TRANSIT MAP COLOR CODING AND STREET DETAIL
Effects on Trip Planning Performance

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The majority of mass transportation research studies have been concerned with the operational and financial aspects of particular transit systems. In contrast, little concern has been shown for determining the information requirements of the transit system user. These requirements have either been ignored or assumed to be adequate by most mass transportation researchers.

One of the most common methods used by cities for conveying information about public transit to potential travelers is the transit system map. Despite the fact that such maps are in nearly universal use, there is little consistency in the basic properties of these maps from city to city. Furthermore, two separate research studies (HUD, 1969; Liff, 1971) have clearly indicated that transit system maps are consistently less preferred to other potential sources

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of transit system information (e.g., telephone, bus driver, or asking someone). In commenting on this problem, Liff (1971) indicates a need for developing the map-reading skills of the public transit user. Alternatively, it can be suggested that there is an equally important need to design transit system maps which are better suited to the needs and/or abilities of those people they are meant to serve. In this regard, Robinson (1952) noted that one of the major problems for the map-making industry is that those who specify, order, and buy maps are not cartographers but educators, government officials, or, in the case of transit maps, transit system officials.

The economic needs of public transportation systems are similar to other enterprises, to maximize profits or minimize losses. They are, however, subject to other pressures to maintain a public service, which in some cases result in low fares and accepted losses. Even within these constraints, the pressure is on the managements of transit companies to maximize ridership.

The primary user of most public transit systems is the worker who rides the same bus, at the same time of day, over the same route five days a week. The recurrent transit information requirements of these riders are very low. They need only information concerning changes in their particular work-based travel patterns. The potential rider who is not a regular user of the system has, on the other hand, a very high information requirement. The trip being contemplated may be the first of what is intended to be regular trips to work, or it may be a non-work based trip involving a variety of purposes. The trip might involve the use of a large part of the transit system, including transfers from one part of the system to another. For any number of reasons this kind of trip may appear quite formidable to the person who is planning it.

Transit systems rely heavily on maps to provide necessary information to potential passengers. It is, therefore, reasonable to assume that the effectiveness of these maps will

have a bearing on the ridership of the system. If they are easily understood and accurate, the potential passenger has confidence that the trip will be easy to complete and will be disposed to ride the system. If they are difficult to read and the trip is difficult to plan, the passenger is less confident in his or her ability to complete the trip successfully via public transit. In such cases, the potential system user may seek other sources of transportation or simply cancel the trip being planned.

Two potential sources of difficulty in transit map comprehension are the individual attempting to use the map and the map itself. Variables related to the first source of difficulty might include such things as general intelligence, spacial abilities, visual acuity, age, education, and experience. Those related to the second source of difficulty might include map size, complexity, quality of print, and color use. Knowledge regarding the relationship between any of the above variables and transit map comprehension would be of great use to those concerned with the transfer of transit system information.

The present research was designed in order to investigate the effects of two map-related variables on the objective performance and subjective experiences of individuals attempting to utilize a transit map to plan a trip within a city. The first map characteristic chosen for study was the presence or absence of color-coded transit routes. The question raised in regard to color coding was quite straightforward: does the use of color-coded transit routes improve the ease and accuracy with which trips can be planned? The importance of this question should not be underestimated. Given the added costs of color reproduction, should it be found that color coding does not significantly improve trip planning, the extra money might be better spent on other map-related or non-map-related information transfer devices. Based upon a simple principle of perceptual contrast, it was hypothesized that color coding would improve trip planning accuracy.

The second map characteristic investigated was considerably more complex in its implications for trip planning. Specifically, it concerned the amount of street detail depicted on the transit map. Conceptually, one can imagine a dimension of detail running from extreme detail, in which transit routes are displayed together with all city streets and their names to extreme lack of detail, in which only transit routes appear. On the one hand, a transit map depicting all city streets and their names provides the potential traveler with useful information concerning just which bus route is closest to his points of departure and destination. It also provides the trip planner with information about exact locations for catching and departing from buses. On the other hand, a highly detailed map would also contain much information that was superfluous for the trip planner (e.g., streets and street names that are unrelated to the trip being planned). This extra information might actually confuse the individual in his search for relevant information. Another consideration is that, holding map size constant, a map with a great degree of street detail would have to utilize much smaller print in displaying street names than a map with considerably less detail. In other words, variation in street detail would normally result in some variation of print size and legibility. Maps utilizing less than complete street detail would probably be easier to read but might lack information required by the trip planner to locate starting and destination points as well as points of entry and departure from buses. In order to develop a deeper understanding of how color coding and street detail might affect a potential traveler's ability to utilize a transit map in trip planning, a controlled experiment was designed and carried out.

