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Reginald G. Golledge

Working Paper
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Path Selection and Route Preference in Human Navigation: A Progress Report

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The University of California Transportation Center
University of California at Berkeley

Abstract: Two critical characteristics of human wayfinding are destination choice and path selection. Traditionally, the path selection problem has been ignored or assumed to be the result of minimizing procedures such as selecting the shortest path, the quickest path or the least costly path. In this paper I draw on existing literature from cognitive mapping and cognitive distance, to define possible route selection criteria other than these traditional ones. Experiments with route selection on maps and in the field are then described and analyzed to determine which criteria appear to be used as the environment changes and as one increases the number of nodes along a path (i.e., as trip chaining replaces a simple Origin-Destination (O-D) pairing.

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INTRODUCTION

Not only do we select and follow a limited set of paths through the complex environments in which we live, but we have developed many models capable of finding solutions to these path selection problems (e.g., linear programming; traveling salesmen; shortest path). The question is, however, are these the criteria used by humans to solve their own movement problems - or are they methods best suited to mathematical or computer determination of optimal paths through complex multi-node networks to ensure economic efficiency of commercial or fleet traffic, but yet using criteria of which people in general are unaware, or are incapable of using? To explore this question, we examine the process of human navigation and report on pilot experiments that provide insights into the variety of Path Selection criteria used in different contexts.

BACKGROUND

Navigation seems to be one of the primary functions of vision in virtually all biological systems. The processes involved includes cue or landmark recognition, turn angle estimation and reproduction, route link sequencing, network comprehension, frame of reference identification, route plotting strategies (e.g., dead reckoning, path integration, environmental simplification and en-route choice, shortcutting). These processes are used in encoding environmental information for internal processing and use in wayfinding situations. Because of human inaccuracies and errors in recognizing places and coding geometrical components of landscapes, history has seen the development of a variety of technical aids designed to substitute for these human frailties. For example, the prismatic compass was developed to provide greater accuracy than was possible by visually estimating direction. Distances were not measured accurately until the development of distance units and devices such as surveyors' chains, theodolites, range finders, and now ultrasonic laser beams. To find one's way efficiently through complex network structures, computer programs focusing on criteria such as shortest path, minimizing total distance or time traveled, or maximal covering (Church & ReVelle, 1976) now replace the human interrogation of the network for destination choice and for optimal or feasible path selection in most transportation planning interactions where aggregate flows are allocated to routes. But what of the navigation and wayfinding activities of individuals? Do they conform to such principles?

Human navigation usually involves vision which in turn implies the use of inexact measurements and error prone or distorted cognitive maps. This is in contrast to the computerized algorithms for solving navigational problems that rely on explicit quantitative models and exact solution procedures. Some critical features of human navigation and wayfinding that have recently been highlighted are:

(1) The human navigation system interacts with and adapts to the environment in which it is navigating (Golledge, 1995).

(2) Navigation proceeds by initiating body motion and receiving and translating sensory feedback received from self perception of motion over time (Loomis, et al. 1992).

(3) The imagery developed by sensing the environment constrains the nature, type, speed and direction of motion (Golledge, 1992; Kitchin, 1994; Gärling, et al. 1984).

(4) Potential routes are imaged as larger or shorter depending on whether they proceed towards or away from a primary node or reference point (Sadalla, Burroughs, & Staplin, 1980).

(5) Many route-distances are imaged as being non-symmetric (Montello, 1992).

Thus, human navigation is often conceived of as a suboptimal system, as compared to vehicle navigation which is often considered as optimized movement in a precisely specified networked environment.

RESEARCH QUESTIONS

We wished to examine questions about: (a) how characteristics of the global stimulus environment affected route choices overall; (b) how the differences between pairs of points affected route choice within a given environment; and (c) how varying network properties influenced path selection criteria.

Questions investigated included the following:

- Do people try to retrace routes when the task involves using more than a single origin or destination?

- How consistent are people in terms of their criteria for route selection as the environment changes (e.g., from simple grid to grid with curves or grid with diagonals)?
- How often do people retrace the same route when traversing between origins and destinations?
- How often is the same criteria chosen when traveling routes of different complexity?
- What criteria do people usually think they use when they are performing route selection tasks in the laboratory and in the field?
- What criteria do people feel they use most frequently when choosing routes in their normal everyday movements through real world environments?

HYPOTHESES

Specific hypotheses to be examined were:

(a) The dominant route selection criteria will change as the environment changes.

(b) The dominant route selection criteria will change as trip complexity changes from a single origin-destination pairing to a multiple stop trip.

(c) As the number of potential "stops" increase in a trip chain, the probability of retracing a route will decrease.

(d) Traditionally accepted criteria such as shortest path or least time will dominate as route selection criteria.

(e) Route selection criteria will not change as orientational perspectives change.

(f) Route selection criteria will not differ between map base or laboratory conditions and real world route following conditions.

EXPERIMENT #1: The Laboratory Tasks: Route Selection from Maps

In this project we studied the kinds of routes that people select when navigating through a given environment. Experiments were undertaken in the laboratory to observe routes taken and then inferences were made about the criteria that was used. Initially, subjects were given a series of maps on which two locations were marked. These maps consisted of simple rectangular grids.

