of the variables followed the normal distribution.

The GIS analyses were carried out with ArcGIS 9.3 and 10 software and with MapInfo 8.3 software. Among the most central GIS analyses were creating buffers around children's homes and calculating the residential density and the portions of green structure and of children within these areas.

3. Results

3.1. Experientially meaningful environmental affordances – descriptive results

The children located altogether 12,343 affordances (see Fig. 3 for the affordances around the city centre of Turku). The total number of localized affordances by an individual child varied from 1 to 58, with the mean being 8.2. The age groups differed significantly in the number of localized affordances ($Z = -5.8$, df = 1498, $p = 0.000$), the younger children mapping almost 9 places per child and the older only 7.5 on average.

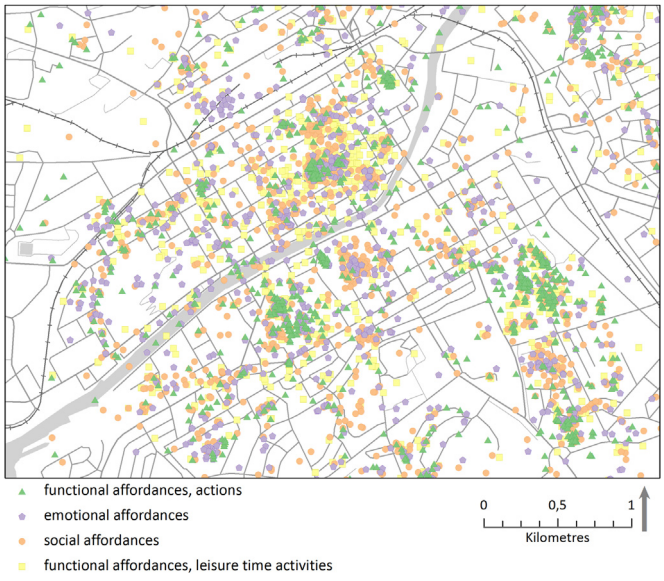

Fig. 3. The affordances marked by the children in the city centre of Turku.

The most often located functional affordances at the action level (What do I do in Turku?) were bicycling, playing ball games, and running. In the leisure-time activity category (Leisure time in Turku), computer use, shopping, and playing sports were among the most commonly located activities. Place mappings concerning meeting friends, being yourself, and being in peace and quiet dominated in the social affordance category (Alone and together in Turku). And in the emotional affordance category (How does Turku feel?), safe, feel-good, and peaceful places were marked most frequently (see Table 1).

Boys reached their affordances alone significantly more often (34%) than girls (28%), whereas two-thirds of the places marked by girls were reached with friends (63%), the proportion for boys being 57%. These differences between genders were significant ($\chi^2 = 34.7$, df = 2, $p = 0.000$). There was no gender difference in the proportion of affordances reached in the company of an adult (9%). Interestingly, there were no significant differences between the two age groups regarding the company in which the affordances were reached.

Affordances that were most often reached in the company of an adult were seeing a show, going to a museum, and spending time with adults. The smallest parental attendance was reported in places of bullying, playing, hanging/dangling and adventuring. Affordances most often reached alone were places where one gets to be in peace and quiet, where one is lonely, spends time on a computer or with animals.

In all, children liked the affordances they marked on the map. There were small but significant differences between the age groups and genders in average positivity towards the affordances: girls liked their affordances a little more (mean likeability 80) than boys (77) ($t = 4.1$, df = 10,039, $p = 0.000$), and the older age group a little more (80) than the younger (77) ($t = -4.5$, df = 10,039, $p = 0.000$).

The affordances that children liked the most on average were a good place to be (mean = 92, $N = 212$, SD = 14), being at a computer (mean = 90, $N = 384$, SD = 18), cleanness (mean = 89, $N = 123$, SD = 18), and safety/security (mean = 89, $N = 268$, SD = 16).

3.2. Urban structure and affordances

Urban structure was significantly different in the four different affordance categories. The differences applied to the floor area ratio ($F = 102.0$, df = 3, $p = 0.000$), the housing density of the built environment ($F = 29.8$, df = 3, $p = 0.000$), and the latter's close companion population density ($F = 33.7$, df = 3, $p = 0.0000$) and for a contrasting measure, the proportion of green structures ($F = 116.4$, df = 3, $p = 0.000$).

