FOLLOWING INFORMAL STREET MAPS
Effects of Map Design

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ABSTRACT: To study the effectiveness of map style and map complexity on street map-following performance, drivers utilized one of six informal street maps to drive to a destination in an unfamiliar location. Using a 2 × 3 factorial design, 78 undergraduates were randomly assigned to one of six map design conditions: two levels of style (written verbatim or graphic illustration) and three levels of complexity. The low-complexity map contained a direct route, including relational (left-right) directions. The medium-complexity map contained a direct route, relational directions, five adjacent streets, and major mileage estimates. The high-complexity map contained a direct route, relational directions, 16 adjacent streets, major mileage estimates, and seven landmarks. Map style significantly affected driving time, as written verbatim maps resulted in less total driving time than graphic maps. Subjects with higher cognitive abilities (as measured by the Wonderlic Personnel Inventory) took less time to reach the final destination than did those with lower cognitive abilities. Neither the effects for map complexity nor the style by complexity interaction were significant. Also, male and female performance did not significantly differ.

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Formal and informal street maps are an integral aspect of many occupations. Cab drivers, delivery personnel, police and fire departments, and many other occupations depend on the use of accurate street maps for successful job performance. While the importance of maps cannot be questioned, relatively little research has been conducted on the ability of people to follow informal street maps (Ward et al., 1986). Even though some research has investigated human spatial cognition as it applies to the learning of a particular environment (Evans, 1980), informal street map following has generally been ignored in the cartographic literature (MacEachren, 1986).

This lack of research is especially surprising as previous research has indicated that reading a map while driving is considered by drivers to be more dangerous than driving activities such as drinking coffee or dialing a mobile telephone (Smith, 1978); when giving directions people often incorrectly describe landmarks and produce irrelevant and inaccurate information (Riesbeck, 1980); maps can be so difficult to read that it takes over a minute simply to find a name on a street map (Phillips and Noyes, 1977); and intense stress can result from getting lost or disoriented (Binet, 1894). Furthermore, the growing interest in computer-assisted vehicle navigation aids indicates that more information is needed regarding types of information that should be included in street maps (see McGranaghan et al., 1987, for a review and discussion of this literature).

PREVIOUS RESEARCH

Previous research investigating street maps has focused on two areas: information used in giving directions and information used in following directions.

INFORMATION USED IN GIVING DIRECTIONS

A recent study investigating this area involved 176 college students looking at maps and then giving directions to an imaginary person (Ward et al., 1986). The results of the study indicated that, in general, people give gave drivers four different types of instructions and asked them to drive to a destination. Subjects received directions through (1) a customized map, (2) a tape-recorded set of directions, (3) both a customized map and a tape-recorded set of instructions, or (4) a regular street map, which served as the control condition. The results indicated that hearing instructions on tape led to fewer directional errors, less driving time, and shorter driving distances than receiving instructions through either the customized or the regular street map. The addition of a map to the tape condition did not lead to more effective navigation.

Gilmartin (1986) studied recall of geographic information presented in a 1,000-word passage. Her findings revealed that males recalled more spatial-related information than did females, males and females did not differ in the amount of nonspatial-related information recalled, and that females tended not to use the maps they were given. Research has also indicated that there are a number of individual differences in following street maps. In studies of driver familiarity with an area, Chase (1983) and Pailhous (1969) found that drivers who were unfamiliar with an area utilized major arteries, while drivers familiar with the area used secondary streets. Streeter and Vitello (1986) found that unfamiliar drivers made more navigational errors than did familiar drivers.

Different aspects of cognitive ability were also investigated in several studies. Streeter and Vitello (1986) discovered a significant relationship between cognitive abilities in map memory, building memory, and map following and self-reports of navigational ability. Sholl and Egeth (1982) found that higher scores on vocabulary and mathematical aptitude tests were related to higher map-reading performance. Thorndyke and Stasz (1980) found that scores on the Building Memory Test were related to map learning.

However, Goldin and Thorndyke (1981) found that people who are good map learners are not necessarily good map readers or followers. In other words, remembering the features on a map and understanding and interpreting the meaning of the features are separate aptitudes.