Three different routes were laid out from a common origin a to common destination. Subjects were asked to imagine that they lived in a town built around the grid network shown on each map, and to imagine that moving from the origin to the destination represented a daily home-work or work-home activity. They were asked to decide which of three routes they would take. The routes allowed them the choice of taking the longest leg first, the shortest leg first, or a stepwise route that approximated a diagonal join between origin and destination (simulating most direct, least effort or least time). Given the regularity of the grid, however, each route was exactly the same distance and varied only in its configurational properties. Maps and routes were configured so that trips were undertaken either as one travels from South to North in conventional coordinate terms or from North to South. Different configurations of O-D paths were provided while actual distances were kept constant. When choosing a route, subjects were required to place or hold the maps horizontally with the northern edge being furthest from the body. No rotation or translation of a given map (or subject) was permitted. However, by rotating a map 90° in either a clockwise or counter-clockwise direction and re-labeling the furthest edge as north, the same geometric configuration can be maintained while orientation and perspective changes. This procedure was followed for all map types.

A second task involved route selection after the number of nodes to be visited en-route was increased (i.e. trip chaining). Again, routes were configured so that travel took place either from South to North or North to South. In this task the environment was changed from a regular grid to one with some diagonal linkages.

A third task involved changing the regular grid to include curved roads and nonorthogonal and intermittent intersection blockages. Polygons representing either negative or positive externalities (e.g., waste dumps or parks) were interspersed throughout the maps. Blockages were described on different trials as parks (a positive attractor) or waste dumps (a negative attractor). The same route choice task was repeated controlling directional components and total length of trip. In this task the number of places to be visited was again increased to see if criteria were used that differed from simple barrier-free origin-destination selection. After each map trial was completed, individual suggestions were solicited regarding what route choice criteria were perceived as being used on these tasks, and what criteria the subject "usually" used in daily real world interactions. Such variables were examined to isolate the type of reasoning or inference that underlies path selection.

Subjects

Subjects consisted of 32 adults, 16 women and 16 men. Most were students. Ages ranged from 20-35 years of age. Approximately 50% were geographically trained.

DATA COLLECTION

The type of route chosen in the map computed by subjects was entered into a spreadsheet. Maps were examined to disclose what type of criteria were used to select routes. Results of matching these route types with routes actually chosen by subjects (i.e. percentage time each route was chosen) were tabulated (Table 1) which lists examples of path selection criteria.

Table 1

Ranking of Criteria Most Often Used
in Route Selection

Criteria	Rank
Shortest Distance	1
Least Time	2
Fewest Turns	3
Most Scenic/Aesthetic	4
First Noticed	5
Longest Leg First	6
Many Curves	7
Many Turns	8
Different from Previous	9
Shortest Leg First	10

(i) <u>Fewest Turns</u>: For each environment, the total number of people who chose a route with the fewest possible turns between each pair of points was recorded. If there was more than one unique route on the compiled map that had the fewest turns possible, then all such numbers were aggregated and the number of people using all such routes was recorded. The actual number of turns that defines "the fewest" for each pair of points was also recorded. The proportion of people in the particular stimulus group who chose a route with the fewest turns was calculated.

(ii) **Longest Leg First**: This spreadsheet was prepared in a manner similar to Fewest Turns. Here the total number of people who chose a route in which the longest leg of their chosen route was the first segment of the route was first recorded. "Longest" was defined in terms of total distance (not number of blocks). If no one chose a route in which the longest leg was first, then the number of people entered was zero. The number of legs of each route was also recorded.

(iii) **Preference for Curves**: The question here was whether people had a preference for routes involving curves. For each pair of points, the number of people who indicated routes including at least one curved portion were averaged. Each unique route was recorded. The overall preference for curves was quite high. There was quite a bit of variation between routes. However, this measure does not take into account how many curved routes were possible between each pair of points.

(iv) **Preference for Diagonals**: This was similar to the Preference for curves spreadsheet. Again, the overall preference for taking a diagonal was quite high.

(v) **Shortest Route**: For the diagonal and curve maps, actual distance was measured to determine the true shortest routes. For the regular Grid maps, since all routes that remain within the boundaries of the two points are necessarily of equal length, the question was whether subjects chose a route that would seem to minimize Euclidean distance by traveling "through the middle".

(vi) **Most Aesthetic**: This criteria could only be used with the final set of maps in which polygons representing parks and waste dumps were included. Routes heading away from waste dumps and/or following an edge of a park were labeled most aesthetic.

(vii) **Other Criteria**: Other criteria were defined in similar ways by observing characteristics of the chosen route and inferring what might have prompted its selection.

Detailed results of this study are published elsewhere (Golledge, 1995) but some of the more interesting results are reviewed here as being pertinent to several of the hypotheses offered earlier.