EXPERIMENTAL OVERVIEW

The purpose of this experiment was to determine the effects (if any) of color coding and street detail on trip planning. Subjects in the experiment were asked to plan a

relatively complex, triangular bus trip in the city of Fort Worth, Texas. While to some extent the choice of Fort Worth was arbitrary, it does represent a medium-size city, with a population of approximately 400,000 and a fairly extensive public bus system. Furthermore, the city is in close proximity to the university at which this research was conducted, and it was desired to assess the potential relationship between familiarity with a city and trip planning performance. Subjects were given one of four different types of transit maps to use in planning their trip. These maps varied with respect to color coding and street detail. The principal dependent measures of interest in this experiment were planning time, accuracy, perceived difficulty, frustration, and confidence.

METHOD

SUBJECTS

A total of 86 students (62 males and 24 females) from four different classes at a large state university participated in this experiment. Students participated voluntarily during regularly scheduled class meetings. Nine subjects (6 males and 3 females) had to be dropped from the data analyses because of incomplete data. This left a total of 77 students (56 males and 21 females) in the final subject sample.

TRANSIT MAPS

Base Map (OTC). The base map chosen for this study was the official transit system map published by the city of Fort Worth. Hereafter, this map will be called the "OTC," these letters standing for "official transit, color." This map is similar to many other system maps used by cities of moderate size. The overal map measures approximately 43 cm. by 56 cm. The map ratio was approximately 1:43,000. The background for the transit routes is a city street map printed

in gray. The width of streets is varied corresponding to their size, or importance. All street names appear in three point (approximately 0.08 cm) print. The combination of small letters and low contrast makes street names difficult to read. Transit routes overlay the background street grid. Twenty-six separately labeled routes are shown utilizing eleven different colors. Each route is labeled with a black rectangular "flag" bearing a white letter or letter-number designation. In addition, the name of the route (area served) is written on the map alongside the route in easily distinguishable black letters. The names of streets along which the routes run are sometimes obscured by the colored route markings making them difficult to read.

All transit routes were terminated at the boundary of the central business district, an area circumscribed by a heavy black line and labeled "Downtown Free Zone." In this area, all bus routes merge and travel down the same street. Any bus in the area may be boarded without paying any fare. Fares are only collected from passengers who board or depart buses outside of this downtown area.

Conceptually, this map is color coded and represents a condition of considerable street detail.

Map 2 (OTB). The first modification of the OTC was a simple photographic reproduction without the use of color coding. This map is shown in Figure 1. Size, detail, symbology, and legends remained, of course, the same. Distinction between the transit routes and background streets remained because the routes were printed in heavy black while the background remained gray. Hereafter, this map will be designated "OTB," the letters standing for "official transit, black."

The purpose of the OTB was to maintain a high level of detail while eliminating color coding. Comparison of performance using this map with performance using the OTC would indicate the degree to which color coding aids the trip planner, with level of detail held high and constant.

Map 3 (SMR). The second variation of the transit system map involved constructing a new map by combining information presented in each of the seperate stick route maps, for all the separate routes in the city, published by the city of Fort Worth. This map is shown in Figure 2 and will, hereafter, be called the "SMR," the letters for standing for "stick map routes." This map was the same size and scale as the OTC. It depicted the entire transit route system and, just as in the single route maps, the names of all streets along which buses run. All cross streets and their names, which appear on the separate stick maps, were also depicted on this composite map. The entire map was printed in black on a white background. No route information other than letter or letter-number labels were given. Street names were printed in much larger (11 point) print than on the OTC and OTB.

Conceptually, the SMR map provided much less street detail than either of the other two previously described maps. That detail which was present, however, was clear and easy to read.

Map 4 (MJR). The third and final map variation was similar in overall amount of detail to the SMR; however, the form in which this detail appeared was shifted. This map is shown in Figure 3. Like the SMR, all transit routes and labels were present. Unlike the SMR, however, the names of all nonmajor streets were eliminated, including the names of some streets along which buses run. Detail not found in the SMR was provided by adding to this map a grid of the major streets in the city. This map, will, hereafter, be called the "MJR," these letters having been extracted from "major streets and routes." The MJR was expected to aid trip planners with their orientation in the city. This was done, of course, with a loss of much small street detail, even along the bus routes.

