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# Using virtual environments to investigate wayfinding in 8- to 12-year-olds and adults

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ABSTRACT

Wayfinding is the ability to learn and recall a route through an environment. Theories of wayfinding suggest that for children to learn a route successfully, they must have repeated experience of it, but in this experiment we investigated whether children could learn a route after only a single experience of the route. A total of 80 participants from the United Kingdom in four groups of 20 8-year-olds, 10-year-olds, 12-year-olds, and adults were shown a route through a 12-turn maze in a virtual environment. At each junction, there was a unique object that could be used as a landmark. Participants were "walked" along the route just once (without any verbal prompts) and then were asked to retrace the route from the start without any help. Nearly three quarters of the 12-year-olds, half of the 10-year-olds, and a third of the 8-year-olds retraced the route without any errors the first time they traveled it on their own. This finding suggests that many young children can learn routes, even with as many as 12 turns, very quickly and without the need for repeated experience. The implications for theories of wayfinding that emphasize the need for extensive experience are discussed.



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## Introduction

Researchers have long been interested in how navigation develops (Bullens, Iglói, Berthoz, Postma, & Rondi-Reig, 2010; Karimpur & Hamburger, 2016; Purser et al., 2015). Navigational abilities such as route learning are used by most people every day as they travel from one place to another place. Route learning refers to the ability to encode spatial and other information along a route well enough to retrace that route on future occasions (Merrill, Yang, Roskos, & Steele, 2016; Rissotto & Giuliani, 2006).

Adults can often learn routes quickly and effectively after only one or two experiences of the route (Gärling, Böök, Lindberg, & Nilsson, 1981; Montello, 1998), and this is the case even when the routes are 1 or 2 km long and/or include a large number of choice points at junctions (Farran, Blades, Boucher, & Tranter, 2010; Karimpur & Hamburger, 2016). The ease with which adults learn routes suggests that adults have developed appropriate strategies for encoding routes (Montello, 2017). One important strategy is encoding turns in relation to landmarks (e.g., "the left turn after the school"). Adults may be particularly well adapted to focus on landmarks and turns, and there is evidence for distinct brain activation for landmarks and routes (Wegman & Janzen, 2011). Adults show increased activity in the parahippocampal gyrus when attending to landmarks at decision points (Janzen, Wagensveld, & van Turennout, 2007), and the anterior cingulate gyrus and the right caudate nucleus are activated when adults learn the turns along a route (Janzen & Weststeijn, 2007).

In contrast to adults' competence in learning new routes after only brief experience, the evidence about children's ability to learn new routes after only brief experience is less clear. Siegel and White (1975) argued that children's route learning requires repeated experience because children first need to learn individual landmarks along a route; only then do they associate those landmarks with particular decisions (e.g., left or right turns) before they can combine a series of landmarks and turns into a fully learned route. There is evidence that children do, like adults, focus on landmarks (Jansen-Osmann & Wiedenbauer, 2004; Lingwood, Blades, Farran, Courbois, & Matthews, 2015a, 2015b). van Ekert, Wegman, and Janzen (2015) found that similar regions of networks involving the hippocampus and the inferior/middle frontal gyrus were activated during a memory test for previously seen landmarks in both children and adults.

Despite children's focus on landmarks, children do not always learn routes as well as adults (Jansen-Osmann & Wiedenbauer, 2004). This may be because in real life or in complex environments, children may be less good at identifying what is an effective landmark. Younger children may be especially dependent on landmarks that are nearby or next to turns, whereas older children tend to use distant landmarks for wayfinding (Cornell, Hadley, Sterling, Chan, & Boechler, 2001; Purser et al., 2012). Older children are also more likely than younger children to use verbal strategies such as counting the number of steps taken or number of buildings passed when retracing a route (Duroisin & Demeuse, 2015). Having better strategies for learning landmarks or estimating distances along routes means that children's route learning does improve with age and may account for reports of age-related improvements in wayfinding in complex environments (Cornell, Heth, & Alberts, 1994; Cornell, Heth, & Broda, 1989; Heth, Cornell, & Alberts, 1997).

In contrast to the studies showing that children do need repeated experience of a route to learn the route, researchers have found that preschoolers can learn a route without error after only a single experience (Spencer & Darvizeh, 1983), and Cornell and Hay (1984) reported that 6- and 8-year-olds who had seen a route only once were able to retrace the route with an average of less than one error. The latter finding implies that a number of children retraced the route without error at all. Cousins, Siegel, and Maxwell (1983) showed that 7-, 10-, and 13-year-olds could retrace a route after one experience of it. The fact that even very young children can retrace novel routes after one experience goes against the suggestion that children need multiple experiences of a route before they can learn it successfully. Rather, it seems that children can encode a route as effectively as adults and do not need to progress through "stages" of route leaning such as learning landmarks, turns, and then completed routes. The latter would support Montello's (2017) argument that there is no qualitative difference between "landmark" and "route" knowledge. According to Montello, knowledge of landmarks and knowledge of a route develop in unison and are inseparable aspects of route learning rather than sequential stages in learning a route.