Route Selection Criteria

(i) **Fewest Turns**: It was apparent that as the environment changes, so does the popularity of this criteria, dropping from a high of 67% in a simple regular grid environment to 25% in a curvilinear environment. Data were reported for each of three environments (Grid, Diagonal, Curves). Path selection criteria changed when perspective changed , i.e. when travel was from a distant origin or to a distant destination. In the case where perspectives differ, there is a remarkable difference in choice of this strategy when the path to be traveled heads from Sth to Nth (65%) as opposed to heading from Nth to Sth (7%). A significant difference occurred in the diagonal environment also, but not in the curvilinear one.

With regard to the more complicated situation in which an intervening point was included on the trip (e.g., from home base A to intermediate point E to destination point C) substantial differences were found in path selection criteria in each type of environments. Focusing still on the fewest turns criteria, for the simple orthogonal grid map where the origin was in the Nth, *46%* used the fewest turns as a strategy but only *38%* used it when the origin was in the South. For the map with diagonals, 9% and 4.5% used fewest turns when A was in the Nth and Sth respectively; for the map with curves, 12% used it when A was in the Nth, while 21% did so when A was in the Sth. Similarly variable results were obtained for all the different criteria selected.

(ii) Shortest Path: Because of the way the simple regular grid was configured, all routes were of equal distance. Shortest path criteria thus could only be examined in the grid with diagonals, and grid with curves cases. This criterion is the one generally accepted as dominant in most network flow or routing models. It makes sense that it should be so if one is trying to maximize economic utility or minimize costs or time expended in travel. In these experiments however, we again found inconsistencies in criterion use. For example, in the diagonals case, with a single O-D path, 58% used the strategy, while 84.5% used it in the trip chaining cases. Sixty-eight percent used the strategy when the origin was in the Nth, while 80% used it when the origin was in the Sth. For the environment with curves, 74% used it when A was in the Nth, while 90% used it when the origin was in the Sth. Eighty percent adopted it in the trip chaining case, but 54% used it for single O-D pairings.

We next considered situations where individuals were required to travel between A and B in each direction. Here we were concerned with the question of whether the same route was retraced, and if so, what this did to the route selection criterion. As an example, results are presented for the "longest leg first" criterion.

First in the simple grid environment, route retrace was not usually followed. For example, 44% subjects chose longest leg first when traveling from A to B when A was located in the Nth. However, *61%* chose this strategy on the return route. This means the return route could *not* have been a retrace of the original! More confusion occurs when we change perspectives and pursue a path when A is in the Sth to a northerly located B. Here, only 29% used this criterion. In the reverse task, however, 64% chose the strategy!

On the map with curves, 35% chose this strategy when traveling from a distant origin to a close destination, but only 12% chose the strategy on the retrace task. When the origin was close and the destination distant, 13% chose it on the outbound journey and zero chose it on the retrace. When diagonals were included, a similar outbound and retrace pattern occurred, but with a close origin, differences again fluctuated widely from 7% to 20%.

When considering trip chaining, differences in criteria selection become marked depending on orientation. In a simple grid, 33% chose longest leg first when traveling from a distant origin towards a close destination, but *zero percent* did this on the return trip. When traveling from a close origin to a distant destination, 14% chose the strategy, but zero percent chose it when traveling the reverse route.

On the map which included some diagonals and again required traveling through an intermediate point, when the origin was distant, *35%* used longest leg first, but on the return trip *zero percent* used that strategy. When the origin was in the Sth, *33%* used longest leg first and again on the return trip *zero percent* used it. In the curvilinear condition 15% chose the strategy when A was distant while zero selected it on the return. It might be suggested that in these cases, a pure retrace strategy may have been used, thus precluding any "longest leg first" strategies from being implemented. Visual examination of subjects' maps tends to confirm this explanation. The occurrence of zero percent choice on the return trip *does* indicate that exact route retracing *was* a possible option as a route selection strategy.

Although there have been questions raised regarding the suitability of using maps in wayfinding tasks (Lloyd & Cammack, 1995), this set of exercises provides evidence that human path selection may not be the simple process that is usually assumed in network flow solution algorithms. While shortest path and least time were most highly ranked, it was also obvious that as one changed the complexity of the environment, and as trip making became more complex because of chaining several nodes together, path selection criteria changed. Also, there was no clear evidence that trip retracing was carried out except in some complex environments where chaining was required. Thus, it seems that some accounting for well known behaviors such as taking different routes to and from a given destination, or perceiving that routes heading in some direction are more acceptable than those heading in different directions (i.e., that there is an orientation bias in selecting routes) that can be partly accounted for by changing route selection criteria.

Given these laboratory based results, we now turn to a field experiment to see if they are duplicated or whether the experimental situation produced "artificial" behaviors.

Experiment #2: Path Selection in a Real Environment:

A second study was consequently undertaken to examine path selection criteria in a real world rather than laboratory setting.

Using information derived from the laboratory experiment, possible routes between two pairs of origins and destinations on a Western United States campus were used. Subjects were all familiar with the study area and were asked to select routes in both forward and reverse directions between the chosen points. Paths conforming to the criteria types identified in the laboratory experiment were defined and matched against the routes actually selected by subjects. Research questions again focused on inferring which criteria were used in path selection, whether route retraces were used, and what criteria were used most frequently. Only single O-D pairs were used; no trip chaining was investigated.