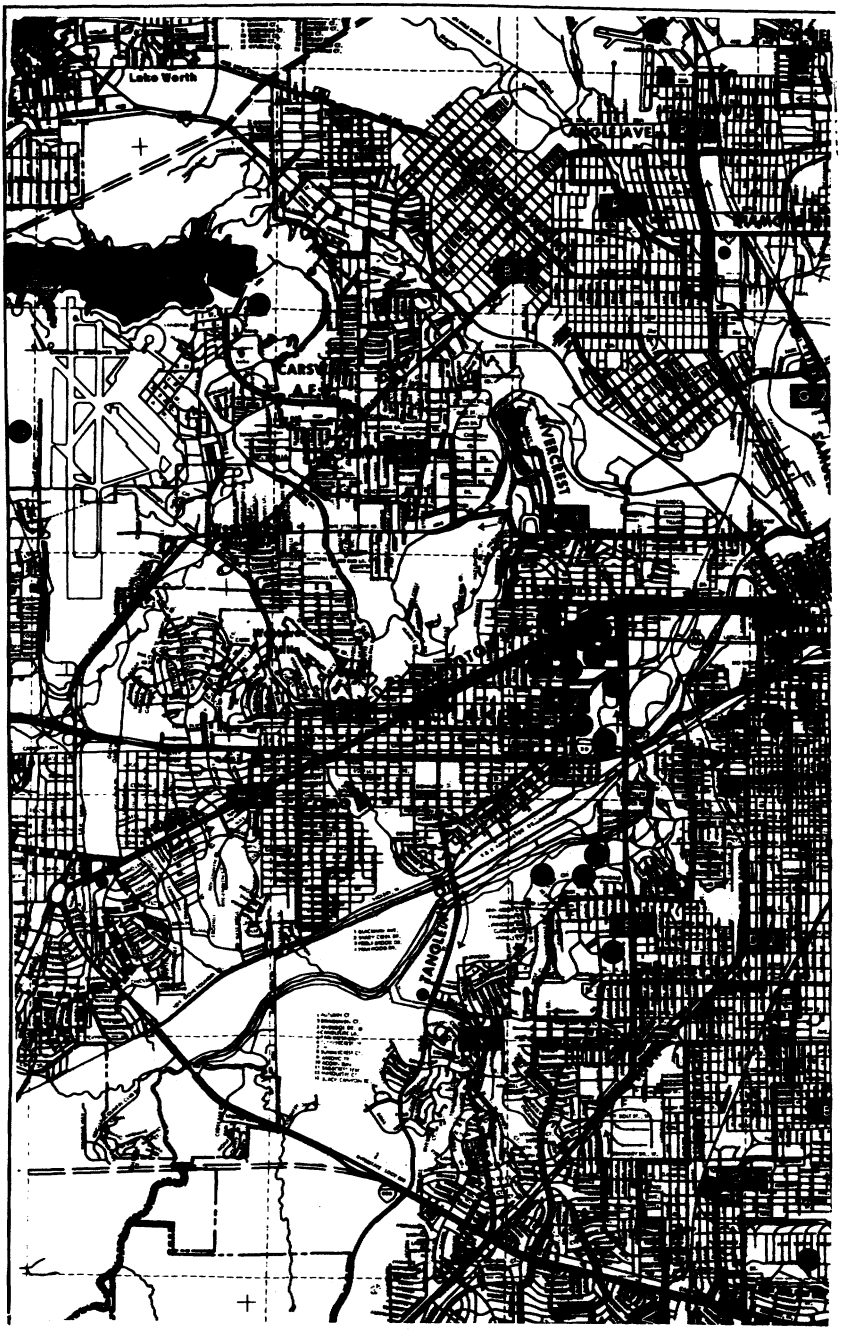

Figure 1: OTB—Official Transit Map (Black and White)

