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HOME RANGE AND THE DEVELOPMENT OF CHILDREN'S WAY FINDING

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Twenty years ago, we began a research and training partnership with a division of the Royal Canadian Mounted Police. The RCMP are responsible for search for missing children in rural towns and some wilderness parks.

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They wanted to improve their methods and align them with what was known about child behavior. We soon received a call regarding a 9-year-old boy who had wandered away from a campground. The search had progressed for a week and some clues had been found leading toward a swamp. The constable in charge of the operations asked ''How far can 9-year-olds go?''

About a month later, we investigated an incident involving a 3-year-old boy who walked away from his back porch and was later found playing in a farm implement sales yard, surrounded by shiny new tractors. The constable who located the boy reported that the boy did not want to go home. His mother had not considered searching at the tractor yard because it was too far, but she was not surprised in hindsight: ''Every time we go by that place he wants to stop. His uncle took him for a tractor ride when he was a baby, and ever since then, tractors have been his favorite toys. But—how did he get there?''

We approached these two questions as issues for research in child development. In this chapter, we review answers from studies we have completed as well as from the multidisciplinary effort to understand the development of large-scale spatial cognition. Much of this effort has been heavily influenced by philosophical questions such as the innate comprehension of location and the progression of cognitive development that leads to abstract and systematic representation of space (Newcombe & Huttenlocher, 2000). In contrast, our police partners needed to know behavioral tendencies of lost children, or at least how representation influences way finding decisions. Hence, we have gathered research on age-related abilities for orienting and using bearings during travel, monitoring self movement, selecting landmarks and recognizing places, learning routes, and developing way finding strategies.

I. Definition of the Topics

The study of *home range* addresses the question of how far a child can go. A child's home range refers to the outdoor territory that surrounds his or her home and provides a context for independent travel, play, and exploration (Anderson & Tindal, 1972; Stea, 1970). Home range expands as children discover sites from established territory or attempt to reach destinations that they have heard about or experienced from different means of approach. In modern Western societies, the home range of newly walking infants may be restricted to a porch or a fenced yard. In an East African society, the home range of older toddlers may include trips to a water source, sometimes over 100 m distance along a fixed route through the community (Munroe & Munroe, 1971). In both societies, 3-year-old toddlers may be permitted brief unsupervised travel away from their immediate home area, such as voluntary visits to neighboring friends or play sites within calling range of parents. By 5–7 years of age, many children have accompanied peers or older playmates to sites that are beyond the views from their home.

Home range thus represents the local geographic competency of a child. This competency is based on personal knowledge of the neighborhood and requires *way finding*, or perceptual and cognitive processes for directing travel. The study of way finding addresses the question of how children get to places. The term has only recently appeared in academic writings (Lynch, 1960), but is reminiscent of historical accounts of wilderness pathfinders (Gowans, 1989; Parkman, 1872/1920). Behavioral geographers point out that a comparable term, *human navigation*, is most frequently used to refer to formal procedures for locating position and plotting a course for ships and aircraft, whereas human way finding usually refers to the process of selecting paths from an environmental context (Bovy & Stern, 1990; Golledge, 1999). The process of way finding is not solely a matter of reading natural cues, because adults of all cultures refer to maps or verbal or written descriptions for devising routes and making choices at intersections, especially in unfamiliar territory (Kitchin & Freundschuh, 2000; Stea, Blaut, & Stephens, 1996). Because of the sociocultural representation of routes and places, much of the study of human way finding differs from the study of animal navigation. Although animals may have mental representations of their environments and behavioral algorithms for foraging and homing (Gallistel, 1993), they do not use external aids such as cartographic maps, compasses or odometers.

Similarly, children do not typically use external aids. Yet, as early as three years of age, they may attempt independent travel outdoors, using routes they have been shown to neighborhood play sites, exploring while keeping familiar places in sight, and returning home when called. More demanding way finding problems typically occur with the expansion of home range into unknown territory during early and middle childhood (age from 3 to 12 years; Matthews, 1992; Moore & Young, 1978).

II. Distance and Dispersion of Travel

Researchers from several disciplines have described the extent of children's excursions in rural and urban locales in a variety of cultures (Biel & Torell, 1982; Hart, 1979; Matthews, 1987; Munroe, Munroe, & Bresler, 1985; Spencer & Darvizeh, 1983; Tindal, 1971; Whiting & Edwards, 1988). Most of these descriptions are based on children's self reports, identification of sites from aerial photographs, and sketch maps. However, our police partners required information in a format that could address the requirements of directing a search operation. They were familiar with summaries of lost person behavior

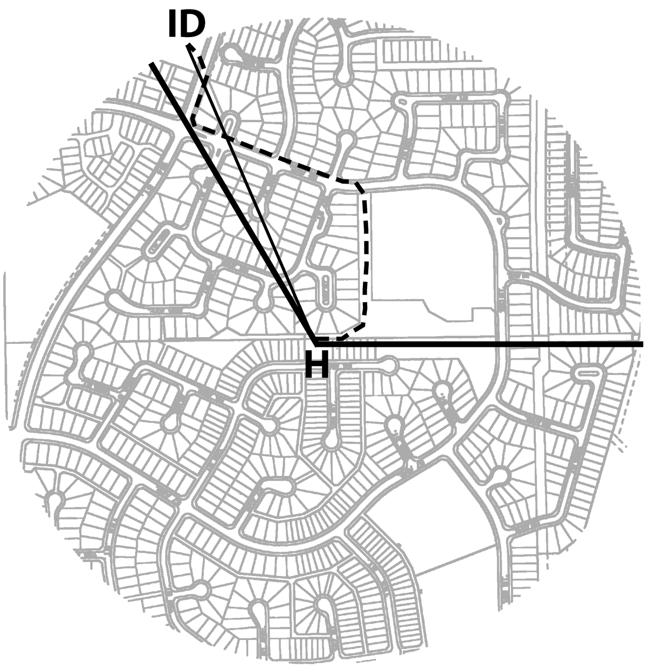

Fig. 1. The crow's flight distance is measured along a straight line between the child's home (H) and intended destination (ID). The child's actual path is depicted as an irregular dashed line and the dispersion of travel can be indexed as the angle of the segment that minimally includes the actual path. Here, the child's path is on both sides of the crow's-flight line, so the total angle of dispersion consists of a small and large angle.

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(Syrotuck, 1979) and requested that we first establish the crow's flight distance between the child's home and the farthest destination they travel to independently.

Studies of home range indicate that the maximum crow's flight distance is a good index of the child's way finding competence, although sites for activities are typically not the same distance in all directions (Matthews, 1987). Because the maximum crow's flight distance represents the child's farthest destination, the measure usually reflects recent attempts to visit a new place. However, because of the layout of paths, distractions and barriers in their neighborhood, children's travel to their destinations is longer than that estimated by a straight line (see Figure 1). Nevertheless, the measure of the crow's flight distance to the child's farthest destination has been found to reflect the ease of travel within different environments and parental restraints on travel (Hart, 1979).