NEED FOR FURTHER RESEARCH

While the above studies have shed some light on the area of street map reading and following, many unanswered questions remain—the most important of which involves the best way in which to design maps. Previous studies investigating self-reported desirability of certain map characteristics have not determined whether using these characteristics actually leads to more effective navigational performance than not using them. For example, Ward et al. (1986) found that people like to give directions using landmarks and Streeter and Vitello (1986) found that subjects preferred maps with landmarks and distances. However, neither study determined if inclusion of these map characteristics actually improved performance in reaching a destination. In no study did subjects actually follow maps.

It is the purpose of the present study to investigate a number of map-reading issues by having drivers follow maps that differ in both complexity and style. The hypotheses for the study are:

(1) Similar to the results of Streeter et al. (1985), subjects receiving written verbatim directions will drive to a destination in less time than will subjects following customized graphic maps.
(2) Due to the use of cues such as landmarks, distances, and relations found in previous research (Streeter and Vitello, 1986; Ward et al., 1986), subjects receiving complex maps will drive to a destination in less time than subjects receiving more simple maps with less detail.
(3) Consistent with the results of Streeter and Vitello (1986), Sholl and Egeth (1982), and Thorndyke and Stasz (1980), there will be a significant relationship between cognitive ability as measured by a general mental ability test (Wonderlic Personnel Inventory) and

time taken to reach a destination using a map. The issue addressed in this study is whether a general test of cognitive ability, as opposed to a specific test of cognitive ability, is related to map-following performance.

(4) Congruent with the implications of Ward et al.'s (1986), Chang and Antes's (1987), and Gilmartin and Patton's (1984) research on map reading, males and females will not significantly differ in the amount of time taken to reach a destination using an informal street map.

METHOD

SUBJECTS

Subjects were 78 (44 male, 34 female) undergraduates enrolled in psychology courses at a medium-sized southern university who voluntarily participated in order to receive extra credit toward their final grade. Each individual in the study was required to have both a vehicle and a valid driver's license. All subjects were unfamiliar with the route to be driven during the experiment.

PROCEDURE

Prior to the driving portion of the experiment, each subject was administered the Wonderlic Personnel Inventory as a measure of cognitive ability. The Wonderlic is a timed cognitive ability test that is commonly used in industry and was chosen because it takes little time to administer and is highly correlated with full-scale I.Q.s as measured by the Wechsler Adult Intelligence Scale (WAIS). With the Wonderlic, the subject is given 12 minutes to complete as many of the 60 problems as possible, with the typical subject correctly completing about 20 items.

Upon arriving at the starting point with his or her vehicle, the subject was joined by a researcher, who gave the subject verbal instructions to obey all traffic regulations and asked the subject to sign a waiver of responsibility in case of an accident (which did not occur).

Once the subject received the instructions, he or she was randomly given one of six map designs. The six maps (located in Appendixes 1-6) differed on the basis of both style and complexity. Two styles of maps were utilized: The first style was a written verbatim set of route directions, while the second style was a graphic illustration of the same route. The graphic illustration maps were hand drawn and hand lettered to simulate the types of informal maps that most people draw. These last map types are similar to the strip maps described by MacEachren (1986) and the process maps distinguished by Downs and Stea (1977). The primary purpose of these types of maps is to aid an individual in moving from one location to another.

The levels of map complexity were varied based on the amount of information and the number of available referent points (Castner and Eastman, 1985). The low-complexity map contained a direct route, including relational (left-right) directions. The medium complexity map contained a direct route, relational directions, five adjacent streets, and major mileage estimates. The high-complexity map contained a direct route, relational directions, 16 adjacent streets, major mileage estimates, and seven landmarks.

In the driving portion of the experiment, the starting time was noted on a data sheet as soon as the vehicle was placed into gear. During the course of the drive, the researcher did not tell the subject if any navigation errors occurred. After arrival at the destination point (a house, the address of which was contained in the six maps), the researcher recorded the amount of elapsed time.