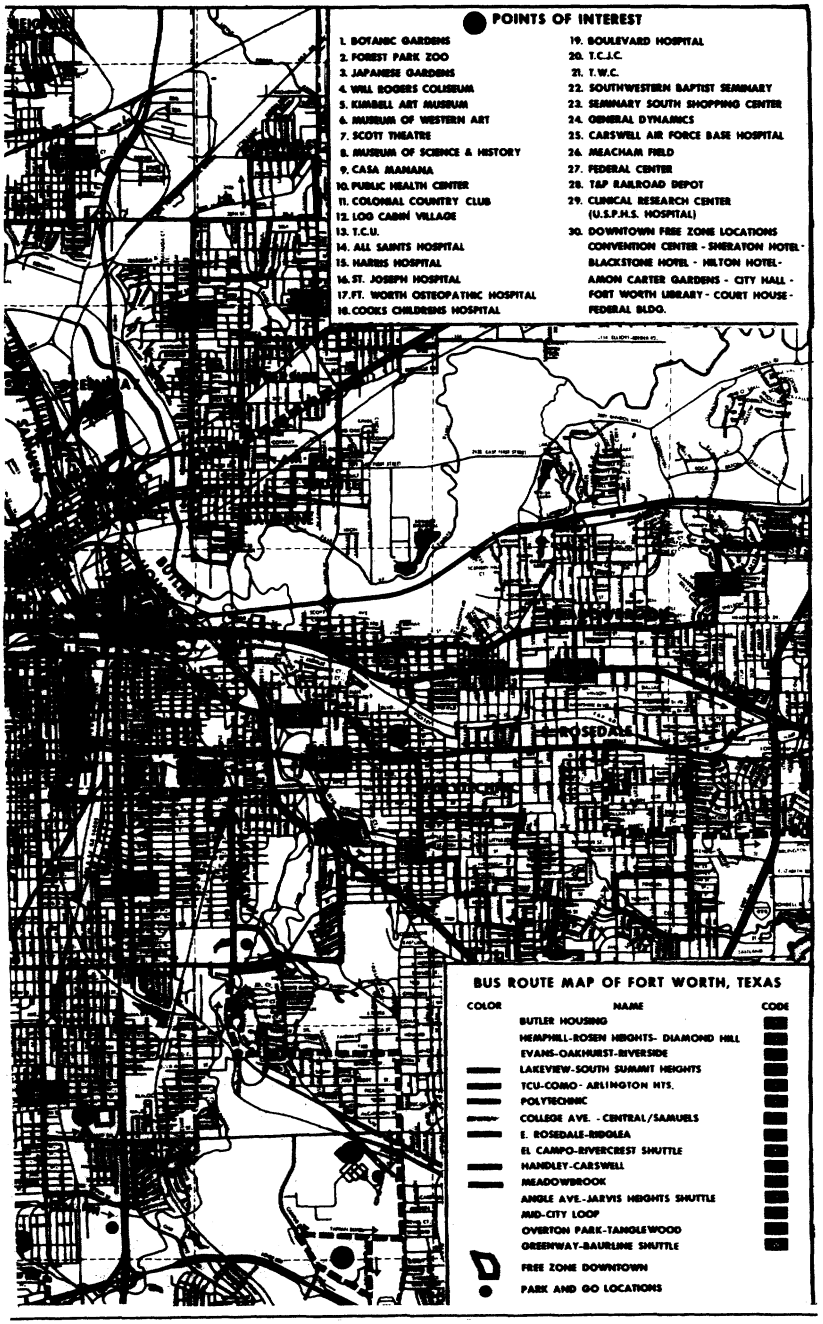
POINTS OF INTEREST
1. BOTANIC GARDENS
2. FOREST PARK ZOO
3. JAPANESE GARDENS
4. WILL ROGERS COLISEUM
5. KIMBELL ART MUSEUM
6. MUSEUM OF WESTERN ART
7. SCOTT THEATRE
8. MUSEUM OF SCIENCE & HISTORY
9. CASA MANANA
10. PUBLIC HEALTH CENTER
11. COLONIAL COUNTRY CLUB
12. LOG CABIN VILLAGE
13. T.C.U.
14. ALL SAINTS HOSPITAL
15. HARRIS HOSPITAL
16. ST. JOSEPH HOSPITAL
17. FT. WORTH OSTEOPATHIC HOSPITAL
18. COOKS CHILDRENS HOSPITAL
19. BOULEVARD HOSPITAL
20. T.C.J.C.
21. Y.W.C.
22. SOUTHWESTERN BAPTIST SEMINARY
23. SEMINARY SOUTH SHOPPING CENTER
24. GENERAL DYNAMICS
25. CARSWELL AIR FORCE BASE HOSPITAL
26. MEACHAM FIELD
27. FEDERAL CENTER
28. T&P RAILROAD DEPOT
29. CLINICAL RESEARCH CENTER (U.S.P.H.S. HOSPITAL)
30. DOWNTOWN FREE ZONE LOCATIONS CONVENTION CENTER - SHERATON HOTEL - BLACKSTONE HOTEL - HILTON HOTEL - AMON CARTER GARDENS - CITY HALL - FORT WORTH LIBRARY - COURT HOUSE - FEDERAL BLDG.
BUTLER
ROSEDALE
BUS ROUTE MAP OF FORT WORTH, TEXAS
COLOR
NAME
CODE
BUTLER HOUSING
HEMPHILL-ROSEN HEIGHTS- DIAMOND HILL
EVANS-OAKHURST-RIVERSIDE
LAKEVIEW-SOUTH SUMMIT HEIGHTS
TCU-COMO- ARLINGTON HTS.
POLYTECHNIC
COLLEGE AVE. - CENTRAL/SAMUELS
E. ROSEDALE-RIDGLEA
EL CAMPO-RIVERCREST SHUTTLE
HANDLEY-CARSWELL
MEADOWBROOK
ANGLE AVE.-JARVIS HEIGHTS SHUTTLE
MID-CITY LOOP
OVERTON PARK-TANGLEWOOD
GREENWAY-BAURLINE SHUTTLE
FREE ZONE DOWNTOWN
PARK AND GO LOCATIONS

Figure 1:

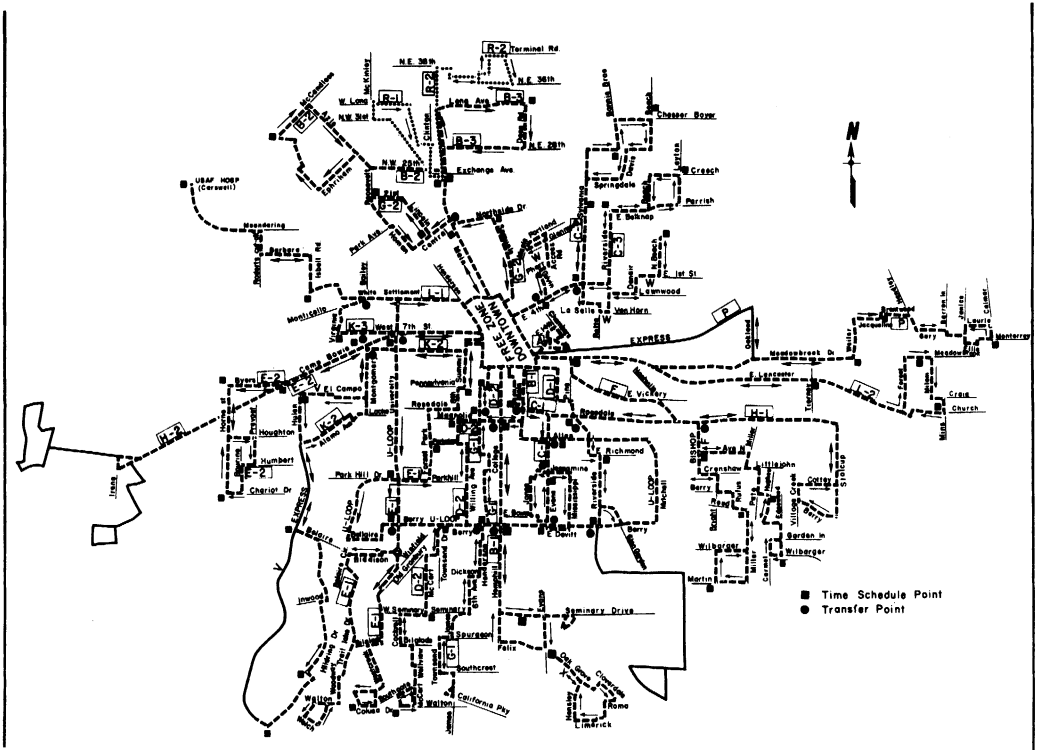

Figure 2: SMR–Stick Map Routes

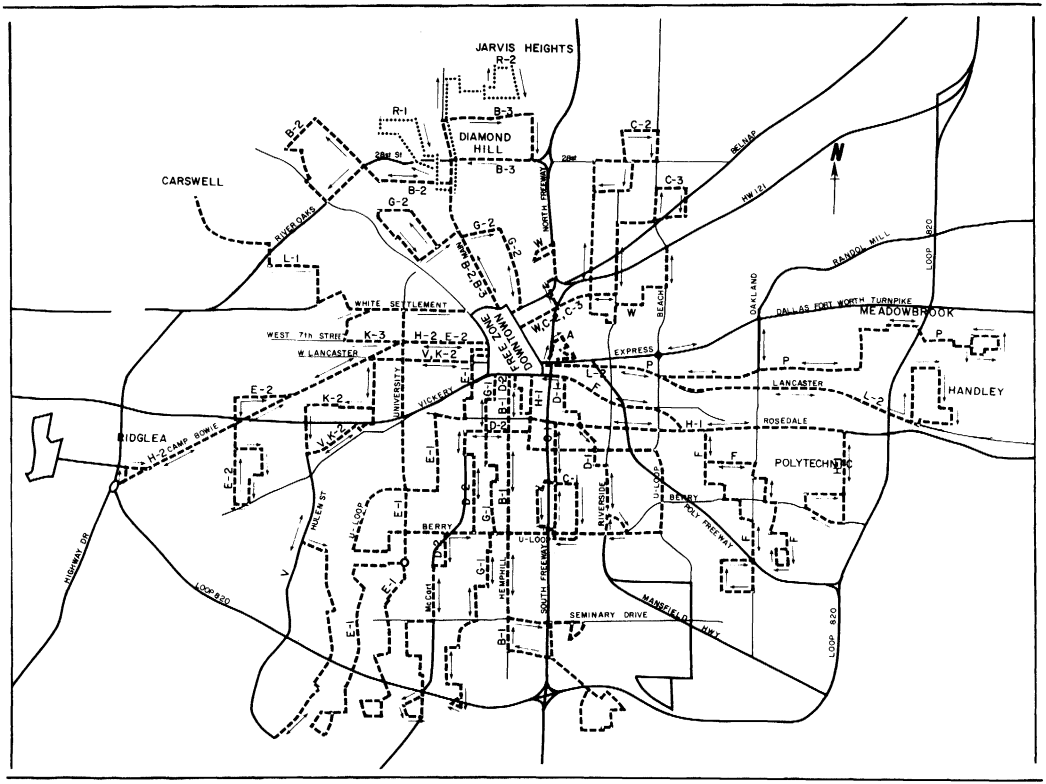

Figure 3: MJR—Major Streets and Routes

PROCEDURE

All subjects were tested during a regularly scheduled class period. After a general description of this study and its relationship to trip planning and an appeal for cooperation regarding the research, each subject was given a six-page questionnaire and two folder maps. One of the maps was a city street map of Fort Worth. It was approximately 53 cm by 71 cm in size and about the same map ratio as the transit maps. This street map included the names of every street in the city as well as landmarks such as parks and museums. Added to the city street map were three clearly distinguishable points labeled "H," "D," and "R." They were printed and circled in black ink and represented the starting and destination points for three test trips to be planned. The other map given to subjects was one of the four transit maps (i.e., OTC, OTB, SMR, MJR) described previously. These transit maps were distributed randomly to subjects in each class. All subjects were told not to look at their maps until they were instructed to do so.

Subjects were asked to fill out the first page of the questionnaire and stop. Questions on this page pertained to age, sex, color blindness, education, and city of residence. There were also several questions designed to assess the subjects' familiarity with the city of Fort Worth and its transit system.

When all subjects had compled page one, they were told to turn to the next page and read the instructions along with the test administrator. The instructions briefly stated the purpose of testing how well they could plan a sample travel activity by bus trips in Fort Worth. The following trips were then described in the questionnaire:

> You are now at home, which is located on Ellis Avenue between N. W. 22 and 23 Streets. You have an appointment with your doctor later this morning. The doctor's office is located on the corner of Kilpatrick and Faron Streets. After your visit with the doctor, you have a lunch date at a restaurant located on Tucker Street right off Illinois Avenue. After lunch, you will be returning home.

Subjects were told to open only their city map and note the locations of their home, the doctor's office, and the restaurant, denoted by the circled letters "H," "D," and "R," respectively. They were then told to use the other map (transit map) which they had been given in order to plan the trip which they believed would result in a minimum of walking and riding time. Instructions also indicated that all buses run to the area marked "Downtown Free Zone" on the transit map. They were told that "all buses run along Throckmorton Street in the downtown area and that transfers were simple to accomplish along that street in the CBD."