The principal hypotheses were similar to those examined in the map experiment. It was hypothesized that: (i) shortest distance and shortest time would be the two primary criteria; (ii) route retraces would occur frequently on both routes; and (iii) people will use the same criteria in this real world experiment that they use in everyday activities.

Subjects/Environment

The study was conducted on the campus of a Western United States university in the area between Ellison and Cheadle Hall (see Figure 1). The environment consists of a central open courtyard containing large regularly spaced planters. The courtyard adjoins Ellison Hall in an area divided by pathways and grassy areas. Two routes were selected for the study. The Stairs Route (A-B) consisted of the origin/destination pair of the flagpole at the north east corner of Cheadle Hall and the stairway door at the west end of the north wing of Ellison Hall. The Elevator Route (X-Y) consisted of the origin/destination pair of the flagpole at the north east corner of Cheadle and the elevator entrance at the east end of the north wing of Ellison .Each of these round trip routes was subdivided into forward and reverse components resulting in four route conditions:

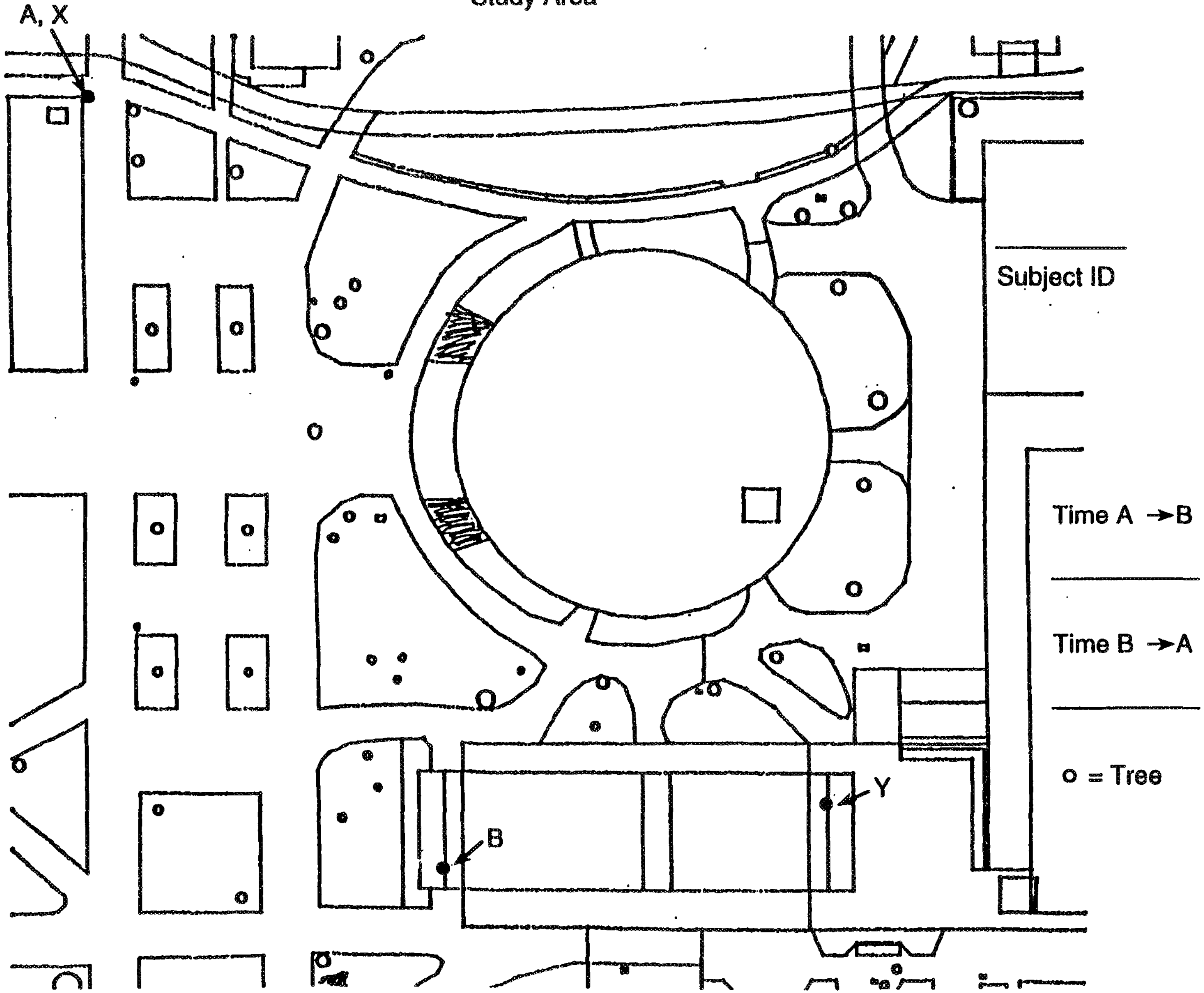
Fig. 1

- forward stairs: here the subjects' first task began at the flagpole, traveled to the stairs and returned; his or her second task began at the flagpole and traveled to the elevator and returned.
- reverse stairs: here the subjects' first task began at the stairs, traveled to the flagpole and returned; his or her second task began at the elevator and traveled to the flagpole and returned.
- forward elevator: here the subjects' first task began at the flagpole and traveled to the elevator and returned; his or her second task began at the flagpole and traveled to the stairs and returned.
- reverse elevator: here the subjects' first task began at the elevator and traveled to the flagpole and returned; his or her second task began at the stairs and traveled to the flagpole and returned.