Our police partners were familiar with the measure of the crow's flight distance because records of lost person incidents include two sites, the point last seen and the point found. By plotting on maps and connecting the point last seen and the point found with a crow's flight line, Syrotuck (1979) was able to summarize the extent of travel by people lost in wilderness parks. Records typically include little evidence of the actual paths of the lost person and reconstructions of events by the lost person are unreliable, so Syrotuck recommended using the median crow's flight distance traveled as a radius for a circular area to contain possible paths. The circle could be centered on the point last seen when a report of a lost person was received. Search managers could direct initial operations to the circular area if they judged that the circumstances of travel of the lost person were similar to those characterizing the summarized incidents. To use this procedure, urban and suburban police needed summary data for children traveling from their homes.

Our response was to introduce the research issue to suburban parents and ask to accompany their children on a walk. We asked individual children to take us on an adventure by leading us to the farthest place they had ever traveled to alone (Cornell & Heth, 1996). We followed from behind, using a surveyor's wheel (1 rotation = 1 m) and a digital watch to keep track of distance and time. These measurements and notes taken during the trip were used to draw the child's route on 1:5000 survey maps. The children made all the decisions about routes and could rest or walk home at any time. We followed them everywhere, including shortcuts through shopping malls, across snow-filled vacant lots, and once through an ongoing soccer game. Children interrupted their walks to throw stones, to stand on a fire hydrant to survey the upcoming path, or to dash off to kick a pile of leaves.

We first noted that many young children had selected more remote sites than their parents were aware that they had visited. After summarizing the data, we also noted that our observations included longer trips than those learned about from interviews. For example, we recorded that 6-year-olds led the way to sites that were on average 769 m crow's flight distance from their homes, demonstrating 3–4 times more distant travel than reported in studies asking children of the same age to name the places they could travel to alone.

Methodological differences may not be the only source of these different results. There are significant cultural and cohort differences between the children who have participated in studies of home range (Moore & Young, 1978). Nevertheless, children consider "showing the way" to be an accomplishment and will eagerly lead peers and adults to favorite places. While reconstructing their route to these places, children can point to and name landmarks that they recognize. The scenes and objects surrounding the path cue a variety of memories in a familiar spatiotemporal order. The trip provides an effective mnemonic, a match between the context of encoding and the context of retrieval of memories. Similarly, behavioral observations of taxi drivers indicate that their environmental knowledge prompted while route finding on city streets is 25% better than their verbal descriptions in the laboratory (Chase, 1983). The implication for the determination of home range is that the child's experience must ultimately be assessed in natural contexts, including meaningful goals and familiar skills (Gauvain, 1993).

We were able to observe how police search managers used data regarding children's home range during search operations (Heth & Cornell, ~~2005a).~~ Although they used the median crow's flight distance traveled to draw a circular area for search, they usually did not search all portions of the area equally. They initiated an investigation to determine the intended destination or recent favorite sites of the missing child. They would then segment the circular area to prioritize search at these sites.

We extracted data from our observations to help search managers delineate a prioritized segment when the intended destination had been learned. The segment was based on the median dispersion of travel that we had witnessed when children led us to their suburban destinations. We plotted their actual paths, which included both what children set out as their established route and their wandering on the way to their chosen destination (see Figure 1). We then drew lines to bracket minimally all of their path on either side of the crow's flight line that connected their home with their destination. If the child did not show extensive travel lateral to the crow's flight line, the brackets delineated a segment that resembled a wedge. An individual child's dispersion can be expressed by the angle of the segment and typical dispersion for an age group within a circular area for search can be indicated by descriptive statistics.

Interestingly, the median size of the segment increases from 138 to 216° between 7 and 10 years of age, indicating that older children show more dispersion in their distant travel. A segment of greater than 180° indicates that the child has gone beyond the expanse between their home and their intended destination. Dispersed travel as this challenges the argument that development in middle childhood is associated with efficient route choices, or least distance solutions. Children between 7 and 10 are exploring and wandering. In the section that follows, we consider the cognitive processes and representational capacities used to address the requirements of such way finding adventures.

III. The Ontogeny of Way Finding

A. ONSET AND MOTIVATION OF SKILLS

It is difficult to establish a developmental milestone for the start of independent way finding but 8- to 11-month-old infants are able to find locations in a large room if they have had more than 6 weeks of crawling or walking experience (Clearfield, 2004). Most infants walk unaided between 9 and 17 months after full-term birth and by 20 months, the average toddler will have tried running, walking sideways, and walking backwards (Bayley, 1969; Knobloch & Pasamanick, 1974). Despite these early abilities, analyses of gait indicate that mature patterns of walking may not develop until 3 – 5 years of age (Rose-Jacobs, 1983; Sutherland *et al.*, 1980). The distance that children can walk is restricted by their endurance and body size; for example, biomechanical analyses indicate that the frequency of stepping by 1- to 5-year-old children is limited by their stature and musculature (Grieve & Gear, 1966).

Nevertheless, by 18 months children seldom fall when walking and parents are often taken aback at their toddler's lack of hesitancy to leave their side after spotting an intriguing event. The development of way finding skills seems to be a result of these intrinsically motivated adventures. We can see the early process of joining familiar paths in the activities of the missing 3-year-old boy who was located in a tractor yard. At our request the day following the incident, the boy led his mother on the same paths that he had used to find his way to the tractor yard. He showed that he had followed a sidewalk that friends had used to go to a school ground, made a line-of-site shortcut under a torn fence, played on some school swings, made another line-of-sight shortcut to a sidewalk that he had previously walked with his mother, followed a route they had often taken to a convenience store, and crossed the street where he had previously seen the tractors. He had traveled 610 m as the crow flies, which places him beyond the 75th percentile of Canadian children of the same age group who lead researchers to their most distant destinations (Cornell & Heth, 1996). The boy stated that he did not mean to go to the tractors when he went to the swings, but his reaction when found indicated that he enjoyed the outcome of his way finding. Observations such as these remind us of how children's curiosity and interests drive their competence. Erratic and extravagant acts of exploration often lead to way finding skills (Cornell *et al.*, 2001).

B. EVIDENCE OF EARLY PROCESSES

Studies of newly walking infants indicate the earliest processes used to direct travel. These processes are part of way finding methods used throughout the lifespan. For example, 14-month-old infants know the way to turn at the first choice point in a room maze after watching their parent turn there (Heth & Cornell, 1980). Under the conditions of these studies, the infant could not simply extend a body posture after visually pointing toward the parent's turn; infants were not released by an assistant until they oriented straight ahead. We believe that processes of observational learning allowed the infant to know the open path; the movement of the parent in relation to environmental cues is encoded visually and translated into a directed action.

1. Allocentric frame of reference

Infants perceive and remember spatial relations between objects and events to know how to turn. In the case of observational learning, the room included posters and windows so that the infant's mother could be seen to walk near a particular wall (Heth & Cornell, 1980). The association of her movement with visible features along the wall would indicate that the infant is using an *allocentric* frame of reference. In an allocentric frame of reference, the position of objects other than oneself are encoded in relation to each other (Hart & Moore, 1973; *geocentric* may be used to indicate Earth as the other-than-self frame of reference). After a portion of the wall has been identified as a landmark close to the place of action, the infant can move straight toward the landmark. We need not assume that the infant has an internal representation of the configuration of the maze during this locomotion; travel toward a remembered wall feature would expose the opening to the path, which could then be the target for a similar direct approach. As long as the way finder discovers opportunities while looking for a sequence of immediate cues, way finding may not require reference to a map-like representation.