After these instructions, subjects were all asked to indicate the starting time on their questionnaire by referring to a digital clock which had been placed in the front of the classroom. They were then told to turn to the next page and begin planning their trip.

The trip planning phase of this reserach was done in three parts. Subjects were asked to plan the first leg of their trip. This involved recording on the questionnaire which buses would be taken and from which streets the buses would be boarded and departed. Two buses were required for each leg of the trip with a transfer in the Downtown Free Zone. After planning the first leg of the trip, subjects were asked to estimate the time, including walking, waiting, and riding that this trip would take by bus. They were then asked to estimate the time this same trip would take by automobile, including parking.

The second and third legs of this trip were planned in exactly the same manner. After completing the last leg of the trip, subjects were asked to indicate the time by referring to the digital clock. They were then instructed to turn the page and answer a series of additional questions. The final two pages of the questionnaire contained a series of questions designed to measure the subject's perceptions of the trip planning procedure. Subjects were asked to indicate the degree of difficulty they experienced in locating their origin and destination points on the transit map, finding the

proper buses to take, and the streets on which to board and exit the buses. They responded by simply checking along 20-point bipolar scales which ranged from "extremely easy" to "extremely difficult." They were also asked to indicate how frustrated they felt while planning their trip and how much confidence they had in the trip they had planned. Again subjects responded along 20-point bipolar scales.

Subjects were then asked to answer two open-ended questions concerning the major difficulties they experienced while planning their trip and any suggestions they might have for improving trip planning.

RESULTS

Table 1 displays the means and standard deviations for each of the primary dependent variables in this experiment in each of the four experimental conditions as well as the combined means and standard deviations across all conditions.