RESULTS AND DISCUSSION

The data were analyzed through a 2×3 analysis of covariance, with cognitive ability serving as the covariate and the amount of time taken to reach the final destination serving as the dependent variable. In order to increase the

TABLE 1
Mean Number of Minutes to Arrive at Destination

	Map Style		
Map Complexity	Written	Graphic	
Low	15.00 (3.95)	15.61 (3.59)	15.30 (3.71)
Medium	13.84 (2.11)	17.23 (6.40)	15.54 (4.98)
High	14.38 (2.84)	17.53 (5.39)	15.96 (4.52)
	14.47 (3.02)	16.79 (5.19)	

NOTE: Standard deviations are in parentheses.

sample size of each cell, sex was included as a variable only when testing for Hypothesis 4. As shown in Table 1, Hypothesis 1 was supported, as subjects receiving written verbatim instructions took significantly less time to reach the destination than did subjects using the customized graphic maps, F (1, 71) = 5.79, $p < .01$. This finding is consistent with those of Streeter et al. (1985), who found that verbal verbatim instructions given with a tape recorder were superior to directions provided by graphic maps.

Hypothesis 2 was not supported, as the level of map complexity did not significantly affect the amount of time taken to reach the destination point, F (2, 71) < 1. The interaction between map style and complexity was also not significant, F (2, 71) = 1.12. These results may mean that even though subjects in previous research say that they like and use map characteristics such as landmarks and distances, the addition of these characteristics to informal street maps does not lead to better navigational performance.

Hypothesis 3 was supported, as there was a significant effect for the covariate, indicating that subjects with higher

TABLE 2
Mean Number of Minutes to Arrive at Destination as a Function of Map Complexity and Cognitive Ability

	Cognitive Ability	
Map Complexity	High	Low
Low	14.41 (1.05)	16.07 (4.82)
Medium	16.61 (2.84)	16.46 (6.46)
High	13.90 (1.44)	17.46 (5.40)

NOTE: Standard deviations are in parentheses.

cognitive ability, as measured by a general mental ability test, drove the route in shorter times than did subjects with lower cognitive ability, $F(1, 71) = 6.58$, $p < .01$. This finding is consistent with the results of Streeter and Vitello (1986), Sholl and Egeth (1982), and Thorndyke and Stasz (1980).

In the spirit of "post-hoc data snooping," we also looked at a possible interaction between cognitive ability and map complexity by using a median split on the Wonderlic scores to place subjects into high and low cognitive ability categories. As depicted in Table 2, the interaction was not significant.

A related topic for future research would be to investigate the relationship between types of cognitive ability and map following performance. That is, in this study an overall measure of general intelligence was related to map-following performance. In previous studies, specific types of cognitive abilities such as spatial accuracy were investigated. Therefore, future studies should compare and contrast the different types of cognitive abilities as they relate to map-following performance.

TABLE 3
Mean Number of Minutes to Arrive at Destination as a Function of Map Complexity and Style

	Sex			
	Male		Female	
	Style		Style	
Complexity	Written	Graphic	Written	Graphic
Low	15.75 (4.98)	14.71 (3.77)	13.80 (.84)	16.66 (3.39)
Medium	14.71 (1.97)	16.62 (7.28)	12.83 (1.94)	18.20 (5.31)
High	14.42 (3.59)	16.42 (4.27)	14.33 (1.96)	18.83 (6.64)

NOTE: Standard deviations are in parentheses.

As depicted in Table 3, Hypothesis 4 was supported, as an additional $3 \times 2 \times 2$ ANOVA revealed that driving times for males were not significantly different than those for females. Neither the interaction between sex and map complexity nor sex and map style was statistically significant (F's < 1). This finding supports the implications of both Ward et al. (1986) and Chang and Antes (1987).

Previous studies conducted on non-street maps (e.g., topographic or reference maps) have found sex differences involving map reading. However, previous research, as well as this study, that investigated map reading or following using street maps found sex differences. For example, in the only study directly comparing males and females on map reading performance with a variety of maps, Chang and Antes (1987) found that males performed better than females when using reference and topographic maps but not when using street maps. Why map type would make a difference is not known and any reasons offered here would only be speculative. Chang and Antes (1987) have suggested that the difference could be attributable to dimensional change and cite the work of Pool and Stanley (1972) as support. More specifically, reference and topographic maps involve using a two-dimensional map to interpret a three-dimensional environment, where the street map involves only a two-dimensional environment (vertical is not a relevant direction for following street maps). However, the inconsistency in research suggests that future studies of gender differences involving map reading or following must include map type as a relevant variable.

