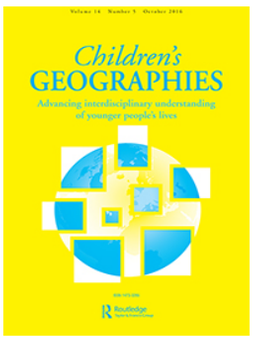

Children's Geographies

ISSN: 1473-3285 (Print) 1473-3277 (Online) Journal homepage: http://www.tandfonline.com/loi/cchg20

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To cite this article: Janet Loebach & Jason Gilliland (2016) Neighbourhood play on the endangered list: examining patterns in children's local activity and mobility using GPS monitoring and qualitative GIS, Children's Geographies, 14:5, 573-589, DOI: 10.1080/14733285.2016.1140126

To link to this article: https://doi.org/10.1080/14733285.2016.1140126

Published online: 10 Feb 2016.

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Children's Geographies, 2016
Vol. 14, No. 5, 573–589, http://dx.doi.org/10.1080/14733285.2016.1140126

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Neighbourhood play on the endangered list: examining patterns in children's local activity and mobility using GPS monitoring and qualitative GIS

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(*Received 31 August 2015; accepted 15 December 2015*)

Children's time and freedom for independent neighbourhood activity is severely declining, which may be adversely impacting their healthy development. This study integrates GPS activity monitoring and environmental analysis in a geographic information system with activity diaries, annotated maps, surveys, and map-enhanced interviews to conduct a deep pattern analysis of children's habitual neighbourhood behaviour ($n = 23$; aged 9–13 years) from each an urban and suburban school neighbourhood within London, Canada. Patterns in children's primary activities and settings, independent mobility (IM) levels, and perception and use of neighbourhood affordances are examined. Participants note a diverse range of local independent destinations, but habitually spend little time playing outdoors in neighbourhoods. Local activity related to free time available, perception of activity affordances, and license to travel independently. Social and environmental conditions of children's micro-neighbourhoods influenced independent destinations and domains. Neighbourhood planning should promote diversity of activity affordances and address conditions that support increased IM for youth.

Keywords: neighbourhood play; children; affordances; independent mobility; GPS monitoring; qualitative GIS

Introduction

More than 20 years ago, a UK study drew attention to the shrinking neighbourhood domains of childhood by highlighting the dramatic loss in a child's independent home range within just three family generations; a young boy in Sheffield in 1919 had permission to walk alone almost 10 km to a favourite fishing spot, compared with his great-grandson, who was only allowed to travel on his own the 300 m to the end of his street (Hillman, Adams, and Whitelegg 1990). Research from several developed countries has documented similar decreases in children's independent activity and mobility within local environments, including dramatic declines in the number of children travelling to school without adult supervision (Buliung, Mitra, and Faulkner 2009; Fyhri et al. 2011; McDonald et al. 2011; Pooley, Turnbull, and Adams 2005; Villanueva et al. 2012; Witten et al. 2013). Concomitantly, there is some evidence that the size of children's independent activity domains also appear to be shrinking; one recent study reported that one-third of the

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8–12-year-old participants did not venture more than 100 m from their home on their own (Veitch, Salmon, and Ball 2008).

Given the enormous health threats facing contemporary children, including rising rates of obesity, asthma, and injury (Anandan et al. 2010; Gilliland et al. 2012; Ogden et al. 2012; Tremblay et al. 2010), one might ask why the loss of independent neighbourhood-based activity should provoke much concern. The predominant discourse of protectionism would suggest that we insulate children from health threats by protecting them from risk at all costs, including limiting their unsupervised play and travel (Gill 2007; Karsten 2002; MacDougall, Schiller, and Darbyshire 2009). Unfortunately, there is little awareness of the detrimental corollary of such protective actions. Rather than a neutral or negligible impact, the loss of experience and developmental benefits from reduced neighbourhood activity may have significant adverse effects on children's health (Kyttä 2003; Mikkelsen and Christensen 2009; Shaw et al. 2012), and should garner as much attention as other contemporary threats to children's well-being.

We still know very little about children's perception and use of neighbourhood environments, and the factors which may be restricting independent neighbourhood activities. More researchers are now examining children's independent travel, particularly to school (see Schoeppe et al. 2012; Shaw et al. 2012 for reviews), but only a few studies have focused on independent journeys to other destinations, or the specific environmental settings of contemporary child and youth activities (see Fyhri and Hjorthol 2009; Rainham et al. 2012; Villanueva et al. 2013). A recent review highlights gaps in children's environments research, stressing the need to focus on the specific geographical contexts of children's activities, as well as the social, cultural, and economic factors which may be underscoring their local behavioural patterns (Shaw et al. 2012).

