FOUR DIMENSIONS OF NEIGHBOURHOOD FORM RELATED TO CHILDREN'S WALKS TO SCHOOL

Vivian Romero

Victoria University, ISEAL, Melbourne, VIC, Australia

INTRODUCTION

The disciplines of town planning and public health have investigated the connection between walking and neighbourhood form (e.g., Frank et al. 2003; Frumkin et al., 2004). In particular, Terri Pikora and her colleagues (2003) created a schema to classify a range of potential elements that may influence an adult's decision to walk. By reviewing the health, urban planning and transport-related literature, they created a socio-ecological framework to classify a range of potential elements that may influence an adult's decision to walk. This framework identifies four dimensions of neighbourhood form related to walking: functionality, safety, destinations and aesthetics. Functionality relates to the efficiency of movement provided by the layout of the streets and footpaths for its pedestrian users. Safety relates to those features that affect personal safety and traffic safety. Destinations relate to the availability and accessibility of neighbourhood facilities. Aesthetics describe the features that create "interesting and pleasing physical environments" (Pikora et al., 2003, p. 1696). Collectively, these four dimensions "collate all potentially relevant factors" (ibid, p. 1697) and provide a framework that could be applied to school travel research to assist in the understanding of the physical factors that affect walking. The applicability of these dimensions have been tested in studies and have been found to affect the likelihood of adults walking for transport or recreation (e.g., Hoehner et al., 2005; Pikora et al., 2006; Badland et al., 2009). These four dimensions, however, have yet to be applied to children's school travels on foot.

This paper aims to provide an empirically grounded understanding of Pikora et al.'s design dimensions in relation to children's walks to and from school. It reviews school travel studies investigating neighbourhood design elements. Town planning and public health researchers have invested much time in analysing the factors that facilitate as well as constrain children's walks to school. The resulting empirical evidence can be conveniently categorised into street functionality, traffic safety, school destination and natural aesthetics. Therefore, the following sections categorise the school travel literature to provide the empirical evidence needed to substantiate the use of these design dimensions in light of the school walk as well as to develop the argument that design features of walkable paths to and from school are invariably misunderstood.

STREET FUNCTIONALITY

The layout of the street determines the degree to which the streets and associated footpaths maintain links through a neighbourhood and thus its functionality for pedestrians (Handy & Clifton, 2001; Southworth, 2005). The layout of the street can be categorised on a gradient of grid to curved patterns (Southworth, 2005). Streets aligned on a grid pattern tend to promote short walkable blocks through the design of a set of streets crossing each other at approximately right angles (Frank et al., 2003). Streets aligned on a curvilinear pattern tend to feature large blocks, wide roads and streets that end in cul-de-sacs (Girling & Helphand, 1996; Stein, 1951).

The layout of the streets can affect how long a child needs to travel on foot between two points. For example, if a child walking in the neighbourhood with streets arranged in a grid pattern has a more direct route and shorter distance to travel than a child walking in the neighbourhood arranged in a curvilinear pattern. Neighbourhood streets arranged on a grid pattern can provide a direct route between two destination points. The street layout connecting home and school determines the degree of directness of the school route and thus influences the distance and time of a walking trip.

Parental perceptions of the effects of street layout on a child's walk to school have been investigated (Frumkin et al., 2004; McMillan et al., 2006; Tranter, 1993; Ziviani, Scott & Wadley, 2004). For example, to determine whether different types of street layouts affect whether children walk to school, Marc Schlossberg and his colleagues (2005) distributed questionnaires to the parents of children studying in Years 6 to 8 (i.e., 11 to 15 years of age). They selected four neighbourhoods in urban areas of Oregon based upon whether the street layout was arranged on a grid or curvilinear pattern and controlled for the distance between home and school. Their results imply that children whose routes to school contain more intersections and fewer dead-end streets are more likely to walk. These routes typically reflect streets based on grid patterns. Therefore, according to the surveyed parents, streets that provided their children with easy access and options of route choice promoted the perception of highly walkable school routes. Similar results were

reported elsewhere (Kerr et al., 2006; Mota et al., 2007). Although these studies concluded that parents perceive that certain types of street layouts affect their child's walk to school, investigations into children's perceptions of street layouts have provided different conclusions.