Overall, the results of this study extend and strengthen the findings of previous research. It appears that verbatim directions (either written or oral) are superior to graphic informal street maps, that males and females follow street maps equally well, and that people with higher cognitive ability are better navigators than people with low cognitive ability.

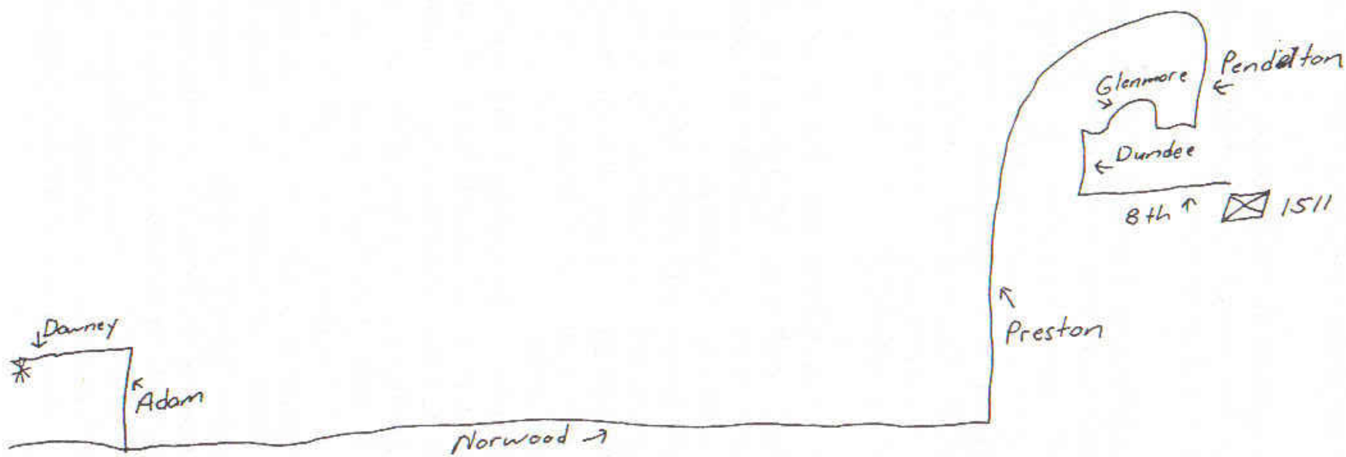
The only unexpected finding involved the lack of an effect for map complexity. In research by Ward et al. (1986) and Streeter and Vitello (1986), subjects indicated that they used the "nonessential" referent points on maps, such as landmarks and distances. While navigators may use these characteristics, the results of the current study suggest that the extra referent points are neither necessary nor especially helpful.

There are four plausible explanations for this finding. First, it is possible that the subjects in this study did not use the additional referent points because they were both driving and looking at the map. As Smith (1978) noted earlier, drivers consider following a map while driving to be a very dangerous activity. Furthermore, Castner and Eastman (1985) have demonstrated that complex maps lead to eye fixations of longer durations than do less complex maps. Thus the potential danger involving the longer eye fixations required to use the complex aspects of maps may cause the driver to ignore everything other than the basic map details.