ACCURACY OF TRIP PLANNING

Each subject in the experiment was assigned a total accuracy score by summing the number of errors made in planning each of the three legs of the experimental trip. Each leg of the trip called for six pieces of information. Thus, a subject's total accuracy score had a hypothetical range from 0 (no errors made) to 18 (maximum number of posible errors). Examination of Table 1, top row, reveals that the average number of errors made by subjects in all of the experimental conditions was 6.18. This average degree of error suggests that most subjects in this experiment would have considerable difficulty in planning, without assistance, a successful bus trip given the information they had been provided. Considering that all of the subjects were college students, this result is surprising. Further-

TABLE 1
Summary of Experimental Data*

Variable	Map Type								Combined	
	OTC		OTB		SMR		MJR			
	Mean	St.D.	Mean	St.D.	Mean	St.D.	Mean	St.D.	Mean	St.D.
Number of Errors	4.63_a	3.76	8.46_b	4.62	6.39_a	4.47	4.83_a	3.78	6.18	4.41
Planning Time	19.58_a	8.16	19.64_a	4.93	20.94_a	4.80	17.17_a	5.69	19.35	6.05
Est. Time of Bus Trip	160.11_a	78.47	158.50_a	73.01	129.33_a	46.90	138.11_a	98.27	147.31	75.87
Est. Time of Auto Trip	87.37_a	37.51	76.96_a	31.03	75.72_a	19.83	70.67_a	23.74	77.67	30.15
Difficulty of Finding:										
Start & End	11.73_a	5.36	13.59_a	4.81	14.67_a	5.13	10.28_a	5.33	12.71	5.31
Correct Bus	6.71_a	5.19	11.68_b	5.74	$9.09_{a,b}$	5.31	7.29_a	5.60	8.82	4.69
Street Name	10.60_a	6.51	14.32_a	5.53	11.12_a	5.68	11.13_a	5.99	11.91	6.03
Frustration in Planning	7.09_a	5.20	13.82_b	6.30	13.39_b	6.15	11.49_b	5.92	11.51	6.40
Confidence in Trip Plan	13.18_a	6.43	5.73_b	4.71	$7.91_{b,c}$	6.56	$10.00_{a,c}$	6.73	9.08	6.61

*NOTE: For each variable (row), means which contain the same subscripts are not significantly different from each other by means of Duncan's multiple range test ($p < .05$).

more, it should be assumed that had the sample in this experiment been more representative of the average potential bus rider, an even greater number of average errors would have been made.

In order to assess the general effect of map type on trip planning accuracy, an analysis of variance was performed on accuracy scores with map type as the independent variable. The results of this analysis revealed a significant effect of map type on trip planning accurcy ($F = 3.65$, $df = 3/73$, $p < 0.05$). In order to determine which of the map types differed significantly from the others, Duncan's multiple range was performed. The results of this analysis revealed that a significantly greater number of errors were made with the OTB map than with either the OTC or MJR maps ($p < .05$). The number of errors made in the OTC, SMR, and MJR conditions were not significantly different from one another. What these results suggest is that color coding can significantly improve trip planning accuracy when a map includes a high degree of street detail. Furthermore, these results suggest that in the absence of color coding, a reduction in small street detail can significantly improve trip planning accuracy, if the user is given a grid of major streets for orientation.

PLANNING TIME

Total time taken by each subject to plan the experimental trip was calculated by subtracting the time at which they began to plan their trip from the time the trip planning was completed. As revealed in Table 1, the average time taken in planning the three trips across all four experimental conditions was 19.35 minutes.

An analysis of variance on planning times revealed no significant effect of map type. That is, average planning times in the different map conditions were not significantly different from one another.

ESTIMATED TIMES FOR BUS AND AUTO TRIPS

As indicated in the methods section, subjects were asked to make estimates of the amount of time it would take to make each of their trips by bus (including riding and waiting time) as well as estimates of how much time the same trip would take by automobile (including parking time). Estimates for the time required for the entire itinerary by bus and by auto were obtained for each subject by summing the three separate trip-time estimates that they made for each mode. Table 1 reveals that on the average, estimates of bus time and automobile time across all map conditions were 147.31 and 77.77 minutes respectively. In other words, subjects estimated that the entire trip by bus would take roughly twice the time required by automobile.

Analyses of variance performed on both estimated bus times and automobile times revealed no significant effect of map type on either of these time estimates.

For additional information, researchers actually made the experimental trips by bus and by automobile. Waiting time and riding time were carefully measured for the bus trip, as were parking time and riding time for the automobile trip. Subjects' average time estimates were compared with the actual times required. Two interesting points might be noted. First, subjects' time estimates were not as divergent from the actual times measured by the researchers as one might have expected, given the subjects' lack of familiarity with the planned trip and their general difficulty experienced in reading maps. Second, subjects slightly underestimated the amount of time necessary for the bus trip and slightly overestimated the amount of time necessary for the automobile trip.

DIFFICULTY EXPERIENCED IN TRIP PLANNING

Subjects responded to three questions concerning the degree of difficulty they experienced in planning their trip. All responses were made along 20-point bipolar scales ranging from "extremely easy" to "extremely difficult."