Activity-level functional affordances differed significantly from all the other categories and were in the most densely built areas (floor area ratio on average 0.75). Emotional affordances (mean 0.44) differed nearly significantly from both the social (mean 0.5) and action-level functional (mean 0.38) affordances (Tukey's $p = 0.02$ and $p = 0.018$, respectively). Examples of affordances where the FAR is highest are going to cinema, shopping, and visiting library, museums and sporting events. Affordances with the least densely built surroundings include actions such as sleigh riding, climbing, and skiing or skating, but also beautiful places and places where air feels good to breath.

Looking closer at the differences in housing density around affordances, the differences distil into the action-level functional affordances being situated in the least densely built surroundings (mean 16 housing units per hectare). The mean housing density for the other categories lies between 23 and 25 housing units per

hectare, the differences being not significant. Population-wise, similar findings apply. The size of the population around action-level functional affordances differs from all the other categories – it is smaller. Also, emotional affordances and activity-level functional affordances differ from each other, the latter being in significantly more densely populated settings. The affordances where housing and population densities are high include going to the cinema, using a computer, playing, and spending time with adults. These can be seen as affordances typical for residential areas. Within the five most densely housed affordances are also emotional places where the feeling is rowdy or rough (mean 34 hu/ha).

The amount of greenery varies significantly between all the categories. Action-level functional affordances (green structures on average 44%) and emotional affordances (mean 33%) were located in the most green environments. Leisure-time, activity-level functional affordances (mean 27%) and social affordances (mean 29%) were situated in the least green places. The most green affordance surroundings are around places where respondents ski or skate, swim, and play water games, but also around places experienced as beautiful. The list of least green affordance surroundings includes the already listed city-life affordances of shopping, visiting the library, and going to the cinema, but even less green are places where new friends can be made and places that are noisy.

The affordances marked by girls (mean percentage green 32%) were in significantly less green surroundings than those marked by boys (36%) ($t = 6.1$, df = 12,309, $p = 0.000$). There were no differences between age groups. Correspondingly, the affordances marked by girls were in significantly more densely built surroundings (mean 23.7 hu/ha, FAR 0.58) than those marked by boys (20.5 hu/ha, FAR 0.45) ($t_{hu/ha} = -4.2$, df = 12,309, $p = 0.000$ and $t_{FAR} = 8.2$, df = 11,993, $p = 0.000$).

Interestingly, when the density of the built environment is examined as housing density, the younger age group's affordances are in nearly significantly denser settings (mean 22.8 hu/ha) than those of the older age group (21.3) ($t = 2.0$, df = 12,309, $p = 0.045$). But when we scrutinize density as floor area ratio, the opposite holds true: the older age group has marked their affordances in significantly denser surroundings (FAR 0.56) than the younger age group (FAR 0.46) ($t = -7.3$, df = 11,993, $p = 0.000$). This suggests that the affordances of younger children concentrate on residential areas, whereas those of older children concentrate on commercial or central areas.

3.3. Urban structure effects on the independent access to and positivity towards the affordances

Next we analysed the effect of the urban structure on children's independent access to their marked affordances. Gender was included in all the logistic regression models but is not reported upon separately. Housing density around affordances increased the likelihood of a child coming to the affordance alone (OR = 1.004, CIs 1.003–1.005, $p = 0.000$). The amount of population around the affordance had a similar effect on the likelihood of accessing the affordance independently (OR = 1.004, CIs 1.003–1.005, $p = 0.000$). An increase in the floor area ratio decreased the likelihood of reaching the place alone (OR = 0.786, CIs 0.734–0.843, $p = 0.000$). Interpreting these results, affordances that are situated in residential areas are likely to be reached alone, whereas affordances situated in densely built urban cores are likely to be reached with others. The proportion of green structures did not have any significant effect on the likelihood of independent access.

Some of the urban structural variables were associated with children's stated preference for affordances, namely population around affordances (OR = 1.002, CIs 1.001–1.004, $p = 0.001$) and the proportion of green structures (OR = 1.004, CIs 1.002–1.006, $p = 0.000$). Gender and age group were included in these logistic regression models, but their effect on the models is not reported upon separately. An increase in the size of population around affordances increased the likelihood of stating a positive value of likeability, and interestingly, the result was different between different affordance categories. The effect of the population numbers on positivity was found specifically in the emotional (OR = 1.002, CIs 1.000–1.005, $p = 0.03$) and social (OR = 1.004, CIs 1.002–1.007, $p = 0.001$) affordance categories. The more people there were living around the affordance, the more likely the children were to state a positive preference towards the affordance. The green structures' positive effect on the likelihood of a positive perception held only in the emotional affordance category (OR = 1.009, CIs 1.006–1.011, $p = 0.000$), and here the greenness around the emotional affordance significantly increased the likelihood of liking the place.