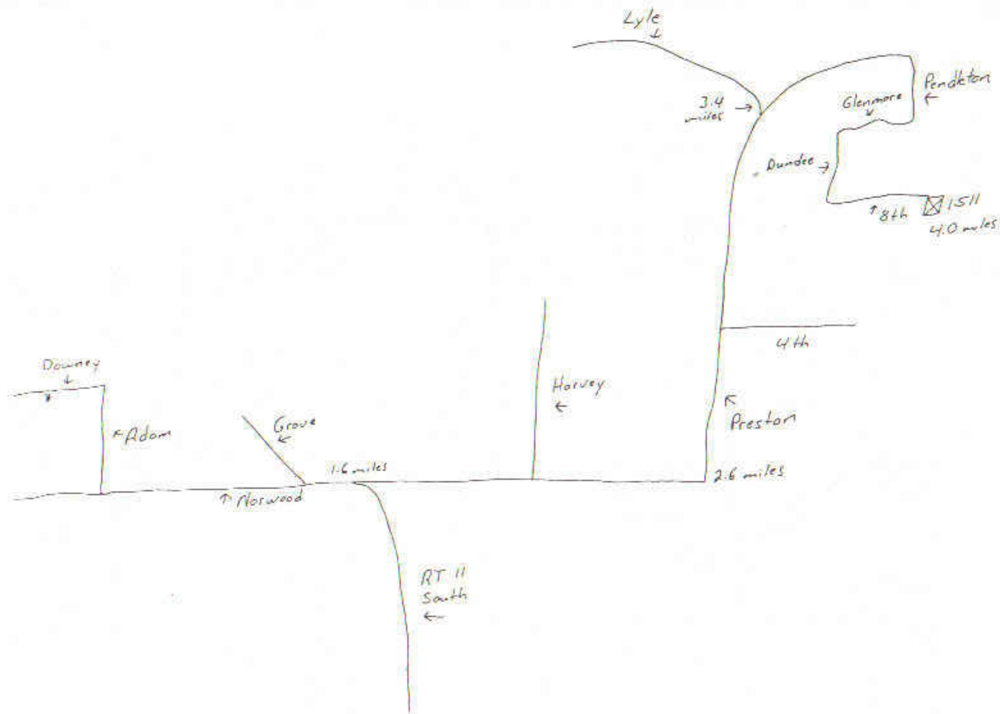
A second explanation could be that our subjects did not use the additional information because they might have had experience with previous maps that contained inaccurate information. That is, previous research (e.g., Mandler and Parker, 1976; Byrne, 1979; Appleyard, 1976) has shown that maps drawn of familiar settings are often distorted and inaccurate. Thus people may be so leery of trusting information on informal street maps that they just do not use the information.

The third explanation is that since the drivers in our study were not familiar with the landmarks and streets, the additional information provided in the complex maps was of little value. This idea is consistent with the writings of Gold (1980) and Appleyard (1976), who believe that landmarks are only important for and used by people who are already familiar with an area, and of Rapoport (1977), who believes that perception of direction is influenced by familiarity with the city.

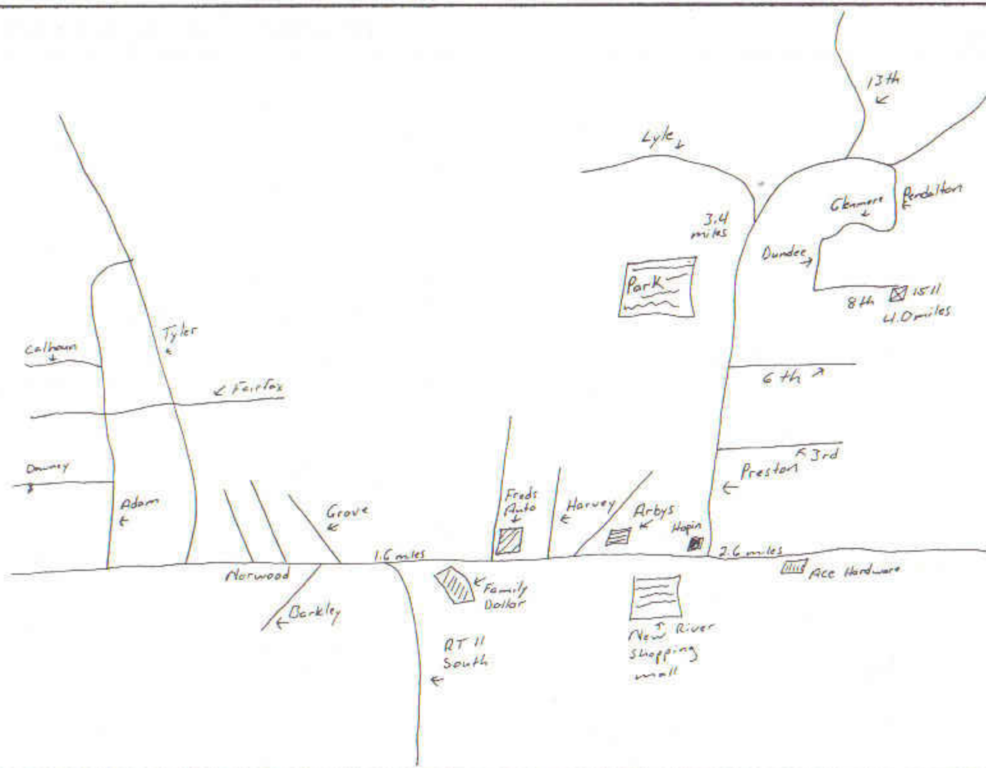
The fourth and final explanation is that map complexity was not a factor in this study due to the particular location and route. That is, every city and every route are different, and the characteristics of the city and the route used in this study may not have encouraged a need for additional referent points. The route used in this study was both fairly direct and possessed a fairly regular layout. Previous research has shown that distance estimates are easier to make with regular layouts (Canter and Tagg, 1975) and direct routes (Lee, 1971). Thus, if our route was characteristic of variables making distance estimation easier, then it would make sense that providing distances on more complex maps would lead to faster navigation. Further research is necessary to determine which of these three explanations is most valid.