2. Egocentric frame of reference

In one situation where infants viewed the layout of a short maze from a 45° elevation, the room was circular and devoid of distinctive features (Rieser *et al.*, 1982). When held aloft centered in front of the maze, the open floor could be seen in relation to the midline of the infant's body. Because events in space are perceived differently by sense organs on either side of the midline, the position of the open floor is specified by an *egocentric* frame of reference (Howard & Templeton, 1966). In an egocentric frame of reference, the positions of objects are encoded in relation to self. Because there were no landmarks to approach, the infants' correct choices indicated they had encoded the location of the opening in relation to an egocentric framework.

3. Memories of movements

The infant's performance in one-choice mazes also indicates an early ability to keep track of one's own movements (Heth & Cornell, 1980). The history of movement from a place can be used to infer one's position relative to events or landmarks that were perceived at the onset of the movement. The process is called *dead reckoning* (Gallistel, 1993; Cornell & Heth, 2004). The direction and distance of movements can be registered internally through patterns of efferent, kinesthetic, vestibular, and proprioceptive sensations; moreover, infants and adults seem particularly sensitive to changes in external visual events accompanying movement (Loomis *et al*., 1999; Schmuckler & Tsang-Tong, 2000).

As an example, consider the infant's ability to choose a path that has been seen from a different perspective than at the choice point (Rieser *et al*., 1982). At the outset of this problem, 25-month-old infants were taken to the left or right side of the central starting point for a short maze. They were then lifted to see their mother seated within the layout of barriers. The open path to the mother was either near the infant or across the maze. The infant was then moved by the researcher to the central starting point. During movement, the visual flow of textures specify the direction of travel (Gibson, 1979). Once released, the infants who had seen the maze opening close to their original position could approach it by reversing the pattern of movement imposed by the researcher. For the infants who had seen the opening across from their original position, the pattern of movement imposed by the researcher would be consistent with an approach that could be continued once released midway. In this interpretation, we need not assume that infants regulate travel in reference to a map-like representation of the layout of the maze. Instead, we suggest that the 25-month-old infants could register the location of the opening relative to self when viewing it and see visual cues accompanying their movement. This ability seems to be within their repertoire; after displacements, infants as young as 6 months of age can visually anticipate the location of a stable target (Tyler & McKenzie, 1990).

C. SUMMARY

Our interpretations suggest that early processes of human way finding are based on the perception of movement. In particular, we favor Gibson's (1979) analysis of spatial information available in visual flow to indicate how infants can register goals and direct their locomotion at choice points. Systematic changes in the perspective of things accompany the movement of self in a surround of objects and surfaces; these events provide information for orientation within an egocentric frame of reference. The regularities in visual flow also reveal features of the environment whose relations to one another do not change with changes in the viewer's perspective; this invariant structure provides information for bearings within an allocentric frame of reference. Although several sense systems provide internal cues for biomechanical motion, we do not see strong evidence that ambulatory infants can accurately monitor their movements when deprived of vision (Cornell & Heth, 2004; Liben, 1988). As well for adults, the primary information specifying movement may be visual flow.

The demonstration of observational learning as an early solution to spatial choice deserves some emphasis. There is accumulating evidence about how social activities introduce spatial concepts to infants. Their mother in particular may elicit attention to the location and direction of modeled behavior. A mother's location in a room is a primary landmark, frequently updated and associated with neighboring environmental features (Presson & Somerville, 1985). By watching the direction of her head and gaze, infants make inferences about where important things are and how objects and space are partitioned by gesture and linguistic conventions (Baldwin, 1995; Butterworth & Jarrett, 1991). Although no evidence indicates that parents are better landmarks and guides than other adults or animate events, the early attention to caregivers is a natural introduction to the importance of others for demonstrating specific routes, teaching strategies for way finding and using the linguistic and symbolic conventions that are sociocultural representations of space.

IV. Landmark and Place Recognition

A complete description of the information perceived in the immediate environment would not be a sufficient account of way finding. Information must be remembered because the features of large-scale environments that we travel through cannot be perceived from a single vantage point. Experiences along paths and at places can be retained and organized to constitute a route or history of movement. In addition, theories of cognitive mapping and theories of ecological perception both propose that memories of events are integrated so that we apprehend the relative directions, distances and layout of landmarks and paths (Heft, 1996; Kitchin & Blades, 2002). In this portion of our discussion, we first consider that the processing of memories may occasionally allow a simple method of repeating travel without the organizational properties of route and survey representations: children can approach places that appear to be familiar (Cornell, Heth, & Alberts, 1994). The analysis suggests how recognition processes are sufficient to repeat a route or reverse a route, but may be inadequate for off-route way finding. In addition, mechanisms of recognition are necessary to retrieve associations of landmarks and places with actions such as turning or continuing.

Studies of the development of home range indicate that young children independently repeat routes they have walked when accompanied by adults and peers (Hart, 1979; Matthews, 1992). If some landmarks and paths along the way are only partially familiar, processes of way finding may be interleaved with processes of route repetition. Rather than automatically turning at an intersection, the child might have to judge the familiarity of alternative paths. We also know that young children are easily distracted when traveling or playing outdoors at their everyday destinations. They may be drawn to interesting sights, become engrossed in group activities, or seek escapade. More cautious young children will explore new places that allow a view of home or customary paths (Cornell *et al*., 2001). If a path is tried that is beyond what is known, the child can return by turning around and monitoring the recent familiarity of landmarks as they are encountered again. Hence, recognition processes are fundamental for way finding that occurs when partially familiar routes are repeated and newly traveled routes are reversed (Cornell, Heth, & Alberts, 1994). These early processes are practiced throughout subsequent development. Approaching familiarity is typically automatic when adults repeat often-traveled routes (Chase & Chi, 1981; Hasher & Zachs, 1979).

A. DEVELOPMENTS IN RECOGNITION PROCESSES

A developmental study of recognition of landmarks in photographs suggests implications for way finding (Kirasic, Siegel, & Allen, 1980). The photographs were real-world scenes containing distinctive features such as bridges or fountains. These features could readily serve as landmarks to identify a place. Compared to 10- and 22-year-old participants, 6-year-old children were less accurate and slower at identifying photographs of places they had studied. In particular, the youngest children were slow to discriminate between the original scenes and foils that involved either substituting a new landmark or substituting a new environmental context for a previously seen landmark. The results suggest that with the complexity of natural scenes, young children have difficulty differentiating novel and familiar cues.

Two field studies of way finding elaborate this finding. The first involved children's ability to detect that they are traveling off a previously traveled route. Visual recognition can inform us that we are off route in two ways. One is an accumulating absence of familiar or expected cues. The other is noticing something *en route* that we are sure that we have never seen before. These modes of recognition involve an analysis of the heterogeneity of geographical space (Goodchild, 2001). Schoolyards, storefronts, vacant lots, and other distinct features populate the home range of suburban children, forming landmarks and regions of spatial uniqueness. Hence, the development of skills for scanning, discrimination, and anticipatory recall of landmarks is important for differentiating places as familiar or novel. Features within a geographic layout are also spatially correlated, or occur in patches as the result of a convergence of natural forces or arranged zoning. This means that objects that are closer together are more similar than objects that are farther apart; hence, when travel occurs over long distances, features at the beginning of the route are more likely to be different than the ones at the destination. Movement through geographic space also exposes repeated patterns such as the association of greenery with water and the dissociation of trees with asphalt. Hence, the development of perceptual and categorization processes that respond to spatial correlations of features is important for recognizing the context of travel.