All subjects were university staff or students (both graduate and undergraduate). An equal number of men and women, and geography, non-geography students were selected. Subjects were chosen by convenience from responses to fliers advertising the study.

Figure 1

Study Area



METHODS/PROCEDURE

Thirty-two subjects were scheduled for the experiment during daytime hours. All subjects were very familiar with the study area. Subjects were randomly assigned to the four different conditions while ensuring that equal numbers of male and female, and geography non-geography students were placed in each condition.

Subjects were taken to the origin for their assigned route condition and then were read the appropriate directions. They then began to walk a route of their choice to the assigned destination. This route and the time taken to travel it was recorded by the researcher on a map of the area. This procedure was repeated for the reverse section of the route. Subjects then completed a questionnaire on the criteria they used in selecting their route and normal activity behavior, plus evaluations of self confidence in spatial tasks and normal modes of travel.

The average group response for rating route choice criteria usually used and perceived to be used in this field experiment were also examined. According to questionnaire responses, subjects rated shortest route, route taking the least time, and route proceeding in the direction of destination as being the most important. Criteria of fewest turns, first noticed, and "usual route" were next in importance. In general the criteria values are consistent between those used on the task and those commonly used.

To analyze the route choice behavior based on traveling in the environment, all routes used

Figs. 2 & 3

between origin and destination pairs were determined and coded. Figures 2 and 3 show routes chosen between A and B, and X and Y. All possible routes were coded by identifying segments and choice points, and a separate route code was provided for each possible route that <u>could</u> be taken on each task. The number of times a given route <u>was</u> taken was recorded. The maps produced by recording the routes subjects traveled during the experiment were then used to

Table 2.

produce Table 2 which shows the route chosen, time taken to complete, whether the same route was taken in the forward and reverse directions and which direction was traveled more quickly for each subject.

For the Flagpole to Stairway route, 62.5% of the subjects traveled the same route in both