This study works to fill such research gaps by utilizing data collected using a suite of tools, including global positioning systems (GPS)-based activity monitoring, to engage in a deep examination of individual- and neighbourhood-level patterns in children's habitual activity settings, their level of independent mobility (IM), and their perception and use of neighbourhood opportunities for activity. While GPS tracking is being increasingly employed in research to directly monitor children's activity, this study is among the first to blend objective GPS tracking of children's activity with subjective data from a range of qualitative tools, including activity diaries and digital map-enhanced child interviews, to comprehensively examine children's neighbourhood activities and experiences. With this comprehensive analysis we hope to better understand the contemporary relationship between children and their neighbourhoods, and recognize ways to provide more stimulating community environments that can foster child health and well-being.

The developmental benefits of neighbourhood play

Exposure to new social and environmental settings within the neighbourhood during middle childhood and adolescence has traditionally helped foster critical social, physical, cognitive, and emotional developments. Learning to negotiate the challenges served up by diverse local environments during play and exploration is linked to a number of key childhood advancements, including learning to build social relationships beyond the family, improving cognitive and motor skills, as well as expanding children's understanding of the larger physical world (Burdette and Whitaker 2005; Matthews 1992; Prezza and Pacilli 2007; Rissotto and Tonucci 2002; Spilsbury 2005). Independently facing these complex environments breeds a sense of autonomy and competence, giving children confidence to continue broadening the boundaries of their independent domains (Churchman 2003; Gill 2007; Spencer and Woolley 2000). Active and regular

engagement with their neighbourhoods can also foster children's attachment to their local 'place', which in turn supports the development of a healthy self-identity (Chawla 1992; Jack 2010; Ross 2007). Children's ability to spend time playfully and independently exploring their neighbourhood environments may be fundamental to their development and well-being.

The endangered nature of neighbourhood play

Studies have documented a continual reduction in children's free play across all age ranges since the 1950s, with the largest and most noticeable drops in local outdoor play (Gray 2011; Hofferth and Sandberg 2001). In a recent US study with over 800 mothers, 85% agreed that their own children played outdoors less than they did as children; 70% reported playing outdoors daily as children, compared to only 31% of their own children today (Clements 2004). Similarly, in a national Canadian survey, only 14% of children regularly spend their after-school leisure time playing outside (Active Healthy Kids Canada 2012).

Declining levels of outdoor neighbourhood play may also be changing the primary landscapes of childhood. Examining changes in Amsterdam neighbourhoods over several generations, Karsten (2005) noted fundamental changes in the definition and settings of play for contemporary children from that of their parents and grandparents. Play, once synonymous with 'outdoor play' in the public spaces of the neighbourhood, has for many children moved indoors to the private spaces of the home, child care settings, or formal recreational facilities. Kartsen suggests that substantial changes to children's daily schedules and geographies have given rise to at least two new categories of childhood play experience; in addition to the few 'outdoor' children whose play activities remain predominantly in outdoor settings, there is now a large cohort of 'indoor' children who play almost exclusively indoors, often under the supervision of adults. Many others are 'backseat' children who spend a significant amount of their leisure time in vehicles being chauffeured from one activity to the next, with little-to-no time spent outdoors (Karsten 2005).

Burke (2005) similarly argues that the nature and landscape of play has changed so much it is unrecognizable from that of previous generations. Technological developments in home-based entertainment such as television, computers, and video games (Clements 2004; Copperman and Bhat 2009; Tandy 1999), coupled with parents' heightened interest in providing 'safer', supervised activities (Clements 2004; Gray 2011), have made indoor activities more appealing to both children and their parents. Parents no longer view the neighbourhood as a safe play space for children; fears of stranger abduction, or of danger from traffic or bullies, lead many to accompany their children on community excursions, or else keep them indoors all together (Gill 2011; Mikkelsen and Christensen 2009; Pooley, Turnbull, and Adams 2005). Family schedules have also changed to accommodate commuting patterns, and children's increased involvement in structured out-of-school activities (Copperman and Bhat 2009; Gray 2011; Karsten 2002; Mackett et al. 2005). The net result is an increase in the time children spend indoors in private settings, or in vehicles being driven to organized activities (Karsten 2005; Mikkelsen and Christensen 2009; Pooley, Turnbull, and Adams 2005). The public, outdoor settings of the neighbourhood have become inaccessible or infrequent domains for play. For many children, there are now few places beyond home which they can travel to on their own, or even in the company of friends (Veitch, Salmon, and Ball 2008).

The rhythms and settings of children's neighbourhood activities have changed dramatically in recent decades. Independent neighbourhood play and exploration have become endangered childhood experiences, posing significant challenges to healthy child development. It is imperative that we examine the contemporary child–neighbourhood relationship, and the contextual factors that can support or increase children's local activity.