Cornell, Heth, & Alberts (1994) found that, in general, judgments of familiarity correctly decreased as children and adults were led astray for increasing distances from a novel route they had recently traveled. Eight-year-old children were less accurate than 12- and 25-year-olds. A signal detection analysis of recognition processes indicated that 8-year-olds were less likely to judge places off route as novel. In particular, 8-year-olds were more likely to judge that they were on the original route when recognition judgments were made at test sites off route that were close to and facing the intersection of the original route. This bias to accept familiarity does not seem to be inappropriate when approaching the original route after an off-route excursion. However, the 8-year-olds more often did not know the way to turn at that intersection. Cornell, Heth, & Alberts (1994). developed a theoretical interpretation that suggests that there are difficult discriminations of familiarity of paths at the choice point that would have allowed the participants to return along the original route. Cues alongside the off-route approach are familiar because they have been seen from the perspective of initiating the off-route excursion. Cues across the intersection are recently familiar because they have been seen in the background while approaching the intersection from off route; moreover, they may be historically familiar because the child looked down the side path at them when first traveling the original route.

These considerations indicate that off-route way finding by approaching familiar cues may require more than accurate recognition processes. Choices between familiar paths may require accurate temporal coding of the memories of actions and landmarks. Children could differentiate similar impressions of visual familiarity if they could remember the serial order of events; views on the original route have been seen earlier in travel than views off route. In addition, Cornell, Heth, & Alberts (1994) found that 8-year-old children more often did not know the way to go even when they correctly judged that they were off the original route. This could occur because the youngest children were relying on cues that were close to the paths they were walking. When these were unfamiliar, they could not approach a more distant cue that was familiar. As we shall see, the temporal order of cues and the cues that specify the general heading of travel are part of first knowledge that occurs when 10-year-olds find their way along novel routes (Cornell, Heth, & Skoczylas, 1999).

A second field study indicates that young children have difficulty encoding the spatial relations between a landmark and its environmental context (Heth, Cornell, & Alberts, 1997). Eight- and 12-year-old children were escorted on their first walk across a university campus. Along the way, they were instructed to pay attention to designated landmarks at four intersections: ‘‘Look at that brown sand box, the one with the white letters. You should try to remember that brown box to help find the way back.'' Some of these landmarks were then surreptitiously moved, either rotated in place or translated across the intersection before the return trip. During the return, 8-year-old children were more likely than 12-year-old children to judge that they were off the original route when they were at the intersections with changed landmarks. The younger children were also less likely to point to the correct direction to return at those intersections. When later asked, both age groups reliably detected that something was different about the changed landmarks, but the 12-year-olds were more likely to identify that the landmarks had been moved. There were no age differences and high recognition and pointing accuracy at intersections on the original route where landmarks had remained unchanged.

Children were asked to describe what they saw that made them point to a path to return (Heth, Cornell, & Alberts, 1997). When stopped at intersections off route, 8-year-olds were more likely than 12-year-olds to incorrectly name a new landmark as familiar. In contrast, at these same intersections off route, 12-year-olds were more likely than 8-year-olds to correctly name a new landmark as unfamiliar. When stopped at intersections on route, children at both ages said they used the landmarks that had been pointed out to them during the original walk and both age groups reported using 5–9 additional landmarks as well. However, the 12-year-old children reported using the most landmarks and were more likely to name landmarks that were peripheral to the ones that had been pointed out.

In this study, landmarks were classified as peripheral when they were outside of a photograph with a 35° visual field centered on the landmark that had been pointed out for remembering. The tendency of the older children to name landmarks that are more peripheral suggests that one of the general developments in the ability to recognize places is efficient perceptual search (Allen & Ondracek, 1995). When adults study scenes, as fixated objects are more quickly identified and localized, more flanking objects can be fixated (Rayner & Pollatsek, 1992). Processing accompanying successive fixations may serve to link landmarks to other objects or borders in the immediate surround (Blades, 1989; Golledge, 1995; Presson & Montello, 1988). Rapid execution of these processes may have freed 12-year-old children to register objects and spatial relations that were beyond the immediate neighbors of a designated landmark. In other words, efficient perceptual search provides children with opportunities to direct their attention and see places in greater area.

Efficient perceptual search would affect route-learning as well. Younger children typically know less than older children and adults about the sequence of events along a newly acquired route (Siegel, Kirasic, & Kail, 1978). Gaps in route knowledge could occur, for example, if a younger child had been preoccupied with an object next to the path, but the spatial extent of his or her attention to peripheral landmarks was less than that of older children.

The younger child may not have time to register a distant landmark that could be seen from different places along the route. Landmarks in the skyline would be particularly important for anchoring route events in a large-scale frame of reference.

B. SUMMARY

Our review suggests that children's landmark and place recognition abilities at 12 years of age are not reliably different than ~~that~~ of adults. Nevertheless, some basic developments in visual recognition processes are relevant to way finding. The improvements before 12 years of age include increased place recognition accuracy, with an important shift from accepting objects off route as familiar to correctly identifying them as novel. The efficiency of visually processing scenes also increases with age (Day, 1975). More rapid encoding of a centrally fixated landmark may allow older children to move their focus to more of the objects that are sensed in peripheral vision. With a short eye movement, these objects can be identified and seen to be neighbors in the visual field. The extent of scanning may underlie the ability to see that places overlap along a route and are situated in a larger frame of reference.

There were indications that these basic visual recognition abilities are supplemented by other abilities to learn and remember spatiotemporal events during travel. For example, after stepping off route and eventually recognizing that an encountered place was novel, some children attempt to retrace their steps. Retracing is not a simple matter at the intersection of their off-route path with the original path. The children could not simply approach what was familiar because features of all the intersecting paths would have been seen before. In this situation, off-route way finders could choose between alternative paths by approaching landmarks that were temporally encoded as earlier in their travels or by remembering the direction they chose when they turned off path. In the next section, we consider how a recognized place is situated in a series of memories of travel. We also examine associations between recognized places and actions such as continuing or turning. Following a well-known distinction made by Siegel and White (1975), we are moving our discussion from processes of recognition of landmarks to processes of route learning.

V. Memories of Routes

To the extent that environments are heterogeneous, such as neighborhoods with mixed housing and commercial development, children can use landmarks, places, and vistas to distinguish a course of travel. The process of directing travel in accord with a progression of environmental events is known as *piloting*

(Gallistel, 1993). Piloting typically occurs episodically when way finders notice the identity, distance, and bearing of certain landmarks as they are encountered. Children show several developments in the ability to selectively attend to and remember route events that are precursors to this common form of way finding.

During their first experience along a route, children may differentially attend to salient events, such as colorful or animate objects (Allen *et al*., 1979; Cornell *et al*., 2001). With repeated experience along the route, objects are increasingly distinguished from one another and those that were noticed on initial trips may accumulate familiarity (Acredolo, Pick, & Olsen, 1975). The differentiation of features along a route provides details that can help way finders determine whether they are on or off intended paths (Gibson, 1969). In addition, in most models of serial learning, improvements in the quality of representation of route events would facilitate the associations between those events (Brown, 1997). At the same time, as particular landmarks become familiar at places along the route, way finders need not examine them in detail and may explore and examine new objects from that viewpoint. As with our description of visual scanning, sequential attention provides spatial and temporal contiguity of the processing of route events.