A handful of studies have endeavoured to correlate children's opinions with adult observations of street layouts. For example, a study conducted across thirty-four public schools in California asked children to self-report their method of transportation to school (Braza et al., 2004). Children aged 9–12 years were asked to raise their hands if they walked to school; hand counts were analysed according to objective measurements of the street network surrounding the school area. Streets were observed to be on a grid or curvilinear pattern. The results indicated that more children walk to school if they live in areas with grid rather than curvilinear streets (Braza et al., 2004). This result, however, may have been influenced by the schools preparing to participate in highly publicised Walk to School Day events. As the research was conducted one week prior to this event, the children may have had a predisposition to answer that they walked to school even if they did not.

The effect of street layouts upon a child's perception of walkable school routes is, thus far, largely inconclusive. Another study conducted in the USA found no difference in travel patterns between children living in neighbourhoods patterned on grid or curvilinear streets (Sirard et al., 2005). As in Braza et al.'s (2004) study, observations of children's travel patterns were correlated with the layout of the streets in four urban and four suburban environments. In contrast to Braza et al.'s findings, however, Sirard et al.'s (2005) revealed that children do not walk more in one neighbourhood than the other. Quite the opposite results have been found by Anna Timperio and her colleagues (2006) in Australia.

One study of children's school travel patterns concluded that children would not walk to school if they lived on a grid street pattern (Timperio et al., 2006). This group of researchers surmised that cul-de-sac and curvilinear streets might have fewer vehicles travelling than grid streets. They further speculate that traffic safety concerns, rather than street layouts, may have been more influential in dictating travel concerns in children's eyes. Similarly, a study conducted in California suggested that girls are more likely to walk to neighbourhood destinations if the street layout is curvilinear (Norman et al., 2006). In that study, curvilinear street patterns contained a smaller volume of traffic than grid street patterns. The variation of findings in these studies demonstrates that the evidence regarding the relationship between street layouts and school trips made on foot is inconclusive. To date, it is unknown whether grid or curvilinear street patterns permit a more efficient and desirable route for children. Collectively, the findings of these studies begin to uncover the inconsistencies between children's and parents' perspectives of their walks to school and advise a further investigation of children's experiences.

SAFETY

Most of the studies described in the town planning and health literature depict the perceived fear of traffic dangers as a major impingement to children's ability to move freely and safely along streets (Pooley et al., 2005; Thomsen, 2004; Tranter, 1993). In their seminal study, Donald Appleyard and his colleagues (1981) studied the effects of vehicular traffic upon a resident's use of the spaces adjacent to his or her residence. They analysed three neighbourhoods that differed in the volume of vehicular traffic carried. The first neighbourhood consisted of a 'light street' (peak of 200 vehicles per hour). The second neighbourhood was considered to be a 'moderate street' (peak of 550 vehicles per hour) and, the third neighbourhood, a 'heavy street' (peak of 900 vehicles per hour).

Appleyard et al. (1981) particularly noticed how the proliferation of automobiles created an atmosphere of congestion, made crossing the street difficult for children and restricted their street play. Their findings show that the children on the 'light street' had greater use of their footpaths and streets for travelling, playing and meeting with friends than those living on the 'heavy street'. Streets possessing a higher volume of traffic greatly restrict children's mobility on foot. The more traffic, the less the two sides of the street are connected to form a 'face-block' neighbourhood that provides natural surveillance over children's activities on the street.

In relation to school travel, the perception of traffic danger is not significantly different. The street environment between home and school possesses high levels of vehicular and pedestrian traffic because many parents drive their children to school. At congested drop-off and pick-up points, safety becomes compromised as frustrated drivers double-park their vehicles, drop-off and pick-up children on the wrong side of the road and allow children to manoeuvre between idling cars and oncoming traffic (Huttenmoser, 1995; O'Brien et al., 2000). This situation, caused by the parents themselves, perpetuates the perception that children are subject to unsafe street conditions. The paradox is that the adult drivers cause the problem at the school then decide that children are unsafe travelling on foot!

A strong fear of traffic dangers among parents prevents children from being allowed to walk to school. In a recent American study, Tracy McMillan (2007) measured parental perceptions of neighbourhood safety, traffic safety, household transportation options, social/cultural norms and socio-demographic status. A questionnaire was distributed to the parents of children attending 16 Californian primary schools. She found that perceptions of vehicles travelling faster than the school traffic speed limit decreased the likelihood of parents allowing their children to walk to school. Parents fear the consequences of allowing children to walk in unsafe traffic conditions. Similar findings have been reported elsewhere (e.g., Boarnet et al., 2005a; Collins & Kearns, 2001; Eyler et al., 2007; Gielen et al., 2004; Hillman et al., 1990; Timperio et al., 2006).