Figure 2
Routes Taken A-B

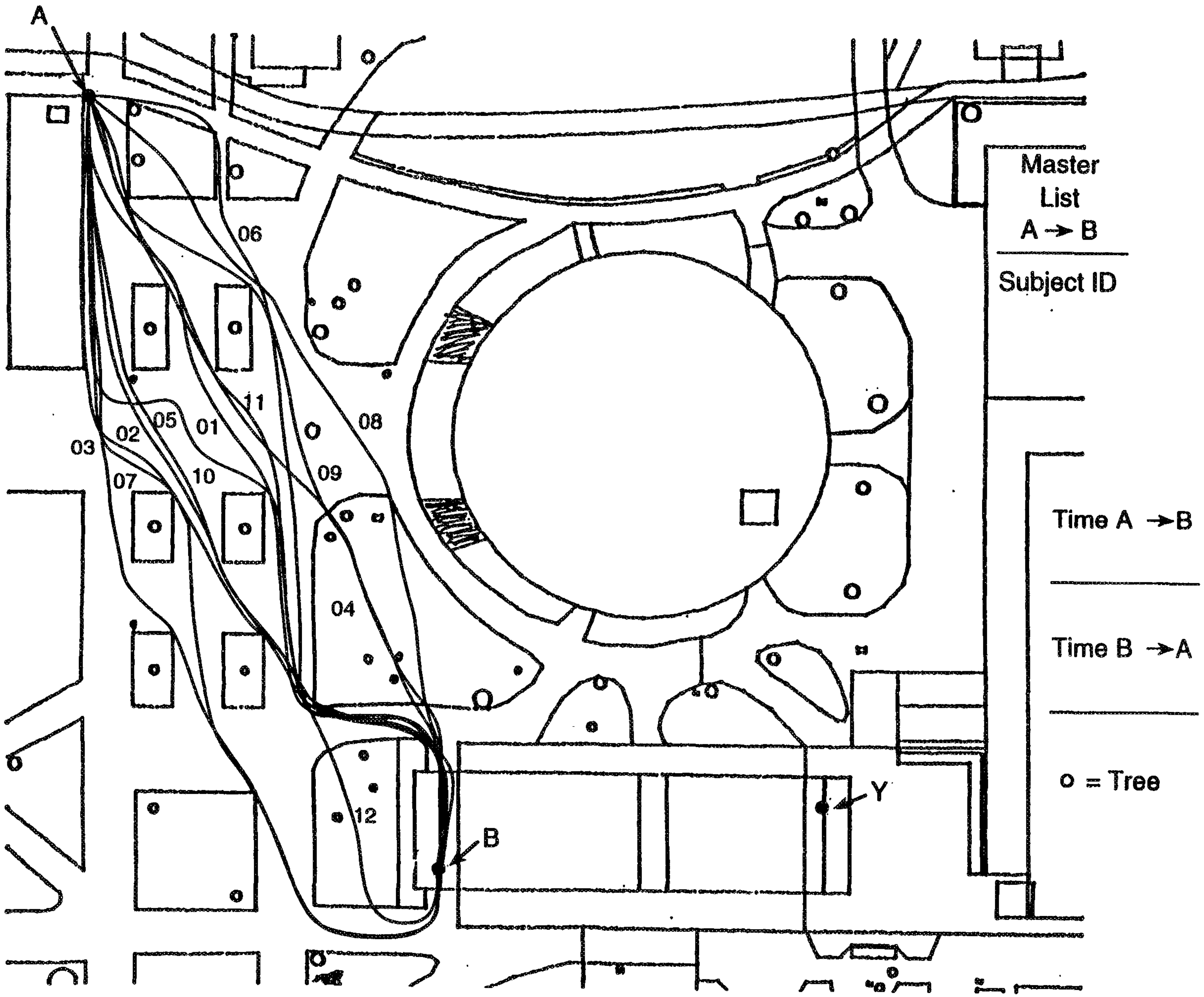


Figure 3
Routes Taken X-Y

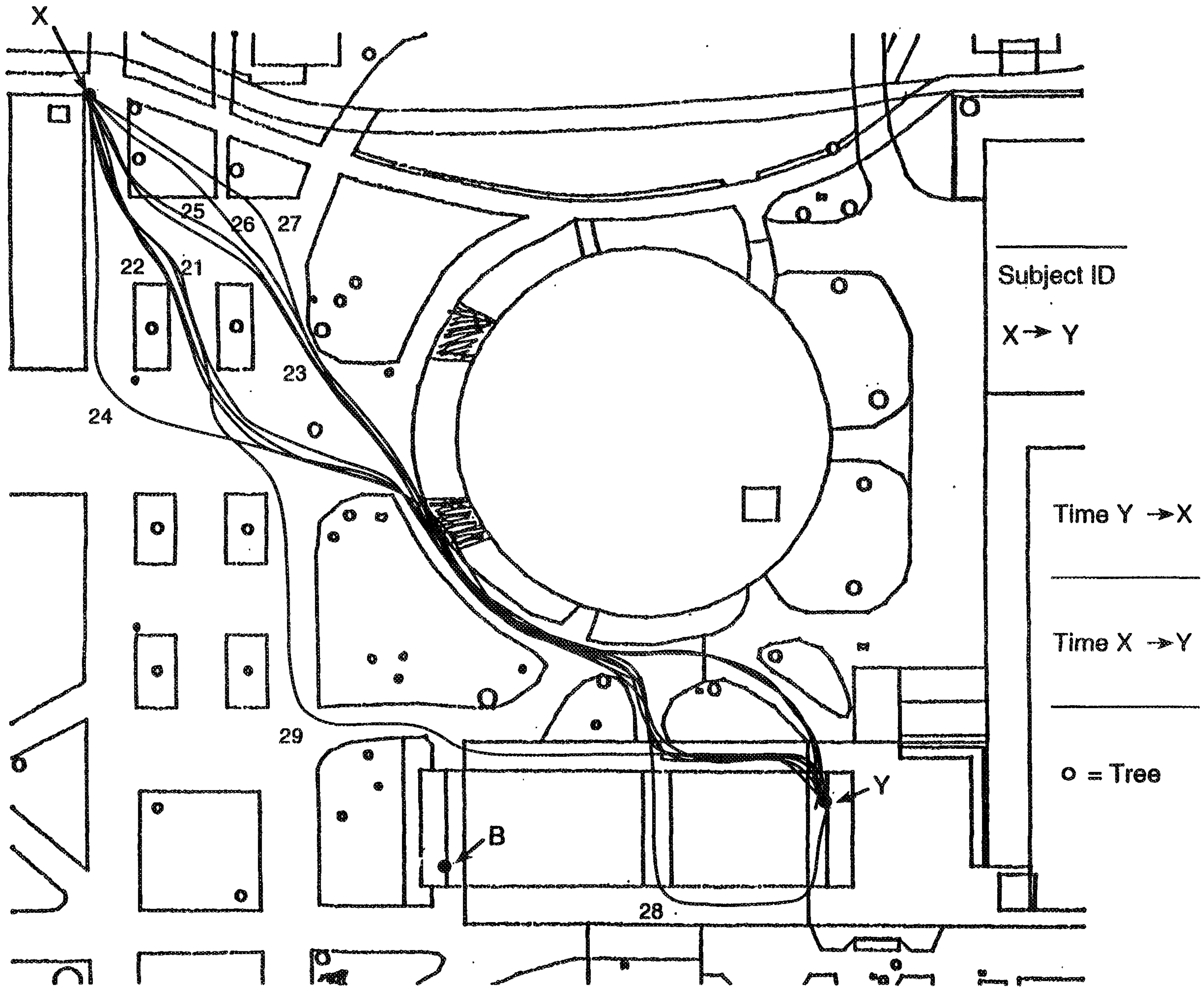


Table 2
Route Choice and Travel Times

Code	Geog/Non	M/F	A-B	B-A	X-Y	Y-X	A to B Route Chosen	Time (mins)	B to A Route Chosen	Time (mins)	X to Y Route Chosen	Time (mins)	Y to X Route Chosen	Time (mins)	Route Same? *	Fastest Route **
✓ 1	Geog	M	X				4	1:19	4	1:18	25	1:33	22	1:34	0	2
✓ 2	Geog	M	X				1	1:10	4	1:04	22	1:18	21	1:20	0	2
✓ 3	Geog	F	X				4	1:15	4	1:15	23	1:26	22	1:28	0	2
✓ 4	Geog	F	X				4	1:15	4	1:13	26	1:27	27	1:28	0	2
✓ 5	NonGeog	M	X				4	1:23	4	1:22	23	1:38	23	1:39	1	2
✓ 6	NonGeog	M	X				4	1:16	4	1:21	22	1:30	22	1:30	1	0
✓ 7	NonGeog	F	X				1	1:30	5	1:32	23	1:49	22	1:50	0	2
✓ 8	NonGeog	F	X				1	1:24	3	1:30	23	1:34	22	1:37	0	2
✓ 9	Geog	M		X			4	1:11	4	1:11	26	1:24	22	1:37	0	1
✓10	Geog	M		X			3	1:36	1	1:27	23	1:39	24	1:49	0	1
✓11	Geog	F		X			4	1:15	4	1:17	23	1:29	25	1:30	0	1
✓12	Geog	F		X			8	1:33	4	1:30	25	1:42	27	1:43	0	1
✓13	NonGeog	M		X			4	1:12	4	1:14	25	1:27	22	1:27	0	0
✓14	NonGeog	M		X			6	1:40	7	1:45	23	1:50	21	1:51	0	1
✓15	NonGeog	F		X			1	1:19	1	1:15	23	1:25	21	1:27	0	1
✓16	NonGeog	F		X			10	1:31	9	1:11	23	1:30	28	1:50	0	1
✓17	Geog	M			X		4	1:20	4	1:19	23	1:44	22	1:48	0	2
✓18	Geog	M			X		1	1:17	4	1:16	23	1:31	22	1:31	0	0
✓19	Geog	F			X		2	1:30	2	1:33	23	1:39	22	1:41	0	2
✓20	Geog	F			X		4	1:25	4	1:23	25	1:43	27	1:41	0	1
✓21	NonGeog	M			X		1	1:25	1	1:23	23	1:34	21	1:34	0	0
✓22	NonGeog	M			X		2	1:26	11	1:35	29	1:52	22	1:45	0	1
✓23	NonGeog	F			X		8	1:22	4	1:12	23	1:33	22	1:27	0	1
✓24	NonGeog	F			X		4	1:03	4	1:04	25	1:19	25	1:22	1	2
✓25	Geog	M				X	4	1:15	12	1:21	23	1:32	27	1:33	0	1
✓26	Geog	M				X	4	1:18	4	1:19	21	1:45	21	1:39	1	2
✓27	Geog	F				X	1	1:29	2	1:28	21	1:48	22	1:42	0	2
✓28	Geog	F				X	1	1:28	1	1:33	23	1:55	23	1:49	1	2