In addition, when children are accompanied on their repeated excursions to distant destinations, they reveal response learning: "I know that we turn up here somewhere" (Cornell, Heth, & Skoczylas, 1999). Similar to the anticipation of landmarks, the recollection of actions can also occur episodically and involve the qualities of the event (stopping, running, going uphill), distance and bearing; these memories are the phenomenological data people use when navigating by dead reckoning (Cornell & Heth, 2004; Sholl, 1996).

In sum, theories of route learning have emphasized the child's differentiation and serial ordering of environmental events (e.g., Siegel & White, 1975) or have emphasized the child's representation of actions (Blades, 1997; Piaget, Inhelder, & Szeminska, 1960). Because these events naturally co-occur during travel, external events such as landmarks may serve to prime, organize, and confirm internal events such as the action of turning. Similarly, actions can produce expectations of events along the route (Cornell, Heth, & Skoczylas, 1999; Cornell, Sorenson, & Mio, 2003). In the next sections, we illustrate how the effects revealed during children's route learning are compatible with theories of associative learning.

A. THE ACQUISITION AND REPRESENTATION OF SERIAL ORDER

In context-based models of associative learning, landmarks and actions would be linked to one another along a time line or serial representation of occurrence

(Brown, 1997). The time of occurrence appears to be on an ordinal scale. For example, after taking a 2.4 km walk through a neighborhood for the first time, 10-year-old children and 24-year-old adults either repeated or reversed the route and were stopped before intersections came into view. Even though they had not been told they were to be tested, at six sites along the route, children and adults were able to discriminate pictures of the next intersection from a picture of an intersection they had passed by recently or a picture of an intersection that was farther up the path (Cornell, Heth, & Skoczylas, 1999).

The serial ordering of route events by children and adults is also evident in scene sequencing tasks and verbal recall of trips (Cousins, Siegel, & Maxwell, 1983; Golledge *et al.*, 1985; Torell, 1990). By 9–10 years of age, children who have walked a new neighborhood route 2 to 4 times seldom err when they arrange photographs of scenes along the route in a sequence (Golledge *et al.*, 1992; Torell, 1990). Moreover, the assessment of route memories yields an effect that is considered to be fundamental to human serial processing: Events that occur near the termini of a complex urban route are more likely to be remembered than those in the middle (Cornell, Heth, & Broda, 1989; Cornell, Heth, & Rowat, 1992; Golledge *et al.*, 1985, 1992). For example, 8- and 12-year-old children were asked to point to the way to proceed at intersections while returning along a 1 km-route around a university core. From the most recent intersection at the end of the route to the intersection near the origin of the route, the pattern of correct choices was a U-shaped serial position curve (Cornell *et al.*, 1996).

The study of the serial nature of route learning provides a good example of translation of basic research into practice. Cornell *et al.* (1996) mathematically described the serial position curve to estimate children's likely errors when reversing a new route. The probabilities of children's errors at intersections during route reversal were then integrated with police procedures to create an algorithm for prioritizing areas for search. The priorities produced by this algorithm were different than those selected by a novice police search manager. The algorithm added unique emphases to areas close to the route and midway along the route reversal. When the algorithm was used in simulated searches, the prioritized areas were consistent with where children had previously wandered from the university core.

B. ACTION NODES AND SEGMENTS OF ROUTES

Patterns of serial memories cannot be adequately explained by chaining between successive pairs of sequential events (Brown, 1997). Models of route learning that link landmark–action and action–landmark associations are stripped-down accounts of how people remember travel. During their very first experience on a route, children may uniquely note special places, differentiate the character of areas, register the patterns of their movements, and observe bearings to distant landmarks.

Golledge (1978) suggested that certain places serve as anchor points or organizational nodes for representing routes. In particular, there are both spatial and temporal labels for the termini of routes (e.g., home–destination, beginning–end, origin–goal), indicating positional distinctiveness for primacy and recency effects in children's memories of travel (Cornell *et al.*, 1996; Golledge *et al.*, 1985; Neath & Crowder, 1990). In addition, early in route learning, 9- to 11-year-old children note places where way-finding decisions or turns are made (Doherty, 1984; Golledge *et al.*, 1985). Intersections are action nodes in representations of routes. As well, intersections are usually open areas that show how paths meet and opportunities to check views of places where paths are headed. These visual prospects are noticed by children as young as 7 years; after viewing a slide presentation simulating a walk through a commercial district, they were asked to select photographs "… that would most help them to remember where they were." They chose scenes in the vicinity of choice points (Allen *et al.*, 1979).

Because a choice point involves environmental features that are associated with a potential or real change of heading, the choice point establishes a place early in serial learning where a route may be segmented. Segmentation, like other forms of chunking, provides a means of organizing information so that a smaller number of superordinate representations can embed a larger number of route events, some of which may be forgotten (Carr & Schlisser, 1969). Segmentation was apparent in a detailed case study when an 11-year-old boy showed clustered retrieval of memories of environmental features. He concentrated his recall on landmarks and path cues in the vicinity of choice points (Golledge *et al.*, 1985). Moreover, the boy's attempts to sketch his route revealed hierarchical knowledge, a tendency to compose first a skeletal map of road sections where way finding actions were necessary. Roads that connected these sections were second to be drawn, followed by landmarks that appeared next to the route.

Intersections are not the only delineators of route segments. By 10 years of age, children can also discern features that characterize different areas traversed by paths (Allen, 1981). For example, when reconstructing a sequence of photographs of a route children partition the route into segments bordered by a wooded park, a university campus, and a residential neighborhood. The ends for these segments were photos depicting environmental transitions. For example, children placed photos of the campus in a row and photos of the residential neighborhood constituted another row; children selected photos showing a major street bounding these two areas as the last scene of the campus row and the first scene of the residential row. Segmentation by environmental features indicates that children are beginning to form place schemas or general expectancies based on world knowledge, such as the expectancies that farmland is flat, that parks have trees and swings, and that malls have food courts. In the outdoors, people often form place schemas when they notice the correlation of geographic features, such as the correlation of a watershed with a downward slope. People use place schemas to check that travel is appropriate in an unfamiliar area (Cornell, Heth, & Skoczylas, 1999). For example, playmates may realize they have misinterpreted the directions to a friend's suburban house if they encounter high-rise construction.

C. SUMMARY

By middle childhood, children's route learning is more than a linear series of associations between landmarks and actions. Landmarks do not have equal status; early in their learning, 9- to 11-year-old children remember those perceived at choice points. The selective memory for choice points suggests that children of these ages appreciate the advantages of staying on route. Nine- to 11-year-old children also organize their memories of routes in a hierarchy, with landmarks, bearings, and actions embedded within segments. Route segments may be delimited by choice points or by the commonalities of the territory they pass through. The segments themselves constitute a smaller number of schematic memories embedded within a larger spatiotemporal framework, defined by the beginning and end of the trip.