Methods

Study participants and settings

This study utilizes data from the STEAM (Spatio-Temporal Environment and Activity Monitoring) project (steamproject.ca), a three-year study designed to examine the effects of the built environment on children's health-related behaviours. Children aged 9–13 years were invited to participate in a week-long multi-tool protocol to document their neighbourhood activities, mobility, and experiences. Year One of the study focused on two school neighbourhoods in London, Canada, categorized respectively as 'urban' and 'suburban', which exhibit similar social and economic profiles but very different built environments. Both neighbourhoods are of low socio-economic status, with household incomes generally lower than the city average, and higher levels of both unemployment and lone-parent families. The 'urban' school neighbourhood has a gridiron street pattern, a diverse mix of land uses, and a higher population density. This neighbourhood also encompasses several commercial corridors, and is well served by parks and recreational facilities. The 'suburban' school neighbourhood conversely has a meandering street pattern with numerous cul-de-sacs and low-traffic volumes, and is dominated by medium-density residential areas with several large parks and a few scattered commercial property clusters. These schools were selected to highlight impacts of the neighbourhood built environment on children's activity by holding socio-economic variables constant.

Participating children (Year One $n = 144$) wore portable GPS monitors (*Visiontac VGPS 900*) during all waking hours for 6–7 days during the spring season (May–June); GPS units marked spatial coordinates for each second of use. Participants also completed daily activity and travel diaries, and annotated aerial photo maps of their community to highlight destinations to which they could travel independently (without an adult). Participants and their parents also completed detailed surveys on children's neighbourhood activities and perceptions.

Within a few weeks of completing the 7-day STEAM protocol, approximately one-third of the children ($n = 48$) elected to participate in interactive small-group discussions. A researcher engaged groups of two or three children in dynamic 60-minute discussions about their neighbourhood perceptions and behaviours. The small-group format was chosen based on previous experiences which demonstrated children's greater engagement in discussions when accompanied by peers, and the ability of peer conversations to highlight contrasts among children's experiences (See Loebach and Gilliland 2010, 2014). Prior to the interview, each participant's GPS tracks from their study week were loaded into *Google Earth* (2011), providing an activity 'breadcrumb trail' which the child and researcher could virtually walk through together, using the participant's activity diaries as discussion prompts. Such visual methods are effective for research with children, as they are less dependent on language skills, and they align well with children's capabilities and interests (Burke 2005; Driskell 2002; Jung 2015). Qualitative data from interviews related to specific neighbourhood resources or destinations were immediately 'pinned' to the appropriate spatial location within *Google Earth*, later to be imported into a geographic information system (GIS). Group discussions yielded rich narratives to complement and clarify data from GPS tracks, diaries, and maps.

Only Year One participants who took part in both the interview and the full STEAM protocol ($n = 27$) were considered for inclusion in this deep pattern analysis. GPS data minimums, however, were also established; only participants who had recorded at least 3 hours of out-of-school GPS data on a minimum of three weekdays, as well as at least 4 hours of data on at least one weekend day, were included. Without a common standard for GPS wear time, validity criteria were guided by current Canadian standards for accelerometer wear time (Colley et al. 2013). The final participant sample for this analysis ($n = 23$) consisted of 12 urban school students

and 11 suburban school students. Child participants ranged in age from 10 to 13 years; the median age was 11.0 years. The majority (82%) of the final participants were female.

Deep pattern analysis of children's neighbourhood activity and mobility

Most contemporary investigations of children's behaviour isolate a single behaviour or environmental condition and then look shallowly across a large sample of children and environments to generalize patterns of behaviour. This study instead works from the position that individual and environmental conditions are operating in fairly idiosyncratic ways to affect children's behaviours, blending together to produce very individualized experiences within a given time and context. Researchers therefore undertook a deep and prolonged engagement with the diverse data-set collected for each participant, including GPS tracks, activity diaries, annotated neighbourhood maps, interview narratives, and child and parent surveys, to develop a complex and more nuanced picture of each child's habitual activity patterns.

Participant's habitual activities were then classified according to a series of behavioural and contextual categories reflecting factors which have been purported in the literature to influence neighbourhood-based activity (See Table 1). The classifications were in turn integrated in a GIS (*ArcGIS* 10.0) with the geographically located qualitative data from interview narratives as well as local built environment data to consider the influence of the local environmental context on neighbourhood behaviour. The built environment around each child's home was characterized (using data obtained from the City of London 2011 and the 2006 Canada Census), noting for example the type and number of nearby commercial, recreational, and other activity resources, as well as morphological elements, such as major roads, rivers, or railroads, that can constrain activity or hinder mobility. We then examined patterns in children's environmental perception and use, both within and between each major category.

Size of independent neighbourhood activity space

Multiple sources were used to spatially locate each child's independent neighbourhood destinations (i.e. those locations to which they are allowed to go without an adult). Each child's pedestrian-based neighbourhood domain, or 'neighbourhood activity space' (NAS), was established within a GIS in a previous study (see Loebach and Gilliland 2014) by isolating activity at all neighbourhood locations reached on foot or bicycle. To ensure each child's full independent

Table 1. Behavioural and contextual category classification.