3.4. Testing the Bullerby model of child friendliness

The series of maps on Fig. 4 represent our operationalization of the Bullerby model. The first of the maps shows the number of

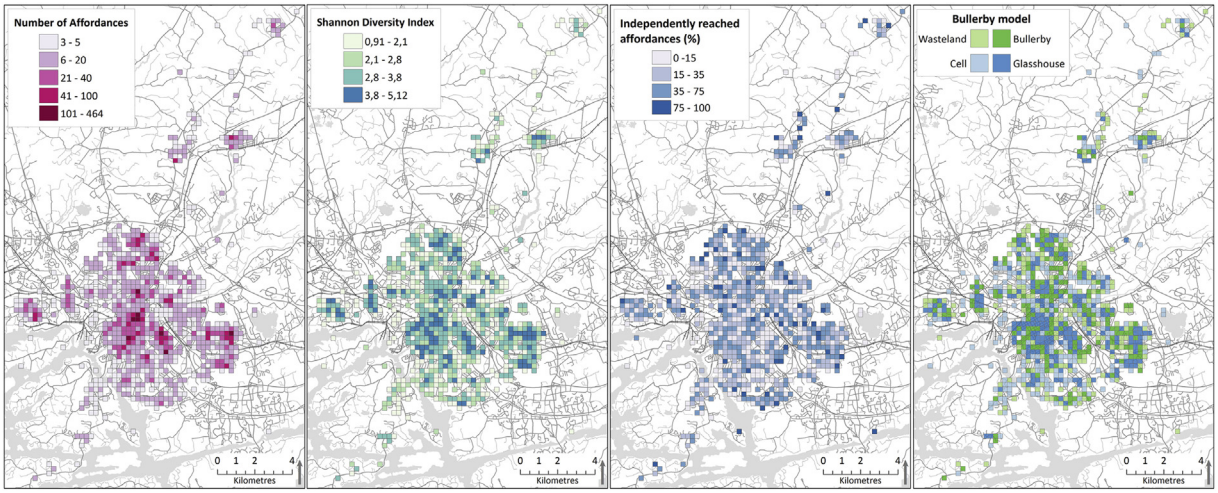

Fig. 4. Child friendliness of the environments in the city of Turku as evaluated with the Bullerby model.

affordances in the 250-m grid cells and gives an idea of the importance of the city centre to the respondents as well as the abundance of affordance localizations around residential areas of Turku. The diversity of different affordance categories in the cells, shown on the second map, follows to some extent the overall number of affordances; but diversity can also be great in cells where the actual numbers are not the highest. Areas in Turku, where the majority of the affordances are reached independently, are scattered around the city, and generally the city centre gathers lower levels of independent access, as can be seen from the third map.

The last of the maps looks at the variety in affordances and independent access to them simultaneously and thus draws a picture of the child friendliness of Turku, as understood according to the Bullerby model. Large areas of the city centre fall into the Glasshouse category, where variety in affordances is large, but independent mobility is on a low level. Bullerby types of environments, where affordances are many and can be reached alone, border Glasshouse environments near the city centre, but areas like this are also scattered around the whole study area. Only larger stretches of Cell types of environments can be found in the areas south and southwest from the centre, on the way to the residential areas on the islands.

According to our operationalization of the Bullerby model, 28.5% of the cells were categorized into Cell and 26.6.% into Glasshouse types of environments, while a little over one-fifth (21.6%) were Wasteland environments and 23.4% were of the Bullerby type. Variables concerning the urban structure, such as population density or proportion of green structures, were calculated for the grid cells, and variance in these structural variables between cells categorized differently according to the Bullerby model was analysed. There was significant structural variation between the grid cells in relation to size of population ($F = 24.6$, df $= 3$, $p = 0.000$) and proportion of green structures ($F = 13.0$, df $= 3$, $p = 0.000$), whereas the cells in the different categories did not vary in their residential density or floor area ratio.