VI. Bearing Knowledge in Way Finding

Since the demonstrations of detour and shortcutting behaviors by animals (Tolman, 1948), psychologists have been particularly intrigued with the notion that our mental representation of our movements while on the ground is organized to reflect a survey of the territory as if seen from above. Knowledge of bearings between self and landmarks, and knowledge of bearings between landmarks are primitives of survey representations (Golledge, 1995). Because well-organized survey representations include formal (typically Euclidean) properties, they have special status or are an ultimate development in stage theories of spatial cognition (Hart & Moore, 1973; Piaget & Inhelder, 1967; Siegel & White, 1975). However, early in development, children are seeing bearing and distance relations of landmarks during ground level exploration of their home range. Even without comprehensive survey knowledge, children may use perspectives of a familiar landmark in the skyline to guide way finding.

Awareness of self-to-object bearings and object-to-object bearings is roughly indicated by 1- to 2-year-olds' ability to point and look where someone is pointing (Butterworth & Grover, 1999). By 18 months of age, infants are accurate within 60° in their first turn toward a visual target that their mother is looking at. Under some conditions, infants' turning indicates that they can extrapolate their mother's line of gaze to one of two targets separated by 60° in the visual field behind them (Butterworth & Grover, 1999). Because the reference target is out of view, this latter performance indicates that 18-month-infants are beginning to represent and parse the spatial surround.

Studies of route reversal performance suggested that older children are registering bearings during their first exposure to novel territory (Cornell, Heth, & Broda, 1989; Cornell, Heth, & Rowat, 1992). These were studies on a university campus that called for 6- and 12-year-old children to return along a guided route. When they were not informed that they would be leading the way back, both children and adults typically failed to reverse the newly-walked route exactly (Cornell, Heth, & Rowat, 1992). They made at least one incorrect path choice at intersections and had to find their way back to the initial route or its origin. Interestingly, when children as young as 6 years of age were wandering off path, the majority correctly headed toward the expanse that contained the origin of the route (Cornell, Heth, & Broda, 1989; Cornell, Heth, & Rowat, 1992). Some of this correctly oriented way finding could be the result of monitoring environmental features on the incorrect path such as the orientation of shadows (Cornell, Heth, & Skoczylas, 1999). By 12 years of age, children were able to direct their off-route way finding in reference to a distant feature such as the position of the sun, a line of trees along the skyline, or a tall building (Cornell *et al*., 1989). Finally, some children may be able to maintain a short course by dead reckoning, monitoring their movements, and correcting any deviations that occur in reference to remembered bearings (Rieser, 1999; Rieser, Garing, & Young, 1994).

A. POINTING OUTDOORS

In the context of way finding outdoors, children as young as 8 years of age demonstrate bearing knowledge by pointing to reference sites along a complex route with intermediate accuracy (Anooshian & Owens, 1979). In this demonstration, children were stopped at the end of four route segments and were instructed to study landmarks from these sites during two initial walks around an apartment complex. During a third walk, they were again stopped at the segment end points and asked to point a telescope as if they could view the other sites, which were not visible. The discrepancy between the bearings indicated by the children's pointing and the actual bearings to the target sites was a 48° mean absolute error. When 5-year-old children are assessed when pointing with their finger, mean absolute error of bearing estimates within a rectilinear building is as low as 20° (Lehnung *et al*., 2001). Mean absolute error by adults in similar tasks in large-scale environments ranges from 20–54° and chance performance is 90° (Cornell, Sorenson, & Mio, 2003; Golledge *et al*., 1993; Greidanus, 2003; Montello & Pick, 1993; Silverman *et al*., 2000). The accuracy of young children's pointing suggests that, in familiar environments, they know bearings to the extent that they could be used to construct Euclidean mental representations (Conning & Byrne, 1984).

Children also learn bearings without instructions to do so. For example, children as young as 6 years of age were able to infer a bearing to a single reference point, the origin of a 1-km walk across a university campus (Heth, Cornell, & Flood, 2002). They had not been told to keep track of their movements, yet had registered information during their first trip that allowed them to point from the end point of the walk with a mean absolute error of 54°. The extent of the children's pointing error was significantly less than chance performance and was similar to the 52° dispersion of their return path when they attempted to retrace the walk. Adult's mean absolute pointing error was 30°, significantly less than the children's under the same conditions of incidental learning and testing. The angular extent of adult's return path was 41°, close to the minimum dispersion required to circumvent obstacles on the way to the origin of the walk.

Young children show more accurate knowledge of bearings when they are in familiar environments. Children of 3 – 4 years of age point more directly to non-visible targets in their own homes (23° mean absolute error) than when pointing at non-visible targets in an area around their home where they frequently went on walks with their parents (45° mean absolute error; Conning & Byrne, 1984). Interestingly, when these young children pointed to targets from neighborhood sites that were relatively less familiar, their inaccuracy tended to be biased in the direction of routes they used to walk to the targets. Adults show a similar bias (Chase, 1986; Heth, Cornell, & Flood, 2002). The implication for both age groups is that mental representations of large-scale spaces are influenced by the course of travel through those environments.

B. SUMMARY

Developmental studies indicate that bearings are perceived and registered by young children as they travel outdoors and that development consists of increasing accuracy, especially in the ability to estimate bearings after initial experience in an environment. Knowledge of bearings seems particularly useful when children are expanding their home range into territory where there are no familiar landmarks near paths. Six-year-old children who showed more accurate estimates of bearings to the origin of their walk showed less spread of wandering when they had stepped off route during their attempted return (Heth, Cornell, & Flood, 2002). Way finders can avoid excessive lateral movement if they "steer a course," or make adjustments to return to an imagined bearing to their goal after deviations through travel corridors (Jonsson, 2002).

The evidence that very young children can use bearings and that people register bearings incidentally is compatible with ecological theories of orientation as the result of perceptual processes rather than deliberate mnemonics and calculations (Gibson, 1979; Heft, 1996; Rieser, 1999; Sholl, 1996). Ecological theory suggests that children's early examples of survey perspectives and inferences concerning bearings are derived from sensorimotor experience (Pick, 1988; Rieser, 1983). As the infant is picked up by the parent, or as a child climbs the playground ladder, objects and places the child was viewing at a horizontal elevation undergo continuous perspective transitions until surveyed from above. As children walk through their neighborhood, they can see that the position and form of distant objects do not change as much as those near their paths. By 12 years of age, children select these relatively stable objects to monitor their bearings during travel.

VII. Strategy Development

Our review of home range activities indicated that efficiency is not always a priority for children—they sometimes choose to lollygag. Nevertheless, the consequences of errant travel provide strong motivation for learning way-finding skills. One of the oldest studies of children's fears reported that the "dread of getting lost is common" in school children and adults alike (Hall, 1897). Infants and toddlers may not realize that the world consists of expansive and complicated spaces. Although they can be apprehensive about separation from their parents, when attracted, they will readily follow an animal into the forest or strike out on little expeditions with no concern for the return trip (Hill, 1999). Parents typically admonish such impulsiveness and even a brief incident of disorientation reinforces for the child the importance of "paying attention" during travel. When children are not instructed what to attend to, they experiment. For example, when leading a researcher to the farthest place from home he had ever ventured to alone, one 6-year-old boy volunteered that he carefully attended downward: "I just know how to get there by looking at the ground. All I need to look at is the ground" (Cornell *et al.*, 2001, p. 223).