✓29	NonGeog	M				X	4	1:25	4	1:22	23	1:41	22	1:38	0	2
✓30	NonGeog	M				X	4	1:11	4	1:11	23	1:24	22	1:27	0	1
✓31	NonGeog	F				X	4	1:29	4	1:26	21	1:42	25	1:45	0	1
✓32	NonGeog	F				X	1	1:31	1	1:33	23	1:34	25	1:45	0	1

* 0 = different route
1 = same route

** 0 = neither faster
1 = first traveled faster
2 = second traveled faster

directions. For the Flagpole to Elevator route, 15.6% of the subjects traveled the same route in both directions. This is a significant difference in route retrace between the two origin/destination pairs. This is apparently due to the existence of some route choice criteria present in this environment that produces a distinctly different route choice decision to be made depending on the direction of travel. Of particular importance is the layout of features near the elevator at Ellison Hall, including the presence of a central grassy area dividing travel into one of two paths. While traveling from the elevator to the flagpole 75% of the subjects chose a route that took them to the north of the grassy area that is encountered when leaving Ellison for Cheadle Hall. While traveling from the flagpole to Ellison Hall 75% of the subjects chose a route that took them south of this same grassy area. (i.e., route choice was dependent on direction of travel). One interpretation of this route choice behavior is that subjects chose a route that took them away from Ellison Hall as soon as possible when leaving the elevator and took them close to Ellison Hall as quickly as possible when approaching their destination. In this interpretation one could hypothesize that the building represented the destination on a larger scale of route planning and that leaving Ellison Hall represents leaving the elevator and conversely reaching Ellison Hall represents reaching the elevator.