Classification of neighbourhood perceptions and activity:	
Category	Level or typology
Size of independent neighbourhood domain	Large, moderate, or small
No. of independent destinations	Low, moderate, or high
Activity schedule	Very, semi, or unstructured
Reduced free time *(on 2 or more weekdays)*	Yes or no
Volume of time spent in-vehicle	Low, moderate, or high
Daily screen time level	Low, moderate, or high
Childhood type (Karsten's typology)	Outdoor, indoor, or backseat
Perception of neighbourhood activity affordances	Low, moderate, or high
Use of neighbourhood activity affordances	Low, moderate, or high
Independent mobility level	Low, moderate, or high

activity space was captured for this study, the *ArcGIS* Tracking Analyst tool was used to trace through participants' GPS data, checking for congruency with activities and locations noted in activity diaries, verifying the relative amount of time spent in noted activities and settings, and adding any undocumented destinations into the GIS data-set. Triangulating these data with interview narratives allowed for the classification of each child's NAS. Compact activity spaces extending only a short distance from home were classified as *small*. Children with small 'habitual' activity spaces (See Loebach and Gilliland 2014), but with some occasional neighbourhood destinations further from home were considered to have a *moderately* sized domain. Children with a large GPS-derived NAS and a large number of independent destinations a fair distance from home were classified as having *large* neighbourhood domains.

Number of independent neighbourhood destinations

We also considered the relative number of independent destinations noted, including from annotated maps, activity diaries, and interviews, as an indicator of the frequency and range of independent use of the neighbourhood. The median number of independent destinations noted by participants was eight locations; the minimum number noted by a participant was 2 and the maximum was 19 destinations. Participants noting more than 10 independent destinations were considered to access a *high* number of local settings; those with fewer than five mentions were considered to use a *low* number of nearby amenities. Children noting between 5 and 10 mentions were considered to independently access a *moderate* number of local destinations.

Degree of independent mobility

Each child's level of IM, or the degree to which they could use or explore their neighbourhoods without adult supervision, was derived by considering the degree of freedom awarded by parents as well as the overall size of the independent domain outlined on the neighbourhood map; each child was also asked directly about their IM level within both surveys and interviews. Together these data were used to establish whether the child experienced a *high level of IM* (no mobility restrictions, or restrictions that defined a large geographic area), a *moderate level of IM* (some restrictions, such as only being able to travel with friends or siblings, or only able to access a moderate geographical domain within a short distance of home), or a *low level of IM* (with either no ability to travel without an adult, or an independent domain confined to the area within a block or two of home).

Degree of structured activity

Both activity diaries and interviews were used to establish the degree to which participants were involved in structured out-of-school activities as part of their habitual weekly routines, such as sports teams, music lessons, or language classes. Children regularly involved in structured activities three or more days per week were classified as having *very structured* schedules, while activities on one or two days were classified as *semi-structured* schedules. Children with no structured activities, or who participated in such activities only on occasion, were considered to have *unstructured* schedules.

Amount of free time

To assess the amount of out-of-school free time for neighbourhood play available to a child, activity patterns evident from diaries and interviews (and corroborated by GPS data) were used

to establish the typical number of days per week their free time was reduced, either due to structured activities, after school care or because of time spent away from home as part of family activities. Children whose out-of-school free time was compromised on two or more school days per week were considered to have *restricted free time* for neighbourhood-based activity. Participants whose free time was reduced only one school day or less, or not habitually restricted on a weekly basis, were considered to have *unrestricted free time*.

Amount of time spent in-vehicle

Children's GPS data and activity diaries were used to establish how much of their out-of-school free time is habitually spent in a vehicle. Children who spent the majority of their free time three or more days per week riding in a vehicle, or who spent a large portion (approximately 1 hour or more) in a vehicle on a daily or almost daily basis, were classified as having *high in-vehicle time*. Children who spent a small portion of each day in a vehicle, or who spent a large portion of time in a vehicle on at least two days per week, were considered to experience *moderate in-vehicle time*. Those participants who spent little to no time in a vehicle on a daily basis, or who spent a large portion in a vehicle on only one day, were classified as having habitually *low in-vehicle time*.

Amount of daily screen time

The detailed activity diaries, corroborated in interviews, allowed us to assess whether a child exhibited a *low*, *moderate*, or *high* level of daily screen time. Screen time activities include watching television, or playing on a computer or portable gaming device; screen time related to homework assignments was excluded. When screen-based activities comprised the majority of a child's free time on a daily or almost daily basis, they were classified as having *high screen time*. Children who spent time in front of screens on a daily basis but also demonstrated substantial involvement in other activities were labelled as exhibiting *moderate screen time*. A *low level of screen time* was assigned to children who did not spend time in screen-based activities on a daily basis, or who spent only a small part of their daily free time in front of screens.

Childhood play experience type

Each child's habitual out-of-school activity patterns and locations were determined by triangulating data from GPS, diaries and interviews, and relative time spent in vehicles. Each child's habitual play experience was then classified according to Karsten's typology of *outdoor*, *indoor*, or *backseat* childhoods. Children were assigned a single 'childhood play experience type' if they spend the majority of their out-of-school activity each day either indoors, outdoors, or in a vehicle.