The boy's statement and subsequent explanation forecast several facets of the development of way finding strategies. Many strategies begin with self-discovery. The boy noted particular features of the path—cracks in the sidewalk, crumbling curbs—as cues for upcoming turns and as reassurance that he was on the correct route. His selectivity was a prospective strategy, limiting his attention systematically to establish a small series of unique events to guide route reconstruction. Although prospective, like the bread crumbs used by Hansel and Gretel, his strategy was vulnerable; a downward pattern of scanning would not help to register landmarks that could be used if he stepped off path during his return. Reactions to errant travel could precipitate a new, more advanced strategy (Siegler, 1996; Cornell *et al.*, 2001). The boy could, as we shall see, begin looking for cues on the horizon during his route learning.

A. SELECTIVE ATTENTION TO LANDMARKS

Modern urban parents may not demonstrate way finding strategies or tell their children much about the lay out of their community because they have reservations about safety (Cornell *et al.*, 2001; Torell & Biel, 1985; Valentine, 1997; Woolley, Dunn, & Spencer, 2000). As a result, children's exploration and expansion of home range may provide raw lessons about characteristics of environments and the requirements of self-directed travel. For example, 12-year-old children quickly learn to attend to pertinent landmarks; after leading a walk to one of their far special places in their neighborhood, they increasingly named objects near choice points as useful to find their way (Cornell *et al.*, 2001).

An analysis of the suburban landscape indicated how children select landmarks from heterogeneous views (Cornell *et al.*, 2001). Videotapes of children's neighborhood walks were randomly sampled and objects that appeared in randomly sampled frames were counted in categories as permanent, distant, unique, or near intersections. While leading their walks, 8- and 12-year-old children said they used unique objects as landmarks, such as a house with a red door or a yard with an alpine rock garden. Both age groups named unique objects as landmarks with four times greater frequency than the baseline count of their occurrence in the videotape samples of the walks. Eight-year-olds named objects at intersections and distant objects (visible in the skyline to be at least two blocks off their route) as landmarks with a frequency corresponding to their baseline counts, whereas 12-year-olds referred to them significantly more often. The baseline count of permanent objects indicated that 8-year-old children showed inappropriate selective attention; they named transient events as landmarks more frequently than the events occurred in the videotape samples. The 8-year-olds named bumblebees, litter dancing as it was blown down the street, dogs barking, and hot rods as things that could help them find their way, but did not associate these events with more permanent site cues. In contrast, 12-year-old children named permanent objects as good landmarks with a frequency equivalent to their high baseline count.

Recordings taken during the walks indicated that characteristics of landmarks were only one of a variety of lessons learned that would allow for efficient way finding. One 11-year-old girl had observed the routes that buses used in her neighborhood, another showed how street numbers could tell you how many blocks there were left before reaching a destination, and an 8-year-old boy correctly noticed that a street exited in the opposite direction of its entrance (Cornell *et al.*, 2001). These reports suggest some of the multiple sources of information that adults say they observe and use when solving problems of orientation and way finding (Cornell, Sorenson, & Mio, 2003). The pattern of reports is consistent with models of executive selection of processes to use readily interpretable information, to monitor progress, and to react to outcomes of problem solving attempts.

B. VERBAL MEDIATION

By 10 years of age, children show a variety of verbal elaborations when they encounter landmarks. Not only are they reading street signs, addresses, and advertising, they invent names for unique configurations of landscaping and buildings and comment on the activities and purposes associated with sites (Torell, 1990). Torell recorded several examples during neighborhood walks with 10-year-olds: a girl named a hill "the Rocky Mountains;" a boy referred to a patterned light-and-dark surface of a commercial square as a "chess board;" after observing bank offices along the square, a girl speculated about "competition in the banking business."

It is well-documented that children's naming or verbal encoding helps to establish the distinctiveness of perceptual cues and allows for rehearsal, organization, and elaboration of associations for later retrieval (Gibson, 1969; Schneider & Pressley, 1989). Yet, there is little direct evidence that children are intentionally using verbal mediators as mnemonics for way finding. Their verbal associations may be covert and automatic, a natural consequence of encountering the heterogeneity in the environment. Nonetheless, verbal processing requires mental effort over and above activities (such as approaching familiar landmarks) that are sufficient for way finding. Traditional definitions of strategic behavior accept that strategies such as verbalization achieve cognitive purpose, such as comprehension and memorizing, and are potentially conscious and controllable operations (Bjorklund & Harnishfeger, 1990). Older children may notice the correspondence between commenting about events they see and their ability to remember routes. For example, verbalization of landmarks increased as 10-year-old children were asked to reconstruct a neighborhood walk over three trips and was associated with increasing spatial accuracy of their sketch maps (Torell, 1990).

C. TRAINING PROSPECTIVE STRATEGIES

Recommendations for way finding and staying oriented ~~are~~ abound. Scouting manuals, wilderness guides, folklore, natural history books, and field notes of anthropologists have described children's tracking games, exercises for map and compass reading, mnemonics for routes and landmarks, and strategies for monitoring travel in relation to geographic frameworks (McVey, 1989). Although the methods are based on adults' intuitions of way-finding processes and pedagogy, very few have been assessed. This is unfortunate because observations of children responding to instructions for strategic way finding reveal the development of cognitive abilities in a natural problem domain. These observations also yield information about the ways that parents can instruct their children so that they do not become lost.

By comparing two attempts to teach 6-year-old children, we illustrate the *look-back strategy* (Cornell, Heth, & Rowat, 1992; Heth, Cornell, & Flood, 2002). Observations of hunter–gatherer cultures indicate that novices are often instructed to look back when experienced travelers show them an important site such as an intersection or water hole (Gould, 1969; Nelson, 1969). Trail breakers and explorers also use this mnemonic (Gatty, 1958). The strategy anticipates that objects and layout are often not recognized from different perspectives; when returning along a route, way finders may make a wrong choice because they had not seen a unique side of a landmark or the angle of confluence of a branching path. In an early attempt to measure the effectiveness of the look-back strategy, Cornell *et al.* gave instructions to 6-, 12-, and 22-year-old participants in way-finding research. Participants were accompanied during their first walk on a university campus and were stopped on 11 occasions to be told, "We have walked far enough so that it might be a good idea to turn around and look where we came from." Analyses of distance traveled and choice point errors indicated that the 12- and 22-year-old participants who received the look-back instructions were more likely to stay on route during the return than cohorts who had been uninstructed. Six-year-old children did not benefit from the instructions and research indicated that, when looking back, they might not select environmental cues that are unique or permanent landmarks.

In a subsequent attempt, Heth *et al.* only stopped participants to receive look-back instructions at three choice points along a novel campus walk. However, Heth *et al.* had analyzed which choice points were likely to be difficult, called for anticipatory recall of the position of landmarks and paths before turning to look back and made explicit the advantages of the participant's choice of landmarks for directing the return. These elaborations effectively reduced 6-year-old's errors at these intersections as well as the distance that they traveled off route when they led the return.

The different results in the two studies fit with Flavell's (1970) description of the development of strategic thinking. With appropriate instructions, children as young as 6 years can execute prospective strategies for attending to and memorizing environmental features; their way finding performance improves (Cornell, Heth, & Broda, 1989; Heth, Cornell, & Flood, 2002). However, younger children may not spontaneously produce strategies from their repertoire that effectively anticipate the requirements of route reversal (Cornell, Heth, & Rowat, 1992). The key for ensuring that young children produce attentive strategies may be emphasis to anticipate what is needed to direct future travel. The successful instructions by Heth *et al.* reinforced for 6-year-olds that landmark choices were good when the landmarks were permanent and their appearances were known at locations during the return.