Looking at population numbers, the main result is that Bullerby and Glasshouse types of environments differ from Wasteland and Cell types (Tukey: Bullerby/Wasteland $p = 0.000$, Bullerby/Cell $p = 0.000$, Glasshouse/Wasteland $p = 0.008$, Glasshouse/Cell $p = 0.000$). Bullerby and Glasshouse represent environments where the residential density is relatively high (on average 240 and 244 persons living in the cells, respectively), whereas Cell (mean 108) and Wasteland (mean 126) are more sparsely populated. The proportion of green structure differentiates the groups in a similar manner, Wasteland and Cell forming the greener pair (means 42% and 46%, respectively), Bullerby (33%) and Glasshouse (33%) being the less green.

4. Discussion & conclusions

Combining place-based knowledge (first based on children's experience and second derived from objective measurable qualities of the physical environment) provided a valuable methodological contribution to studies on environmental child friendliness. The study revealed that as a whole, the studied Finnish children enjoyed widespread possibilities for active and independent mobility and the building of a personal experiential relationship with their outdoor environment. We chose to study environmental child friendliness from the viewpoint of the Bullerby model, concentrating on the affordances that an environment provides the children and on children's independent access to these. These two criteria proved to offer interesting insights on different urban environments. The children had many personally meaningful places in outdoor settings. The softGIS methodology used in the study allowed children to mark personally meaningful affordances on the map, and children located on average eight places per child.

Our results partly confirmed the previous findings from mobility research about the ability of some urban environmental characteristics to promote children's independent mobility. We discovered positive associations between residential and population density and children's independent access to affordances, whereas building density, measured as floor area ratio, had a negative association with children's independence in reaching affordances. Urban density around the affordances marked by the younger and the older age group were different. Older children and adolescents marked their affordances in central locations where building densities were high, while affordances of the younger group were located more in residential areas, where housing density and population numbers were high. One might also assume that the older age group reaches their affordances more independently than the younger, be it alone or with peers, but age group differences in reaching the affordance did not occur in our data. This might have to do with the fact that the affordances of the older group are further away from their home. Ideally, residential areas could be developed to offer more intriguing places for youth. Indeed, not only child friendliness but also youth friendliness of environments should be studied (see also Woolcock et al., 2010).

Green areas are important settings for children's experiences. Especially action-level functional affordances were present in surroundings where green structures were prominent. The greenest of all the affordances were beautiful places. And indeed, when looking at emotional affordances, the larger the proportion of green structures, the likelier the positive evaluation of the place. This reflects well-documented previous research literature on the restorative qualities of green settings: the proximity to nature associated with sparse building promotes mental health as a setting for stress restoration (van den Berg, Koole, & van der Wulp, 2003). We have also found that the amount of green structure around a child's home is positively associated with good perceived health (Kyttä et al., 2012). Then again, different urban structures are important for different experiences. As an example of this, population numbers were bigger around social affordances than any other category. Also, the more residents there were around the social affordance, the more children liked the place.

The ability of the Bullerby model to reveal the essential characteristics of the physical environment that contribute to environmental child friendliness was supported in this study. The approach was especially useful for the analysis of the resource dimension, which is seldom studied in close connection with the physical characteristics of the environment. Physical environments where the diversity of affordances was vast were more densely populated and less green than the less diverse environments. The dimension measuring the independent access to affordances, however, did not show differences between the urban structure of the grid cells categorized into different environmental types of the Bullerby model. The way the access of independence was measured was also problematic, not only because there were missing data but because of the narrow definition of independence being used. Independence of mobility is not necessarily moving alone, but moving without adults, among peers (Mikkelsen & Christensen, 2009). Also, results from a previous study concentrating on children's activity levels in parks highlight the importance of independence from parents or supervisors but with other children present. The presence of parental supervision while the child was in a park had a strong negative effect on children's activity, while the presence of other active children was strongly positively associated with park-based physical activity (Floyd et al., 2011).

While we completely agree on children's mobility being social, in this study we used the narrow definition of reaching the

affordance alone as a measure of independence. This is due to the low parental attendance that the children reported: 9% for both age groups. In other, more restrictive mobility contexts, it would be worthwhile to use the broader definition of independent mobility. We also suggest that in future research, the accessibility dimension should be studied, more broadly taking into account not only independent mobility, but also travel mode and frequency of visits, possibly also the social equality of accessibility. Future research in variable contexts could also enable the finding of some standardized thresholds for the levels of independence and variability of affordances that would have to be met for an environment to be considered child-friendly. It is worth noting that green areas didn't appear as child-friendly in our Bullerby analysis. However, they proved to be very important for the children in the affordance-based analysis. This implies that measuring the emotional response to the place along with the accessibility is important.