Perception and use of activity affordances

Finally, to assess children's perception of opportunities for activity in their neighbourhoods, we utilized the environmental psychology concept of *affordances*. Affordances are the functional possibilities for action inherent in a physical environment that a person can engage to meet their needs or interests (Gibson 1979; Heft 1997; Kyttä 2003). Affordances are relational by nature; an individual will perceive opportunities in line with their physical attributes and capabilities, but also their specific intentions (Heft and Kyttä 2006). For this study, we considered neighbourhood activity affordances to be opportunities in the local environment perceived or used by a participant for engagement in leisure, play and/or social activities. A child's perception or use of

neighbourhood affordances for activity was established via interview narratives and each participant's collected set of frequented neighbourhood destinations. Perception of affordances refers to a child's awareness of activity opportunities in their community, whether they used them or not. Use of affordances, however, was evaluated only as neighbourhood amenities, whether formal or informal, that children confirmed that they use or visit. Children who showcased a strong awareness, or use, of a large number of nearby activity resources were classified as perceiving or using a *high* number of affordances. Children who were aware of, or utilized, few to no neighbourhood opportunities for activity were labelled as perceiving or using a *low* level of affordances. Children who fell in between these extremes, showing an awareness or use of a moderate number of nearby amenities were classified as perceiving or using a *moderate* number of affordances.

Results and discussion

These collective classifications were used to comprehensively analyse individual- and neighbourhood-level patterns in children's perceptions and activity, and to consider relationships within and across categories. Of particular interest for this study were patterns in childhood play experience type (as per Karsten's typology), the perception and use of neighbourhood affordances for activity, and level of IM, which are considered here in detail.

Patterns in childhood play experience setting

Classifying the primary setting of participants' out-of-school play into a single category from Karsten's typology of *indoor*, *outdoor,* or *backseat* childhoods proved difficult, as a child's activity rhythms could exhibit opposing patterns on different study days, or include strong components of more than one type on a single day. Some children, for example, had days dominated by outdoor neighbourhood activity, while other days exhibited exclusively passive indoor activities. Children were therefore classified by a combination of categories if their activities strongly demonstrated two differing play experience types.

Among the participants there were no children whose activities could be solely classified as either *outdoor* or *backseat*, but almost half of the participants were categorized as having a primarily *indoor* experience, exhibiting little to no regular time outdoors, but also little time in vehicles. About one-third of the participants habitually spent some time outdoors, but only 10% regularly spent as much of their daily free time outdoors as indoors. There were only a few children who spent a substantial portion of their free time in vehicles being driven to activities or else along on family errands such as grocery shopping. Most children's activity patterns, therefore, were classified as *indoor, indoor–backseat* or else *indoor–outdoor*.

When we consider these play experience designations against all of other categories by which children or their environments were classified, patterns emerged within each group (See Figure 1). Participants with a strong *outdoor* component to their habitual activity pattern all had unstructured schedules, with little time spent in vehicles and almost no reduction of their out-of-school free time; that is, the children who spent more time outdoors tended to have more available free time at home than other participants. Children in this group also had higher levels of IM, perceived higher levels of neighbourhood affordances and documented more local independent destinations. All participants spending substantial time outdoors had moderate to large NAS; they also demonstrated lower levels of screen time. An environmental analysis of their micro-neighbourhoods (the built environment within walking distance of home) revealed a diverse range of commercial and recreational resources close to each child's home.

Conversely, children classified as *indoor* or *indoor–backseat* generally exhibited one of two distinct profiles of behaviour and conditions (See Figure 1). The first group had smaller sized

