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The meaning of livable streets to schoolchildren: An image mapping study of the effects of traffic on children's cognitive development of spatial knowledge

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ABSTRACT

While much focus has been placed on the physical activity and environmental benefits of providing safe and livable streets for children, few studies look at the mental health and cognitive development benefits from lowering children's exposure to threats from traffic. In response, this study uses innovative cognitive mapping methods through a series of focus-group interviews with nine and ten-year schoolchildren to uncover important ways traffic exposure limits children's cognitive development of their spatial knowledge. To test for these effects, this study focuses on schoolchildren in two similar suburban neighborhoods and schools in suburbs in the San Francisco Bay Area, but differing in the volume and speed of traffic the students are exposed to during their journeys to and from school.

The Cognitive mapping exercises and methods used in this research reveal multi-dimensional effects, including how exposure to traffic, as determined by volume, speed, and the adequacy of walking and bicycling infrastructure, limits children's progression along a cognitive development continuum of spatial knowledge. Specifically, the results show that without adequate pedestrian and bicycle facilities to provide sanctuary from automobile traffic, children are overcome by the negative senses of danger and dislike, commensurate with a limited ability to identify qualities of their neighborhood that are memorable, special, or even positive. In contrast, this study finds that children allowed to have higher levels of interaction with the environment, through independent, active travel modes improve their spatial knowledge development.

By making neighborhood streets safe, comfortable, and livable, this research establishes some key psychological cognitive benefits associated with lowering a child's exposure to automobile traffic by providing adequate pedestrian and bicycle Safe Routes to School (SR2S) infrastructure.

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1. Introduction

How do children view their world? What helps them connect with their environment and community? Or, perhaps more importantly, what gets in their way? To address this and other questions, this research examines how traffic exposure, as determined by traffic volumes and speed and the presence, or lack thereof, of proper pedestrian and bicycle facilities, influences children's progression along a development continuum of cognitive spatial knowledge (Piaget, 1956). While there is much research on the physical activity and environmental benefits of the ability of children to walk or bicycle, few studies look at the mental health benefits from the neighborhood context (Villanueva et al., 2014; Villanueva et al., 2016).

Through a series of focus-group interviews with schoolchildren, and using cognitive mapping exercises analyzed through an innovative method to compare collective results across each participant group, the effects of traffic exposure on children's cognitive development of their spatial knowledge is uncovered. As part of this exposure is due to inadequate ped/bike infrastructure, this research also helps establish how building pedestrian and bicycle facilities can improve childrens' cognitive connection with their respective communities and environment. By making neighborhood streets safe, comfortable, and inviting—in other words, livable (Appleyard et al., 1981) - this research explores the psychological benefits associated with lowering a child's exposure to automobile traffic.

This study focuses on two suburban neighborhoods in Contra Costa County in the eastern portion of the San Francisco Bay Area of California. These neighborhoods were built in the Mid-20th century and likely influenced by Clarence Perry's, 1929 Neighborhood Unit Principles recommending, among other things, that neighborhoods be built around schools "so children would not have to cross a busy street" (Perry, 1929). However, these particular neighborhoods lacked a key component of Perry's walkable, safe, and independent-mobility vision for children—they were built without sidewalks. Neighborhoods that lack this key infrastructure are referred to in this paper as Incomplete Perry Neighborhoods (IPNs). As this IPN condition can be found in many suburban US neighborhoods built around the Mid-20th Century, retrofitting them with Safe Routes to School infrastructure represents a significant opportunity for improvement and the release of a potentially large latent demand for independent walking and bicycling by children wishing to travel to school.

2. Background

2.1. Theory of children's cognitive development of spatial knowledge

The Swiss psychologist Jean Piaget (1896–1980) developed a comprehensive theory about children's development of knowledge and intelligence, known as Piaget's Theory of Cognitive Development, or Development Stage Theory (Piaget, 1956). Piaget (1956) articulated five elements of a child's cognitive development conceptions of space and spatial perceptual structuration, as follows:

1. **Proximity –** Referring to the "nearbyness of elements belong to the same perceptual field."
2. **Separation** – The means of disassociating between two neighboring elements.
3. **Spatial succession or order –** The ability to separate elements in sequence one before the other.
4. **Enclosure –** The ability to organize elements as being between or inside other elements.
5. **Continuity –** Elements can have a coordinated perceptual association.

(Piaget, 1956).

2.1.1. Piaget's cognitive, spatial, perceptual, structuration

Piaget, building on Luquet's three principal stages of children's capacity to draw spatial relationships (Piaget, 1956: 154, Fig. 85) – also theorized that school-aged children pass through three distinct developmental stages of cognitive development between age 2 and adulthood (Piaget, 1956), as follows:

- **Pre-operational Stage** (about ages 2–6) a child in this age group should be able to navigate familiar routes, but is expected to lack the ability to provide any sort of abstract representation.
- **Concrete operational stage** (about ages 7–11) where children can abstractly conceptualize and draw well-known routes, but cannot yet incorporate these routes into the context of a larger, more comprehensive map.
- **Formal operational stage** (about age 11 through adolescence and into adulthood) where children develop the ability to think about abstract concepts, as well as have the ability to completely and accurately conceptualize a large-scale map representation in relation to more well-known areas.

(Piaget, 1956; Maiss and Handy, 2011; Ward, 1978).

As this paper relies heavily on the valuable contributions of Piaget, it is important to acknowledge common criticisms (Lourenço and Machado 1996) (Matusov and Hayes 2014). Much criticism of Piaget's work revolves around his small group of research participants (which included, at one time, his own three children), all of whom were from high socioeconomic and educational backgrounds. Because of this unrepresentative sample, we should cautiously apply broad generalizations of his findings to a larger population. For example, some research has disputed Piaget's argument that all children will automatically move to the next stage of development as they mature. While other research suggests that environmental factors may also play a role in the development of formal operations (Lourenço and Machado, 1996; Matusov and Hayes, 2000), findings which are explored further by this research.

2.1.2. Importance of interaction and active travel toward improving children's cognitive development

An interesting refinement on Piaget's theory of children's spatial understanding is Gary Moore's interactionist theory, which ties a child's interaction and familiarity with the environment to their cognitive development progress along "Piaget's stages"(Maiss and Handy, 2011; Moore 1986a, 1986b). This theory is supported by the findings of other researchers as well (Biel, 1986; Southworth, 1970). Maiss and

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