Despite the need for future research on the Bullerby model, there was evidence that the two basic dimensions, the independent access to and diversity of the affordances, are connected. Our previous study showed, for example, that the number of affordances that children marked was correlated with physical activity on the school journey (Kyttä et al., 2012). This strengthens the conception that there is a close connection between the two central features of a child-friendly living environment, independent mobility and richness of affordances. The affordances were also very central to children in the research using Chatterjee's concept of the child-friendly place (Chatterjee, 2006; Ramezani & Said, 2012). Maybe the learning and competence building that Chatterjee (2005) proposes as a criterion for child-friendliness could in effect be seen as an outcome of the situation where a child lives in a child-friendly environment, rather than characteristics of the environment. In a similar line of reasoning, health outcomes are often attributed to situations where a child (or an adult, for that matter) lives in an environment that allows physical activity.

When discussing the child friendliness of environments, concentrating on outdoor environments can be too narrow a view. One of the affordances children themselves liked most was being at a computer, and also the sheer number of these localizations was the third most liked. Even if this can reflect computer use being one of the few home-based affordances the children were offered to locate, it should be noted that virtual and electronic environments can act as important spaces for play, interaction and socialization for children and youth.

The reliability and validity of research data collected via web-based methodology demand critical evaluation. Finnish children are probably used to communicating via the Internet because 99% of Finnish households with children have Internet access (European Commission, 2011). Earlier studies have shown that adolescents tend to prefer a Web-based over a paper-based questionnaire, and health-related surveys generally result in equal results regardless of the method of implementation (Mangunkusumo et al., 2005). However, web-based surveys can be vulnerable to mistakes in the programming work, as was shown by the missing independent mobility data on emotional affordances. Our research themes – environmental experiences and independent mobility – were studied as perceived, subjective phenomena. To develop valid and reliable measures, we used existing scales and taxonomies from previous studies as much as possible. In most of the themes, self-reports by the youths studied (ages 10–12 and 13–15) are probably more reliable than proxy reports from parents. And children's ability to report their experiences on a map can also be questioned. Nordin and Berglund (2010) have researched the use of GIS-based mapping methods with Swedish children aged 10–15 years and have found them capable of reading maps and using a GIS application for communicating their interests. Even if we did not specifically research children's ability to respond to the mapping questions, it can be hypothesized that the skill level is on a similar level as in Sweden. Orienteering is also a part of the national curriculum in Finland.

Several limitations and strengths of the study should be mentioned. First, as the softGIS method for children was used for the first time in this study, some mishaps occurred. The order in which the affordance categories were shown on the main page was not randomized for different users, and thus the numbers of different affordances, especially between categories, do not indisputably reflect the relative importance of these affordances for the children. Data on independent mobility was missing from 41% of the affordances. Half of this was due to a mistake in the application; but the other half might be due to the vagueness of the definition. Children might sometimes come to the places alone, while other times with friends or adults; and thus it might be complicated to pick just one option. Another limitation was the relatively low quality of the register-based GIS data. This did not allow very fine analysis of the urban environment. In future studies concerning environmental affordances and mobility, the urban structural analyses should include measures concerning the possibilities for light traffic, public transportation options, and functions of the urban environment, such as shops, restaurants, and playgrounds. Finally, the Bullerby grid-based analysis of environmental child friendliness seems to emphasize grid cells where there are plenty of affordance localizations, and this does not necessarily reflect only the importance of these places, but also the number of respondents who live near that place. Then again, the Shannon diversity index used to study the richness of the affordances is logarithmic and takes into account the number of localizations.

The strengths of the study lie in the innovative, Internet-based softGIS method that proved to be a promising way to study the conditions of child-friendly living environments in a detailed manner and in a way that also inspires children. Linking the discussion of child-friendly environments to actual physical environments in a simple way – grounded in the experiences of children rather than in the ideals of researchers – can also make the concept more usable to urban planners. It is important to develop the environmental child friendliness of whole environments and not just focus on school journeys or places specially designed for children. Children do not move around actively if the environment does not offer them intriguing challenges and a rich variety of possibilities for diverse activities. Children should also be seen as abled and active users of their environment and as informants possessing valuable insights into the possibilities and restrictions of different environments.