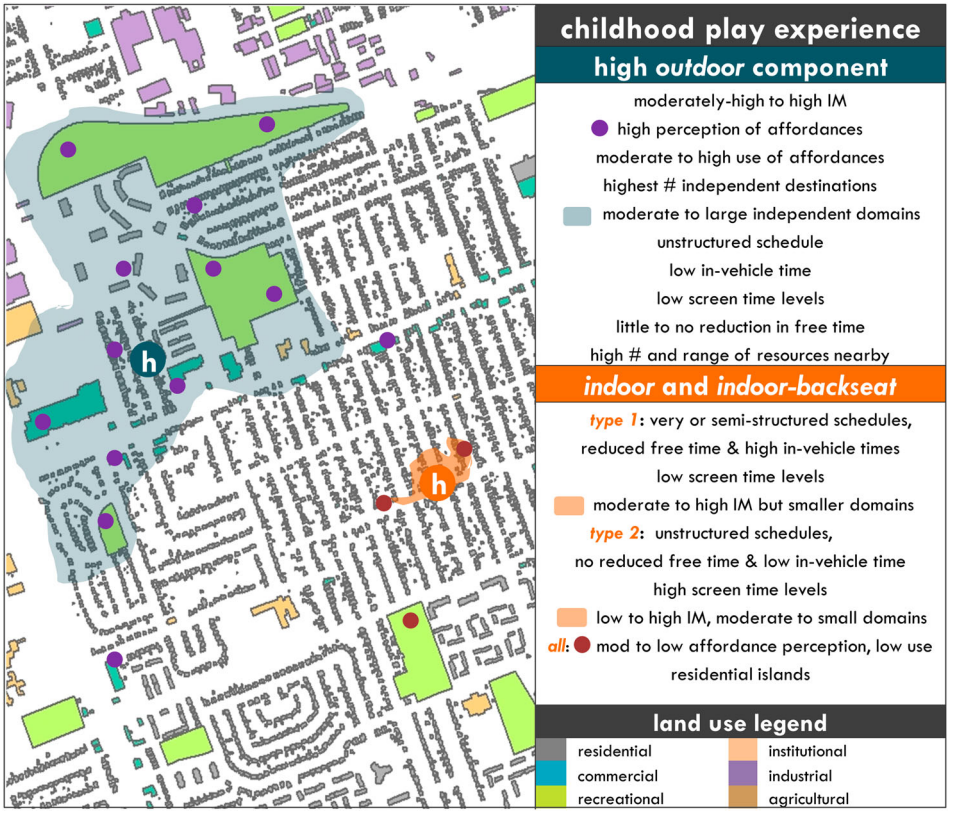

Figure 1. Patterns in childhood play experience type.

NAS, and on the whole spent large portions of their out-of-school time being driven around by car and/or indoors in structured activities, such as dance class or piano lessons; they generally had little free time at home to play outdoors (though this reduced free time also coincided with lower screen time as well). Most of this group however were allowed reasonably high levels of IM and perceived a moderate level of local affordances, suggesting that the lack of time spent playing in the neighbourhood was more a function of free time than permission.

The second distinct group of *indoor* and *indoor–backseat* children all exhibited larger sized NAS, with mostly unstructured schedules and a moderate level of IM like their *indoor–outdoor* peers, but very low use of neighbourhood affordances; that is, they had permission to travel further and utilize neighbourhood resources but they rarely did. Children in this group, however, recorded extremely high screen times. Despite the license and free time for neighbourhood play, participants within this profile chose to spend their leisure time indoors, primarily watching television or playing video games.

Striking similarities were apparent across the entire group of *indoor* children when we examined their local built environments in detail (See Figure 1). The micro-neighbourhoods of nearly all *indoor* children, regardless of neighbourhood type, could be described as 'residential islands'; most lived in almost exclusively residential areas either surrounded by homes or located on the fringes of residential neighbourhoods bounded by significant morphological boundaries such as major roads or ravines. There were few to no commercial or recreational resources within the near neighbourhood, and most of these children acknowledged that there was little to do in

the area. As Sierra[1] explained 'Well it's kind of like … there's not really much places around … that we can go … like, there's just houses pretty much everywhere'. Not surprisingly then, these same children perceived lower levels of nearby affordances and documented very few local independent destinations.

This examination of children's play experience using Karsten's typology highlighted the predominance of indoor settings as well as indoor activities in participant's leisure lives, similar to her own findings (2005). Fewer children than expected were found to have a strong 'backseat' component to their activity patterns, but this may be attributable to the generally lower household incomes in the study neighbourhoods and the high prevalence of single-parent households; participants' parents may have fewer resources to shuttle children to activity destinations outside of the neighbourhood. In line with research documenting declining levels of outdoor free play, only a few children in the study spent significant amounts of their out-of-school leisure time playing outdoors around home or in their neighbourhood.

Patterns in perception and use of neighbourhood affordances

Clear patterns also emerged when we performed a deep analysis of participant's perception and use of neighbourhood activity affordances. Most children perceiving high levels of local affordances exhibited higher levels of IM and large NAS, and the highest number of local independent destinations (See Figure 2). Most of these children also had a habitual *outdoor* component to their