D. STRATEGIES WHEN LOST

The condition of being lost is difficult to describe, but usually begins when a way finder is disoriented (Cornell & Hill, ~~2005~~). Disorientation may include a failure to identify the present location but more typically involves a failure to know how movement may be directed to a desired destination: the original paths, the origin of travel, places with people, or home (Hill, 1999; Montello, 1998). In addition to an inability to find the way, ~~a psychological state is lost that~~ involves reflection on negative consequences. The resultant anguish and physiological arousal can seriously interfere with problem solving (Hill, 1999).

Although when alone, many people move impulsively during their initial reactions to being lost, most settle down and attempt a more effective response (Hill, 1999). As a volunteer for a search and rescue team, Hill has interviewed lost children after they have been found, during the period when they realize they are safe and before their multiple reconstructions of their ordeal are affected by adult feedback. Hill was able to identify four strategies that children used when lost, although he has not gathered enough data to establish the frequency of use of strategies for children of different ages in different environments. In *trail running*, children realize that they are disoriented, then hasten down the nearest trail or follow a least effort course. In some instances, the strategy is directed toward quickly finding out what is in the direction indicated by the travel corridor. Minimizing effort while seeking new information is a rational strategy: trails are thought to go somewhere, other people may be on the trail, and sights along the trail may help to reestablish bearings. However, in their anxiety to achieve these ends, or because of fear-induced arousal, children often run to exhaustion. Even though a trail is fading or taking them farther into rugged territory, an anxious child is unlikely to reverse direction (Hill, 1999).

The other strategies recorded to be used by lost children are classified as *direction sampling*, *view enhancing*, and *staying put* (Cornell & Heth, 1999; Hill, 1999; Syrotuck, 1979). Direction sampling and view enhancing are brief excursions to obtain more information about the surrounding terrain. These strategies involve procedures to return to an anchor point once a bearing or view has been sampled and not found to be informative. Direction sampling involves systematically trying routes that are seen to head off in different directions, whereas view enhancing may involve a singular off-route goal such as a visible peak. As an example of direction sampling, in one urban incident two 9-year-old girls used a playground knoll as an anchor point to search for familiar cues. One girl monitored from the knoll while the other progressed down a street to stand on her toes and look for their school. When she did not see it, she returned to the playground while her friend was still in view. The girls took turns going out from the knoll, moving clockwise around the knoll to search adjacent streets (Cornell & Heth, 1999). The view enhancing strategy is illustrated by a rural incident: a 13-year-old boy reported that he interrupted his walking to climb a tree to scan for any house (Hill, 1999).

Staying put is ~~the considered~~ strategic when children who do so report that their way finding attempts might have led them farther from home. To be strategic, the reports should indicate metacognition, that the child has assessed that he or she lacks enough knowledge or skill to solve the problem independently. Cornell and Heth (1999) tell of an incident involving a 9-year-old girl who had wandered for a week in snow-covered wilderness. The pilot of a search and rescue aircraft spotted her posed on a rocky outcrop overlooking the icy surface of a lake. When recovered, she reported that she had selected the site because she could be seen and she could see a large area where somebody might come looking for her. In this case, staying put included a strategy to take the perspective of a searcher.

E. SUMMARY

The strategies created by children in response to way-finding problems reveal cognitive development in natural settings. Both the design and subsequent modification of their attempted strategies are attuned to the resources, constraints, and outcomes they encounter during their adventures out doors. Some strategies seem to be spontaneous. For example, memories of travel are encoded when children selectively attend to and comment on unique and salient objects they encounter. The attempts to train more prospective strategies indicate that 6- to 8-year-old children may not remember that, to return along a new route, landmarks must be permanent and localized with respect to actions along the paths. Children of 10- to 12-years are attempting strategies to guide way finding off route, including selective attention to distant landmarks and registration of sites as anchors for excursions.

VIII. General Discussion

The cross-cultural study of home range suggests a fundamental human development: children between the ages of 3 and 12 are extending the spatial extent of their activities independently. Measures of home range have been ecologically valid and the norms for distance and dispersion of travel have been adopted into search and rescue methodologies (Colwell, 2005; Heth & Cornell, ~~2005b).~~ Quick reunions of lost children with their parents have terminated extreme emotional duress, reduced the risk of criminal predation, and saved children from exposure and hypothermia (Heth & Cornell, 1998; Hill, 1997; LaValla, Stoffel, & Jones, 1995). In addition, the study of home range has from its onset noted sociocultural and environmental contexts of travel. In all countries where observations have occurred, youngsters are characterized as willing or eager to explore their nearby world. Patterns of activity affirm that home range is a geographic competency and that children learn the characteristics that distinguish large scale natural environments.

For example, geographic and built heterogeneity provides the distinctive cues that become location indicators and landmarks. Intersections along routes are unique discontinuities, providing delimiters for route segments and opportunities for scanning the surroundings. As recognition processes improve, children can not only pilot according to the familiarity of landmarks, but they can also examine more distal objects and discover characteristic patterns of places. Geomorphic processes provide spatial correlation of natural features and children can also direct their activities based on zoned correspondences such as parks and pedestrian paths.

The most impactful lesson accompanying the development of home range may be the vast scale of geographic space. Cognitive capacity, parental restrictions, and the limits of personal knowledge are often breached as children venture alone into new territory. As distance traveled independently from home increases during childhood, so does the dispersion of travel. Walks that are more distant require a longer duration of memories and increases in area could mean as much as a quadratic expansion in the number of environmental features experienced. Naming, temporal ordering, segmentation of routes, and hierarchical organization of areas and landmarks are ways children manage this cognitive load. As children move beyond the sight of their home, they use bearings along the horizon to direct their travel and organize a representation of the vastness. As one 6-year-old way finder explained as he pointed to his distant destination, "I know its there, under the sky."

Toddlers begin exploring close to home and select direct routes, some without turns or loss of views of familiar sites. The adventures of older children include elements of risk, happenstance, and wonder. Hart (1979) provides fascinating evidence that independent children often go out of their way to take "shortcuts" that are frequently longer and more hazardous than the original routes that they know. Because the territory is unknown, planning before such adventures is often incomplete. The child will rely on strategies for way finding rather than specific route knowledge. The challenge is to size up new situations and react successfully. In this sense, adventure fosters adjusting to unanticipated and changing circumstances (Rogoff, Gauvain, & Gardner, 1987). When disoriented, the child may shift to activities that provide information about places and select among strategies to achieve an intermediate goal such as regaining orientation. It is important to emphasize that these processes of way finding have typically been first attempted as processes of route learning. While traveling on a familiar route, if a portion is forgotten, the child is way finding.

The novelty of discovery and the realization of independent achievement motivate children to go beyond where they already know. In the context of local geography, they come across new play sites and meet different peers. When returning home, children can appreciate that errors in route reversal occur where they were distracted and where interesting but transient landmarks no longer appear. Children learn that finding their way back home is easier when they prospectively encode permanent objects in relation to paths, characteristics of places, distant landmarks, actions, and the order of events during outbound travel. Strategy development also involves adaptations to react to novel information, such as when children turn from off route after recognizing that they have never seen a feature of the path. These examples illustrate how the expansion of home range leads to world knowledge and the development of efficient cognitive abilities.

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