Acknowledgements

The authors wish to thank the multisectoral steering group from the city of Turku for extremely active and valuable co-operation. We are very grateful to the headmasters, teachers, and naturally the pupils of participant schools. The idea of using Shannon diversity index was born in discussions with colleagues at Laboratory of Computer Cartography (UTU-LCC) at University of Turku. Marketta Kyttä worked as doctoral researcher of the Academy of Finland during the project. The project was funded by Tekes, the Finnish Funding Agency for Technology and Innovation, and the Finnish Ministry of Education and Culture.

References

van den Berg, A. E., Koole, S. L., & van der Wulp, N. Y. (2003). Environmental preference and restoration: (How) are they related? *Journal of Environmental Psychology, 23*(2), 135–146. http://dx.doi.org/10.1016/S0272-4944(02)00111-1.

Bringolf-Isler, B., Grize, L., Mäder, U., Ruch, N., Sennhauser, F. H., & Braun-Fahrländer, C. (2008). Personal and environmental factors associated with active commuting to school in Switzerland. *Preventive Medicine, 46*(1), 67–73. http://dx.doi.org/10.1016/j.ypmed.2007.06.015.

Bronfenbrenner, U. (1993). The ecology of cognitive development: Research models and fugitive findings. In R. H. Wozniak, & K. W. Fischer (Eds.), *Development in context: Acting and thinking in specific environments* (pp. 3–44). Hillsdale, NJ, England: Lawrence Erlbaum Associates.

Carroll, P., Witten, K., & Kearns, R. (2011). Housing intensification in Auckland, New Zealand: Implications for children and families. *Housing Studies, 26*(3), 353–367. http://dx.doi.org/10.1080/02673037.2011.542096.

Carver, A., Salmon, J., Campbell, K., Baur, L., Garnett, S., & Crawford, D. (2005). How do perceptions of local neighborhood relate to adolescents' walking and cycling? *American Journal of Health Promotion, 20*(2), 139–147.

Carver, A., Timperio, A., & Crawford, D. (2008). Playing it safe: The influence of neighbourhood safety on children's physical activity—A review. *Health & Place, 14*(2), 217–227. http://dx.doi.org/10.1016/j.healthplace.2007.06.004.

Chatterjee, S. (2005). Children's friendship with place: A conceptual inquiry. *Children, Youth and Environments, 15*(1), 1–26.

Chatterjee, S. (2006). *Children's friendship with place: An exploration of environmental child friendliness of children's environments in cities*. North Carolina State University.

Chawla, L. (2002). *Growing up in an urbanising world*. London: Earthscan.

Clark, C., & Uzzell, D. L. (2002). The affordances of the home, neighbourhood, school and town centre for adolescents. *Journal of Environmental Psychology, 22*(1–2), 95–108. http://dx.doi.org/10.1006/jevp.2001.0242.

De Vries, S. I., Bakker, I., Van Mechelen, W., & Hopman-Rock, M. (2007). Determinants of activity-friendly neighborhoods for children: Results from the SPACE study. *American Journal of Health Promotion, 21*, 312–316.

European Commission. eCommunications household survey: The results of a special Eurobarometer survey. Available at http://ec.europa.eu/information_society/policy/ecomm/library/ext_studies/index_en.htm Accessed 10.06.11.

Floyd, M. F., Bocarro, J. N., Smith, W. R., Baran, P. K., Moore, R. C., Cosco, N. G., et al. (2011). Park-based physical activity among children and adolescents. *American Journal of Preventive Medicine, 41*(3), 258–265. http://dx.doi.org/10.1016/j.amepre.2011.04.013.

Frank, L., Kerr, J., Chapman, J., & Sallis, J. (2007). Urban form relationships with walk trip frequency and distance among youth. *American Journal of Health Promotion, 21*(4 Suppl.), 305–311.

Freeman, C., & Tranter, P. (2011). *Children and their urban environment: Changing worlds*. London: Earthscan.

Fyhri, A., & Hjorthol, R. (2009). Children's independent mobility to school, friends and leisure activities. *Journal of Transport Geography, 17*(5), 377–384. http://dx.doi.org/10.1016/j.jtrangeo.2008.10.010.