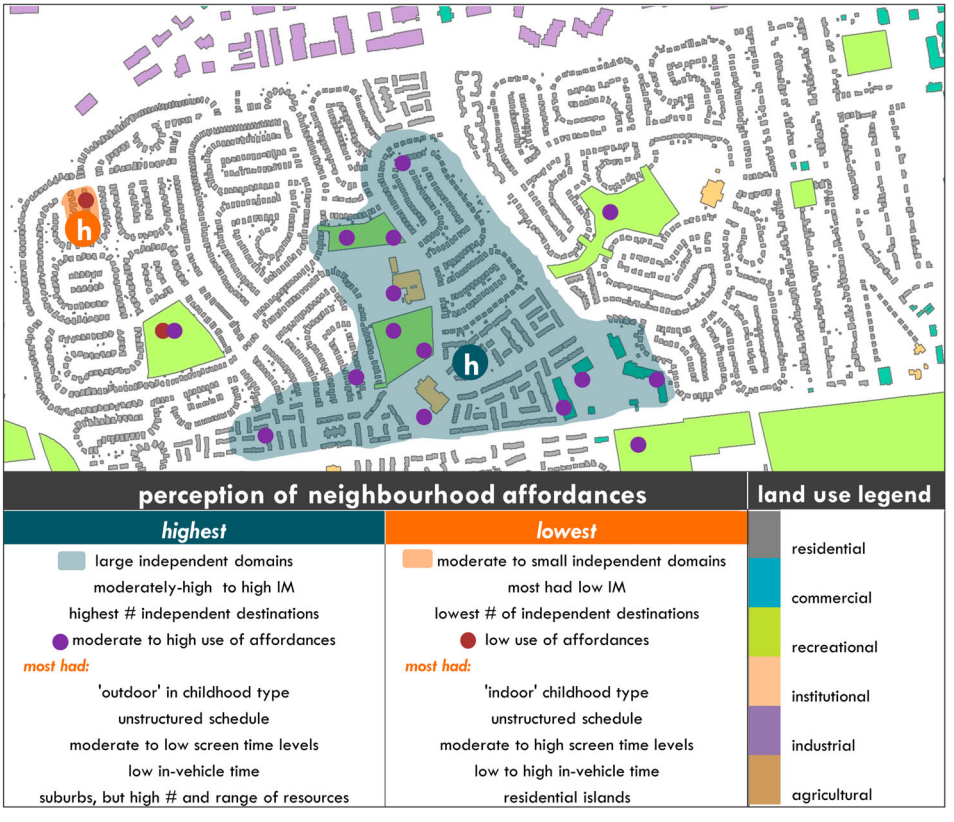

Figure 2. Patterns in children's perception of neighbourhood affordances.

activities, had fairly unstructured schedules, and spent low amounts of time either in vehicles or in front of screens. The majority in this group resided in environments classified as 'suburban', which are often assumed to offer fewer activity affordances. Closer examination of the local built environment however revealed a diverse range of recreational and commercial resources within close proximity to participants' homes, regardless of its overall 'urban' or 'suburban' classification. All children who perceived high levels of neighbourhood affordances generally had permission and significant time available to play outdoors, in an environment offering an ample range of nearby amenities.

Children who perceived few neighbourhood affordances generally exhibited the opposite profile (See Figure 2). Most had low levels of IM, with moderate- to small-sized NAS, and recorded few local independent destinations. The most prominent characteristic, however, was that each child in this group was classified as having strictly an *indoor* childhood; in turn they noted very low engagement with local affordances. Examining the micro-neighbourhoods of this group revealed that, again, most lived in 'residential islands' with few recreational resources nearby. It is unclear whether the lack of perception and use of affordances springs from low independence and time spent outdoors or vice versa, but the results indicate a strong relationship between these factors.

The actual *use* of neighbourhood affordances followed very similar patterns to the *perception* of affordances (See Figure 3). Again, the highest users of local affordances typically had more independence and available free time, which many spent outdoors around the neighbourhood

Figure 3. Patterns in children's use of neighbourhood affordances.

rather than in front of screens. The lowest users of activity affordances had less independence, perceived few local affordances available and generally spent their free time indoors or in vehicles. Though most of these low affordance users lived in 'residential islands', similar to the patterns exhibited by many 'indoor' children, the group generally divided into two activity profiles. One group exhibited relatively unstructured schedules with abundant free time, but with very high screen time levels. The second group had little available free time at home as they had much more structured schedules, and tended to spend much more time being chauffeured to personal or family activities (See Figure 3). Children demonstrating the lowest use of neighbourhood affordances, therefore, either had little free time available, or perceived few neighbourhood opportunities that countered the appeal of television and computer screens.

It is important to highlight that the perception of affordances did not always translate to use. In a few cases, children perceiving high levels of affordances were only awarded low levels of IM, restricting their ability to utilize these activity opportunities. However, mobility level was not always the deciding factor; a few children perceiving many activity affordances and claiming fairly high levels of independence still spent the majority of their time at home, documenting very high levels of screen time. These results suggest that some children, despite having permission to be out, deliberately chose indoor television watching or video game playing over activity opportunities available in their neighbourhoods.

Patterns in IM levels

The children in this study demonstrated a broad range of local independence levels. No systematic pattern of mobility license, as awarded by parents, was apparent with respect to age or gender, contrary to studies that have found these factors to be influential (Brown et al. 2008; Fyhri and Hjorthol 2009; Veitch, Salmon, and Ball 2008). There were also no strict patterns in IM level related to childhood play experience type, time spent in vehicles, or the degree to which their structures were scheduled (See Figure 4).

Noticeable similarities were evident, however, in the characteristics of and time spent within their neighbourhood domains; children with higher IM levels generally recorded not only larger NAS but also spent more time in settings further from home. These children also both perceived and utilized more neighbourhood affordances than those with low mobility, likely as a result of their greater ability to explore their neighbourhood environments.