The two routes further produced interesting differences when retracing is considered. On route A-B (flagpole to stairs), 62.9% took the same route in both a forward and reverse direction. On route X-Y (flagpole to elevator), only 15.6% took the same route.

For both routes 43.7% of the subjects traveled the first direction faster than the return direction. For the stairway route 46.9% of the subjects completed the return portion of the route faster than the first. For the elevator route, 43.7% of the subject completed the reverse segment faster than the first traveled. This doesn't support the intuitive position that subjects would travel the return route faster after having learned the route and environment on the first leg.

Between the flagpole and stairs, two routes (#16 and 9) accounted for 75% of subject's route choices regardless of direction traveled. Between the flagpole and the elevator five routes (#23, 25, 22, 24, and 26) accounted for 75% of subject's route choices regardless of direction traveled.

However, a total of twelve routes were needed to account for all travel between the flagpole and stairs while only nine routes were needed to account for all travel between the flagpole and the elevator. It is interesting to consider this data in light of the differences in the spatial layout of the two route areas. The stairway route is primarily across a plaza that has regularly spaced planters which are obstacles to travel. These planters allow a generally straight line route between origin and destination but to some extent force the traveler to choose 'channels' to a destination. The elevator route differs in that only a portion consists of the plaza with planters. The rest of the route area consists of pathways restricting travel between buildings and around grass areas. Furthermore, these pathways radiate out from the elevator, causing diverging paths away from the elevator and converging paths toward the elevator.

DISCUSSION

Other researchers have pointed to the facts of asymmetric distance cognition (e.g., Sadalla, Burroughs & Staplin 1980). These experiments add to their findings by focusing on the paths actually chosen, the criteria apparently most relevant to that route choice, and noting if there are differences between what criteria were used in a field experiment versus those used in daily travel. Some interesting results developed.

First, when comparing the two experiments, laboratory and field, one notices the similarity between the rating of criteria used in the experiments. In the field, minimizing time was given more support belying the result from the lab experiment in which subjects claimed they did not minimize time in everyday activities.

When considering route retracing, two things stand out. Even in this restricted environment, choice of routes varied depending on direction traveled and with respect to the nature of the environment. The fact that on one route (A-B) 62.9% took the same route both ways was significantly different from the result obtained from the other route (X-Y) when only 15.6% took the same route both ways. In the former, minimizing distance or time or turns could provide reasonable explanations for the observed behaviors. For the other route it appeared that route selection criteria changed indicating that a single selection criteria would seriously under predict the paths chosen. No significant differences were observed among males/females and geography/non-geography groups. Also, it did not appear that any one of the end points (flagpole, stairs, elevator) was considered to be a primary reference point and the others secondary. This implies that, in addition to the previously discovered asymmetry of distance perception among anchoring and other nodes, perceptions of the configuration of the environment itself (particularly different perspectives as one changes direction) may influence route choice. Thus, a route that seems shorter or quicker or straighter from one end may not be so perceived from the other end, thus inducing a change of route. The real question is whether the route selection criteria also change; from examining the actual paths taken and recording response times and other variables, it seems that they often do.

Although the field experiment did not directly test the influence of orientation direction as did the map test, there is room to infer that once again orientation direction played a part in route choice and the criteria used to select that route. Certainly the commonly used assumption that trips will be retraced and that the same criteria will be used for different trips, must be brought into question.

DIRECTIONS FOR FURTHER ANALYSIS

Further study in this research project is designed to develop route classification procedures for the various routes actually taken by people in their everyday travel activities. This will determine if the route choice criteria listed in our questionnaire (shortest distance to travel, has fewest turns, longest leg first, most aesthetically pleasing, shortest leg first, has many curves, takes least amount of time, first noticed, has most turns, usual route, alternative to usual route, and always proceeds in direction of travel) are comprehensive or partial. However, it may not be possible objectively to classify routes based on some of the criteria such as: usual route, alternative to usual route, most aesthetic, and first noticed without extensive survey research. However, classification using the other criteria would allow comparisons to be made between the stated criteria used and the actual criteria used. This could be used to answer various questions including: what was the varying importance of the choice criteria when actually traveling in the environment? How does this rating vary for the different conditions? How does this compare to the varying importance of perceived criteria? For non-route retrace what was the criteria that caused a different route choice for the return trip? What difference does it make to predicting travel when one uses different route selection criteria for outbound and inbound trips? Does route selection criteria change with every change of trip purpose? Travel mode? And whether simple or chained trips are anticipated?

I think it would also be interesting to pursue what characteristics of the route areas have caused the differences between route retrace and differentiate route selection between origins and destinations. With this information as a knowledge base, it would then be appropriate to extend this work to a driving situation (i.e. using motorists as subjects). One could also determine if one or more trip purposes tend to produce route retraces more than others, or if increasing complexity of trip chains produced simple or multiple criteria for each route segment or for the entire trip sequence. A final problem would be to evaluate the degree of realism that can be attributed to conventionally used path selection criteria built into transportation models or the network models built into today's GIS.

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