Fyhri, A., Hjorthol, R., Mackett, R. L., Fotel, T. N., & Kyttä, M. (2011). Children's active travel and independent mobility in four countries: Development, social contributing trends and measures. *Transport Policy, 18*(5), 703–710. http://dx.doi.org/10.1016/j.tranpol.2011.01.005.

Gibson, J. (1986). *The ecological approach to visual perception*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Gilliland, J., Holmes, M., Irwin, J. D., & Tucker, P. (2006). Environmental equity is child's play: Mapping public provision of recreation opportunities in urban neighbourhoods. *Vulnerable Children and Youth Studies, 1*(3), 256–268.

Haider, J. (2007). Inclusive design: Planning public urban spaces for children. *Proceedings of the Institution of Civil Engineers. Municipal Engineer, 160*(2), 83–88.

Haikkola, L., Pacilli, M. G., Horelli, L., & Prezza, M. (2007). Interpretations of urban child-friendliness: A comparative study of two neighbourhoods in Helsinki and Rome. *Children, Youth and Environments, 17*(4), 319–351.

Heft, H. (1988). Affordances of children's environments: A functional approach to environmental description. *Children's Environments Quarterly, 5*(3), 29–37.

Heft, H. (2001). *Ecological psychology in context: James Gibson, Roger Barker, and the legacy of William James's radical empiricism*. Mahwah, N.J.: Lawrence Erlbaum Associates Publishers.

Hillman, M., Adams, J., & Whitelegg, J. (1990). *One false move… A study of children's independent mobility*. London: Policy Studies Institute.

Horelli, L. (2007). Constructing a theoretical framework for environmental child-friendliness. *Children, Youth and Environments, 17*(4), 267–292.

Kahila, M., & Kyttä, M. (2009). SoftGIS as a bridge-builder in collaborative urban planning. In S. Geertman, & J. Stillwell (Eds.), *Planning support systems best practice and new methods* (pp. 389–411). Netherlands: Springer. http://dx.doi.org/10.1007/978-1-4020-8952-7_19.

Krebs, C. J. (1989). *Ecological methodology*. New York: Harper & Row Publishers.

Kyttä, M. (2002). Affordances of children's environments in the context of cities, small towns, suburbs and rural villages in Finland and Belarus. *Journal of Environmental Psychology, 22*(1–2), 109–123. http://dx.doi.org/10.1006/jevp.2001.0249.

Kyttä, M. (2004). The extent of children's independent mobility and the number of actualized affordances as criteria for child-friendly environments. *Journal of Environmental Psychology, 24*(2), 179–198. http://dx.doi.org/10.1016/S0272-4944(03)00073-2.

Kytta, M. (2008). *Children in outdoor contexts affordances and independent mobility in the assessment of environmental child friendliness*. Saarbrücken: VDM Verlag Dr. Müller.

Kyttä, M. (2011). SoftGIS methods in planning evaluation. In A. D. Hull, E. R. Alexander, A. Khakee, & J. Woltjer (Eds.), *Evaluation for sustainability and participation in planning* (pp. 334–354). London: Routledge.

Kyttä, M., Broberg, A., & Kahila, M. (2012). Urban environment and children's active lifestyle: SoftGIS revealing children's behavioral patterns and meaningful places. *American Journal of Health Promotion, 26*(5), e137–e148.

Kyttä, M., & Kahila, M. (2011). SoftGIS methodology – Building bridges in urban planning. *GIM International, 25*(3), 37–41.

Leontjev, A. N. (1978). *Activity, consciousness, personality*. Englewood Cliffs, N.J.: Prentice Hall.

van Loon, J., & Frank, L. (2011). Urban form relationships with youth physical activity: Implications for research and practice. *Journal of Planning Literature, 26*(3), 280–308. http://dx.doi.org/10.1177/0885412211400978.

Ludwig, J. A., & Reynolds, J. F. (1988). *Statistical ecology: A primer on methods and computing*. New York: John Wiley & Sons, Inc.

McAllister, C. (2009). Child friendly cities and land use planning: Implications for children's health. *Environments: A Journal of Interdisciplinary Studies, 35*(3), 45–61.

McMillan, T. E. (2005). Urban form and a child's trip to school: The current literature and a framework for future research. *Journal of Planning Literature, 19*(4), 440–456. http://dx.doi.org/10.1177/0885412204274173.