To further understand parental concerns for children's safety, Rachael Dixey (1999) interviewed thirty-two parents in England. Of the perceived problems of traffic, drug use and danger from strangers, parents felt that the hazardous traffic environment was the greatest barrier to them allowing their children to walk to school. Even though the parents would have preferred their children to walk to school, the speed and volume of the traffic on the roads were perceived to be too much of a safety hazard. Many of the parents shared stories of accidents occurring because of the volume and speed of vehicular traffic. One example was "sometimes the traffic doesn't even stop for the lollipop lady. There was a little lad got knocked down further down the road, a couple of weeks back" (Dixey, 1999, p. 50). Concerned about children's walking safety in such conditions, parents often decide to drive their children to school. Dixey's results qualitatively complement the statistical results reported by McMillan (2007) in her study in California. The presence of high traffic volumes and speeds on streets between home and school clearly affects the safety of children walking.

While parents consider traffic volume and the associated safety risks as hindrances to school journeys on foot, children sometimes see it otherwise. Terence Lee and Natacha Rowe (1994) discovered a discrepancy between parents' and children's perceptions of the risks of vehicular traffic. They distributed questionnaires to both parents and children that asked them to rate the likelihood of eleven potential hazards that might affect a child's walk to school. For parents, traffic accidents were rated third; for children, rated sixth. Their finding suggests that children possess a less negative view of traffic and safety risks than that of their parents (Lee & Rowe, 1994). Timperio et al. (2004) drew a similar conclusion. The results of these studies reveal a discrepancy between what children are expected to experience in terms of safety by their parents and what they actually experience. Similarly, the awareness of traffic safety among 200 children in a Californian primary school was assessed. Surprisingly, while children (75%) believed that cars drove too fast, they also (69%) perceived the surrounding area of their school to be safe for walkers and bicyclists (Romero, 2001). Collectively, these findings imply that while children experience the presence of traffic, this experience does not inhibit their perceptions of safety. Children can and do view traffic differently from their parents.

Children navigating through traffic may not find its congestion as debilitating as their parents think. Research conducted in different parts of the world at different times has shown that children make adjustments to vehicular traffic; navigating their way through traffic can become a game (Abu-Ghazzeh, 1998; Lynch, 1977; Matthews et al., 2000; Tranter & Doyle, 1996). Children can view traffic as a source of entertainment as opposed to a source of fear. As such, children may be motivated to walk to and from school by the existence of those elements that engage their attention (de Monchaux, 1981; O'Brien, 2005; van de Water, 1999). That little is known of how vehicular traffic may engage children's attentions requires further examination. Similar to the findings related to street functionality, contradictions between parental and child perceptions regarding design elements affecting the school walk emerge.

SCHOOL DESTINATION

When investigating the school trip, many studies have focused on the distance children needed to travel to reach their desired school destinations. Both the perceived and actual distances of schools' locations in relation to the spaces where children live influence whether they walk to school or not. To begin, the perceived distance between home and school affects parental permissions for children to walk to school. A stratified random sampling of 10,000 potential respondents in the United States was asked to identify, from a list of potential inhibitors, the items that prevented their child from walking to school (Martin & Carlson, 2005). The list included traffic danger, the distance between home and school, personal harm and weather conditions. Respondents were allowed to select more than one inhibitor. Of the approximately 1700 respondents who had children aged 5 to 18 years, the distance to school was the most frequently selected barrier (61.5%) thought to inhibit children's walks. In a similar survey conducted in Australia, parents were asked to identify factors that prohibited them from allowing their children to walk to school (Ziviani, Kopeshke & Wadley, 2006). Parents were asked to rate the influence of traffic, school proximity to their place of residence, school bag weight, the availability of shelter, footpath conditions and pollution. Ziviani et al.'s work revealed that distance is a statistically significant barrier to children walking to school. Parents will not allow

their children to walk to school if they feel that the distance is greater than they think their children can safely and comfortably walk.