A child's IM level also appeared to be related to local social and environmental conditions. The micro-neighbourhoods of most children with higher IM exhibited distinct morphological boundaries which defined a relatively large but finite geographical area; the delineated activity space usually offered a number of amenities and destinations, and therefore did not require children to negotiate the challenges posed by these boundaries to access play opportunities. The GPS data revealed that none of the participants crossed (on foot or bicycle) a major morphological boundary around their home at any time during the study. Only one interviewee indicated that she had permission to independently cross nearby boundaries, though she rarely did so. In most cases, there were a number of commercial and recreational destinations close to home but not immediately proximate; the appeal of these destinations perhaps drew the children a bit further from home without being so distant as to feel uncomfortable. The micro-neighbourhoods of children with high IM levels also featured safe sidewalks or other low-traffic paths to nearby destinations, which can facilitate easier walking and biking around the home environment. Another commonality was the presence of several nearby friends or peers, which likely increases the appeal of neighbourhood activity to children, and greater comfort with increased child independence among parents. As explained by a young female participant: 'I could go [into the neighbourhood] on my own, but [my parents would] rather I be with friends'.

Figure 4. Patterns by children's level of independent mobility.

Similar patterns emerge for the participants, about one quarter, demonstrating the lowest levels of neighbourhood independence. Again, there were no clear patterns with respect to age, gender, degree of structured schedule, or time spent in vehicles, but children with the lowest IM were all classified as having primarily *indoor* childhoods (See Figure 4). These children, in turn, perceived and used few affordances in their local settings, reinforcing the relationships between IM, time spent outdoors, and the perception and use of local affordances. The micro-environments around the homes of these children were also 'residential islands' with few nearby commercial or recreational destinations to draw them from their homes. A primarily residential area may provide a higher likelihood of having nearby peers, but this social condition was not necessarily enough to expand independent range; children with nearby social ties but few local amenities still demonstrated low mobility and low levels of neighbourhood use. Conditions of the social or built environment both appear influential in children's neighbourhood independence and use, but neither condition on its own is necessarily sufficient to support the expansion of a child's NAS.

Methodological contributions

The unique data collection and analysis protocols used in this study represent a number of advances for children's environmental behaviour research. Integrating insights from child narratives, annotated maps, and activity diaries with GPS tracking data within a 'qualitative' GIS

framework provided the more holistic picture of children's behaviour that is critical to improving our understanding of their unique neighbourhood needs, experiences, and desires. The dynamic map-enhanced interviews using *Google Earth* effectively engaged child participants while validating GPS and diary data, helping to isolate habitual from occasional activities and destinations. These enhanced interviews were also critical for uncovering 'why' (or 'why not') children spend time in their neighbourhoods, and highlighting the specific settings and activities to which they are drawn. This map-enhanced interview technique was effective for pinning perceptions and activities to specific neighbourhood locations, and an efficient alternative to more resource-intensive field tours or photo-mapping exercises (see, e.g. Loebach and Gilliland 2010).

Conclusion

A deep examination of the habitual activities of participating children highlighted that children's neighbourhood activity is tied to a few key and mutually dependent factors: the time and freedom a child has for neighbourhood play or exploration, the perception of diverse affordances that support their interests, and a safe, supportive and interesting local environment. Participants who regularly spent time outdoors in the neighbourhood had more unstructured free time available, experienced higher levels of IM and, in turn, spent more time in their independent neighbourhood domains, exposing themselves to greater activity affordances and experiences. Elements of the local social and built environment also strongly influenced local activity; children who spent more time in their neighbourhoods tended to have higher numbers of friends living nearby and a local environment that offered a diverse range of activity resources without the challenge of major morphological barriers. The opposite conditions severely limited children's neighbourhood engagements and seemed to help drive their activities indoors, including reduced free time or IM, and the lack of alluring amenities or peers nearby. If children are barred from expanding their independent domains, or if the broader environment offers few additional affordances, the neighbourhood environment will not be able to support children's changing activity needs and preferences, and their free time will be spent elsewhere.

Creating affordance-rich, child-friendly environments

Understanding the neighbourhood affordances that appeal to children, and which are perceived as being supportive of their interests, could help to reverse declining levels of local independent and outdoor activity. Parental mobility allowances and a less restricted schedule can also provide children more time outdoors to explore their neighbourhoods, leading to the discovery, shaping and use of more affordances. These interactions build both the skills and confidence that encourages the expansion of children's independent domains, opening up even more experiential opportunities. Communities, planners, and families can help to create affordance-rich environments for children by supporting conditions that expand recreational and mobility opportunities, and limit or eliminate those that would hinder children's neighbourhood activity. Concentrating, in fact, on the affordances a given environment offers to children is an effective strategy for evaluating the 'child-friendliness' of a neighbourhood (Kyttä 2004), and a valuable tool to support the development of safe, supportive, and diverse communities for young residents. Additional research evidence to shore up our understanding of the features and conditions that boost neighbourhood affordances and help to expand children's independent domains would be valuable additions towards this effort.

Acknowledgements

The authors would like to thank the students, parents and staff of the London District Catholic School Board and the Thames Valley District School Board, as well as staff and students of the Human Environments Analysis Laboratory of Western University.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This research was funded by the Social Sciences and Humanities Research Council of Canada, the Canadian Institutes of Health Research, and the Heart and Stroke Foundation of Canada.

Note

1. The names of all people and locations in this study have been changed to protect the privacy of the participants. For the same reason, maps exhibiting children's GPS data or child annotations have been spatially anonymized.

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