Malone, K. (2001). Children, youth and sustainable cities. *Local Environment, 6*(1), 5–12. http://dx.doi.org/10.1080/13549830120024215.

Mangunkusumo, R. T., Moorman, P. W., Van Den Berg-de Ruiter, A. E., Van Der Lei, J., De Koning, H. J., & Raat, H. (2005). Internet-administered adolescent health questionnaires compared with a paper version in a randomized study. *Journal of Adolescent Health, 36*(1), 70.e1–70.e6. http://dx.doi.org/10.1016/j.jadohealth.2004.02.020.

Miettinen, S. (2006). *Lapsena lähiössä. 10–11-vuotiaiden näkökulma asuinalueensa tiloihin [A child in a suburb. Views of 10 to 11 year old children towards the residential spaces in their neighbourhood]* [licentiate thesis]. Jyväskylä, Finland: University of Jyväskylä.

Mikkelsen, M. R., & Christensen, P. (2009). Is children's independent mobility really independent? A study of children's mobility combining ethnography and GPS/mobile phone technologies. *Mobilities, 4*(1), 37–58. http://dx.doi.org/10.1080/17450100802657954.

Moore, R. C. (1986). *Childhood's domain: Play and place in child development*. London: Croom Helm.

Nordin, K., & Berglund, U. (2010). Children's maps in GIS: A tool for communicating outdoor experiences in urban planning. *International Journal of Information Communication Technologies and Human Development, 2*(2), 1–16. http://dx.doi.org/10.4018/jicthd.2010040101.

Nordström, M. (2010). Children's views on child-friendly environments in different geographical, cultural and social neighbourhoods. *Urban Studies, 47*(3), 514–528. http://dx.doi.org/10.1177/0042098009349771.

Page, A. S., Cooper, A. R., Griew, P., & Jago, R. (2010). Independent mobility, perceptions of the built environment and children's participation in play, active travel and structured exercise and sport: The PEACH project. *International Journal of Behavioral Nutrition and Physical Activity, 7*, 17. http://dx.doi.org/10.1186/1479-5868-7-17.

Ramezani, S., & Said, I. (2012). Children's nomination of friendly places in an urban neighbourhood in Shiraz, Iran. *Children's Geographies*, 1–21.

Rantanen, H., & Kahila, M. (2009). The SoftGIS approach to local knowledge. *Journal of Environmental Management, 90*(6), 1981–1990. http://dx.doi.org/10.1016/j.jenvman.2007.08.025.

Reed, P., & Brown, G. (2003). Values suitability analysis: A methodology for identifying and integrating public perceptions of ecosystem values in forest planning. *Journal of Environmental Planning and Management, 46*(5), 643–658. http://dx.doi.org/10.1080/0964056032000138418.

Riggio, E. (2002). Child friendly cities: Good governance in the best interests of the child. *Environment and Urbanization, 14*(2), 45–58.

Schulze, S., & Moneti, F. (2007). The child friendly cities initiative. *Proceedings of the Institution of Civil Engineers. Municipal Engineer, 160*(2), 77–81.

Timperio, A., Ball, K., Salmon, J., Roberts, R., Giles-Corti, B., Simmons, D., et al. (2006). Personal, family, social, and environmental correlates of active commuting to school. *American Journal of Preventive Medicine, 30*(1), 45–51. http://dx.doi.org/10.1016/j.amepre.2005.08.047.

Tranter, P., & Pawson, E. (2001). Children's access to local environments: A case-study of Christchurch, New Zealand. *Local Environment, 6*(1), 27–48.

Veitch, J., Salmon, J., & Ball, K. (2007). Children's perceptions of the use of public open spaces for active free-play. *Children's Geographies, 5*(4), 409–422.

Whitzman, C., Worthington, M., & Mizrachi, D. (2010). The journey and the destination matter: Child-friendly cities and children's right to the city. *Built Environment, 36*(4), 474–486.

Woolcock, G., Gleeson, B., & Randolph, B. (2010). Urban research and child-friendly cities: A new Australian outline. *Children's Geographies, 8*(2), 177–192. http://dx.doi.org/10.1080/14733281003691426.

Wridt, P. (2010). A qualitative GIS approach to mapping urban neighborhoods with children to promote physical activity and child-friendly community planning. *Environment and Planning B: Planning and Design, 37*(1), 129–147.