In addition to perceptions of distance, the actual road distance between home and school influences whether children are willing to walk to and from school. Studies in industrialised Western societies show that the greater the distance between school and home, the less likely that walking will be the method of transport (Bradshaw, 1995; DiGuiseppi et al., 1998; Ewing, Schroeer & Greene, 2004; Martin & Carlson, 2005; Sjolie & Thuen, 2002; Tranter, 1993). For example, a survey of parents of school children attending 51 English schools situated in two compact urban areas found that most children lived within a 2 kilometre radius of their school (Black, Collins & Snell, 2001). Of those children, those residing beyond a 1 kilometre radius of their school were driven to school, whereas those living within a 500-metre radius from their school walked. Their findings show that as the distance of a child's home from school extends beyond 2 kilometres, the likelihood of that child being driven to school increases to 80%. This conclusion is consistent with the findings of a study conducted by Tracy McMillan and her colleagues (2006), who found that children living in California were significantly less likely to walk to school if they lived more than 1.6 kilometres away.

Research results in Australia imitate the pattern described above. A New South Wales study conducted by Dafna Merom and her colleagues (2006) noted that fewer children walk to school when their residences are located more than 1500 metres away. Similarly, a group of researchers led by Anna Timperio (2006) found that children living in Brisbane whose routes to school were up to 800 metres long were more likely to walk to school than children living beyond 800 metres of walking distance. Nathan Harten and Tim Olds (2004) conducted interviews with 176 children living in central, suburban and outlying areas of Adelaide and examined the lengths of walking distances between home and school. In their study, the percentage of children walking to school decreased as distance increased: 90% of children walked from homes located 250 metres or less away from schools; 75% at 400 metres; 50% at 900 metres; 25% at 2000 metres; and 10% at 3200 metres. In summary, at distances beyond about 800 metres, children in the USA, UK and Australia are much less likely to walk to school.

These findings set a basis for formulating walkable distances to schools among children and inevitably show that a 400 metre walking to school distance is feasible. Neighbourhood schools present possibilities for children to walk and are the setting for this paper.

NATURAL AESTHETICS

There are relatively few known studies that investigate how the aesthetics of the neighbourhood affect children's school travels on foot (Giles-Corti, et al., 2009, Panter, Jones & Sluijs, 2008; Pont et al., 2009, Sirard & Slater, 2008). As detailed above, the majority of school travel studies have primarily investigated those design elements as they relate to street functionality, safety and school destination. In fact, recent reviews of the literature identifying the physical design influences of children's walks to school have neglected the mention of aesthetics (e.g., Davison et al., 2008, McMillan, 2005). When aesthetics of the school route have been investigated, the presence of trees have been primarily analysed as the design element mediating the school travel experience (e.g., Evenson et al., 2006; Timperio et al., 2006).

With few studies investigating the effect of natural aesthetics on children's perception of walkable school routes, the results are thus far largely inconclusive. For example, Kelly Evensen and her colleagues (2006) asked adolescent girls to rate their agreement with the following statement "There are trees along the streets in my neighbourhood" (para. 8). Correlating the girls' answers with the frequency of their walks to and from school, Evensen et al. concluded that the presence of trees were not associated with their walks. In contrast, Jacqueline Kerr and her colleagues (2006) reported that children whose parents perceived the neighbourhood to be aesthetically pleasing were two and one half times more likely to walk than those who rated their neighbourhoods as less pleasing. For this study however, definitions of "aesthetically pleasing" were not defined and thus it is difficult to determine which design elements contributed to these parental perceptions. Jorge Mota and his colleagues (2007) broadened the definition of aesthetics by asking children to agree or disagree with the following statement: "There are many interesting things to look at while walking in my neighbourhood" (p. 278). While their findings suggest that higher ratings of neighbourhood aesthetics were associated with higher rates of children walking, it is again unclear which elements constitute "interesting things". Lastly, Nicola Ross (2007) explored the meaning children attribute to their school journeys by asking them to photograph their journeys. Using a content analysis of the photographs, she discovered that the actual routes (e.g. footpaths and streets) accounted for one half of the photographs taken; facilities (e.g. school and parks), one eighth; and natural features, one twelfth. Her results suggest that natural aesthetics do play part in children's experiences of their journey; but do so minimally.