APPENDIX 1: Graphic Design/Low-Complexity Map



APPENDIX 2: Graphic Design/Medium-Complexity Map



APPENDIX 3: Graphic Design/High-Complexity Map

APPENDIX 4

WRITTEN DESIGN/LOW-COMPLEXITY MAP

Leave Psychology Department. Take Downey to Adams. Turn right onto Adams. Take Adams to Norwood. Turn left onto Norwood. Take Norwood to Preston. Turn left onto Preston. Take Preston to Pendleton. Turn right onto Pendleton. Take Pendleton to Glenmore. Turn right onto Glenmore. Take Glenmore to Dundee. Turn left onto Dundee. Take Dundee to Eighth St. Turn left onto Eighth St. Go to 1511 Eighth St., which is the final destination.

APPENDIX 5

WRITTEN DESIGN/MEDIUM-COMPLEXITY MAP

Leave Psychology Department. Take Downey to Adams. Turn right onto Adams. Take Adams to Norwood. Turn left onto Norwood. Take Norwood 1.6 miles to Rt. 11 South. Continue on Norwood 1 more mile to Preston. Turn left on Preston. Take Preston 1 mile to Pendleton. Turn right onto Pendleton. Take Pendleton 2 blocks to Glenmore. Turn right onto Glenmore. Take Glenmore 1 block to Dundee. Turn left onto Dundee. Take Dundee past Ninth St. to Eighth St. Turn left onto Eighth St. Go to 1511 Eighth St., which is just before Pendleton. The final destination is 4.0 miles from the starting point.

APPENDIX 6

WRITTEN DESIGN/HIGH-COMPLEXITY MAP

Leave Psychology Department. Take Downey to Adams. Turn right onto Adams. Go to Norwood. Turn left onto Norwood. Take Norwood 1.6 miles to Rt. 11 South. Continue on Norwood one more mile. You will pass Fred's Auto, Harvey St., Arby's, New River Shopping Center. On your left you will see a "HopIn" store. This is Preston. Take a left on Preston. On Preston you will travel 1 mile and pass 2nd, 3rd, 4th, 5th, 6th and 7th Streets. You will encounter a "Stop" sign at the intersection of Eighth and Preston. Continue on Preston. Near the intersection of Ninth and Preston will be a park. Continue on Preston. Just after 13th St. but before 14th St. will be Pendleton. The "Howard M. Sisson Playground" is at the intersection of Preston and Pendleton. Turn right onto Pendleton. Go two blocks and you will pass a red fence on your right. There is a fire hydrant on your left. Just after the fence and hydrant is Glenmore. Turn right onto Glenmore. Glenmore curves around, for 1 block, and dead-ends with Dundee. There is a "Yield" sign at this intersection. There is also a brick house at the intersection of Dundee and Glenmore. Turn left onto Dundee. Follow Dundee past Ninth St. and up a hill. At the intersection of Dundee and Eighth you will see a white house and a white fence. Turn left onto Eighth. Go to 1511 Eighth St. The final destination is 4.0 miles from the starting point.

REFERENCES

APPLEYARD, D. A. (1970) "Styles and methods of structuring a city." Environment & Behavior 2: 100-116.

APPLEYARD, D. (1976) Planning a Pluralistic City. Cambridge: MIT Press.

BINET, M. A. (1894) "Reverse illusions of orientation." Psych. Rev. 1: 337-350.