The handful of studies and conflicting results suggest that little is truly known abut the effects of aesthetics on children's experiences of their school walks. As suggested by Pikora et al. (2003), the aesthetic dimension incorporates all those features that create a pleasure walk. To this point, researchers have narrowly examines the aesthetic features of children's school walks. This paper argues that there are other elements than the presence of trees that can be considered as pleasurable features to children. Further exploration into certain design elements that enhance the aesthetics of children's school walks is subsequently needed.

DISCUSSION

The research reviewed earlier investigated how attributes of the neighbourhood affect children's walks. The reviewed findings coincide with what Pikora et al's framework conceptualises to influence adults' neighbourhood walks (Table 1). This schema can broadly categorise the designs that may facilitate children's walks.

Table I: Pikora et al.'s (2003) Design Dimensions of Children's School Walks

Design Dimensions	Elements	Literature Cited
Street Functionality	streets, lights, footpath	Braza et al., 2004; Kerr et al., 2007; Norman et al., 2006; Schlossberg et al., 2005; Sirard et al., 2005; Timperio et al., 2006
Safety	crossing signs, pedestrian crossing, speed limits	Boarnet et al., 2005b; Collins & Kearns, 2001; Dixey, 1999; Eyler et al., 2007; McMillan, 2007; Sirard et al., 2005;
School Destination	homes, schools	Black et al., 2001; DiGuiseppi et al., 1998; Ewing et al., 2004; Harten & Olds, 2004; Merom, 2006; Tranter, 1993; Ziviani et al., 2006
Natural Aesthetics	trees, flowers	Evensen et al., 2006; Kerr et al., 2006; Mota et al., 2007; Ross, 2007 ; Timperio et al., 2006

While Pikora et al.'s (2003) design dimensions generally categorise the physical elements affecting children's walks to and from school, these dimensions can be improved. The evidence reviewed earlier indicates that a close distance between home and school is an integral component of what planners, designers, parents and children consider necessary to make school routes walkable. A review of the empirical findings regarding street functionality and safety, however, shows that the effects of the street layout and traffic safety mechanisms on children's school walks are inconclusive. There is a discrepancy between children's and parent's perceptions of the effectiveness of street layout and the risks of traffic. Moreover, little is known about how neighbourhood aesthetics affect children's walks to and from school. Studies have broadly defined aesthetics as "things of interest" without defining what is meant by "things". It is unclear what things interest children as they walk.

The inconsistencies prevalent between children's and parent's experiences suggest that children have specific ideas about what makes school routes walkable; however, the nature of the elements that children consider to make their neighbourhoods walkable remains unclear. While applicable, Pikora et al.'s (2003) design dimensions were not explicitly tailored towards children whose travels may differ from adults' experiences. In one of the few known studies of children's statements of their experiences of their school journeys, Romero (2010) showed how children walking to and from school in the Sydney metropolitan area engaged in a multitude of experiential adventures. Through written questionnaires and focus group discussions, the children in her study expressed how they "got ice cream when I was walking to school" or discover that "they were painting the wall and I got to write my name" (p. 57). Such experiences show that children interact with their environment to create meanings beyond being protected and having an ease of access. The recognition of children's competency to create such meanings and the value of these meanings are largely missing from current school travel studies.

This paper contends that to effectively accommodate school travel, future research should investigate children's experiences of their school travels. "Understanding the characteristics of children who walk or cycle and the reasons for choosing these travel modes, are important first steps in developing effective interventions to increase the number of children [walking]" (Panter et al., 2008, para. 4). An effective design

schema should reflect those design elements that children perceive to facilitate their school walks. Recognising children's interests can help researchers and practitioners to develop and focus on the elements related to children's walks to and from school and thus encourage their walking.

CONCLUSION

As a whole, Pikora et al.'s (2003) design dimensions provide a starting point to characterise those design elements related to children's walks to and from school. Many school travel studies test the contention that the elements thought to facilitate children's neighbourhood walks (i.e., physical elements that facilitate children's safety and provide ease of access) would apply to their school journeys. The functionality of the street, traffic safety mechanisms, primary schools located at walkable distances from residences and the presence of natural aesthetics, to some degree, affect children's possibilities for foot-bound school journeys. This paper does not discount the contributions made by these planning and design elements to design straight-forward walks to school and back home. It elaborates on a set of design dimensions that can affect children's school travels on foot and suggests that these dimensions can be improved through the researching and incorporation of children's interests.

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