BRYANT, K. J. (1982) "Personality correlates of sense of direction and geographical orientation." J. of Personality and Social Psychology 43: 1318-1324.

BYRNE, R. (1979) "Memory for urban geography." Q. J. of Experimental Psychology 31: 147-154.

CANTER, D. V. and S. K. TAGG (1975) "Distance estimation in cities." Environment & Behavior 7: 59-80.

CASTNER, H. W. and J. R. EASTMAN (1985) "Eye-movement parameters and perceived map complexity, II." Amer. Cartographer 12 (1): 29-40.

CHANG, K. T. and J. R. ANTES (1987) "Sex and cultural differences in map reading." Amer. Cartographer 14: 29-42.

CHASE, W. G. (1983) "Spatial representations of taxi drivers," pp. 391-405 in D. R. Rogers and J. A. Sloboda (eds.) Acquisition of symbolic skills. New York: Plenum.

DOWNS, R. M. and D. STEA (1977) Maps in Minds. New York: Harper & Row.
EVANS, G. W. (1980) "Environmental cognition." Psych. Bull. 88: 259-287.
GILMARTIN, P. P. (1986) "Maps, mental imagery, and gender in the recall of geographical information." Amer. Cartographer 13: 335-344.
GILMARTIN, P. P. and J. C. PATTON (1984) "Comparing the sexes on spatial abilities: map use skills." Annals of the Assn. of Amer. Geographers 74: 605-619.
GOLD, J. R. (1980) An Introduction to Behavioral Geography. Oxford: Oxford Ohio Press.
GOLDIN, S. E. and P. W. THORNDYKE (1981, March) An Analysis of Cognitive Mapping Skills (Tech. Report No. n-1664-ARMY). Santa Monica, CA: Rand Corp.
KOZLOWSKI, L. and K. BRYANT (1977) "Sense of direction, spatial orientation, and cognitive maps." J. of Experimental Psychology 3: 590-598.
LEE, T. R. (1971) "Psychological and architectural determinism." Architect's J. 154: 253-261.
MacEACHREN, A. M. (1986) "A linear view of the world: strip maps as a unique form of cartographic representation." Amer. Cartographer 13 (1): 7-25.
MANDLER, J. M. and R. E. PARKER (1976) "Memory for descriptive and spatial information in complex pictures." J. of Experimental Psychology & Human Learning and Memory 2: 38-48.
McGRANAGHAN, M., D. M. MARK, and M. D. GOULD (1987) "Automated provision of navigation assistance to drivers." Amer. Cartographer 14: 121-138.
PAILHOUS, J. (1969) "Representation de l'espace urbain et cheminements" [Representation of urban space and traveling]. Le Travail Humain 32: 87-140, 239-270.
PHILLIPS, R. J. and L. NOYES (1977) "Searching for names in two city street maps." Ergonomics 8: 73-77.
POOL, C. and G. STANLEY (1972) "A factorial and predictive study of spatial abilities." Australian J. of Psychology 24: 312-320.
RAPOPORT, A. (1977) Human Aspects of Urban Form. Oxford: Pergamon.
RIESBECK, C. K. (1980) "You can't miss it: judging the clarity of directions." Cognitive Sci. 4: 285-230.
SHOLL, J. M. and H. E. EGETH (1982) "Cognitive correlates of map-reading ability." Intelligence 6: 215-230.
SMITH, V. J. (1978) "What about customers? A survey of mobile telephone users," pp. 190-193 in 28th IEEE Vehicular Technology Conference, Denver, Colorado, March 22-24.
STREETER, L. A. and D. VITELLO (1986) "A profile of drivers' map reading ability." Human Factors 28: 223-239.
STREETER, L. A., D. VITELLO, and S. A. WONSIEWICZ (1985) "How to tell people where to go: comparing navigational aids." Int. J. of Man-Machine Studies 22: 549-562.
THORNDYKE, P. W. and C. STASZ (1980) "Individual differences in procedures for knowledge acquisition from maps." Cognitive Psychology 12: 137-175.
WARD, S. L., N. NEWCOMB, and W. F. OVERTON (1986) "Turn left at the church, or three miles north: a study of direction giving and sex differences." Environment & Behavior 18: 192-213.