The first question asked the subjects how much difficulty they experienced locating their origin and destination points on the transit map they had been given. Mean responses to this question in each of the experimental conditions and across all conditions are presented in Table 1. Analysis of variance on these responses revealed no significant effect of map type.

The second question regarding difficulty asked the subjects about the difficulty they experienced in trying to locate the correct buses to take from point to point in their trips. Mean responses to this question are presented in Table 1. Analysis of variance on these ratings did reveal a significant effect of map type ($F = 3.43$, $df = 3/73$, $p < .025$). A multiple range test performed between the four experimental conditions revealed significantly more difficulty in identifying the current buses with the OTB than with either the OTC or MJR maps ($p < .05$). No significant differences emerged between the OTC, SMR, and MJR conditions. It is interesting to note that these results exactly parallel the results on trip planning accuracy.

The third difficulty question asked subjects to indicate the degree of difficulty they experienced in trying to determine the street locations at which they would catch and depart from buses. Table 1 displays mean responses to this question. Analysis of variance on these responses revealed no significant effect of map type.

FRUSTRATION

Subjects were asked to indicate how frustrated they felt while trying to plan the experimental trip. They responded on a 20-point bipolar scale from "not at all frustrated" to "extremely frustrated." Average ratings regarding frustration on this scale are presented in Table 1.

Analysis of variance on these ratings revealed a highly significant effect of map type ($F = 5.24$, $df = 3/73$, $p < .01$). Again, a multiple range test was performed to determine which conditions were significantly different from others. These tests revealed that the OTC map resulted in signifi-

cantly less reported frustration than any of the other three experimental maps ($p < .05$). The OTB, SMR, and MJR did not differ significantly from one another on reported frustration. Apparently, a map which was highly detailed and color coded with respect to transit routes produced less frustration than any of the maps in which color coding was absent, regardless of level of detail.

CONFIDENCE

Subjects were asked to indicate how confident they were that they had chosen the best bus routes for their trip on a 20-point bipolar scale from extremely unsure to extremely confident. Average confidence scores are reported in Table 1.

Analysis of variance on these ratings revealed a highly significant effect of map type ($F = 5.44$, $df = 3/73$, $p < .01$). A multiple range test on these data revealed significantly more confidence in the OTC condition than in either the OTB or SMR conditions ($p < .05$). In addition, the MJR condition produced significantly more confidence than the OTB ($p < .05$). Neither the OTB nor the MJR produced a significantly different level of confidence when compared with the SMR.

PROBLEMS ENCOUNTERED

The subjects were asked to list the major problems encountered while planning the trip. The largest number of responses concerned the poor printing and small letters of the OTC and OTB maps. Street names on these maps were extremely difficult to read because of small print size and the low contrast of gray on white. Street names, the complaints stated, could not be located on the transit maps (with about equal frequency in each map type). None of the transit maps had a street index, but each subject had a separate city street map with such an index included.

Approximately one-third of the subjects indicated that they were not familiar with the city map. Another third

indicated they did not understand the transit map. Half of those who indicated they did not understand the transit map were using the OTB map. Several people using either the MJR or SMR maps stated that their major problem was one of correlating the transit map with the city street map in order to locate origin and destination points.

Even though instructions were given in an attempt to alleviate the problem with the downtown area transfer, several subjects using each type of map found this confusing.

SUGGESTIONS

The subjects were asked for their suggestions regarding how to improve the transit maps which they had just used. By far the most consistent suggestion was to print a larger map to allow larger print and more room between adjacent routes. Approximately half of the people using the OTC and OTB maps made this comment. Such larger maps would improve the readability of street names.

The only group to state a desire for color coding were those who used the OTB map. Those with the OTC had color coding, and those with the MJR and SMR apparently had such sufficiently uncluttered maps that they apparently did not feel color coding would be a significant improvement.

The groups with the MJR and SMR maps did express a desire for more street names. Some additional street names could be provided on such maps without reaching the cluttered state of the OTC and OTB maps and without reducing the print size to the point that it is difficult to read.

A small number of the users of all of the transit maps suggested that a better legend or more text would be desirable. The text could perhaps explain the use of the map, what is shown, why some smaller streets are not shown, and the general service areas of each bus.

DEMOGRAPHIC VARIABLES

In addition to the primary data comparisons, the data were collapsed across experimental conditions and grouped

according to sex, familiarity with the city and with the particular bus system, and size of hometown of the subjects.

The subject group included 56 males and 21 females. Comparisons of planning scores based on sex revealed only two significant differences. Females' estimates of bus trip time were less than those of the males ($p < .05$). Both underestimated the time required for the trip by bus, but females estimated 120 minutes on the average while males estimated 150 minutes. Actual trip time was approximately 174 minutes. Female subjects also indicated they were less confident in having chosen the best bus routes than the male subjects ($p < .05$).

No other significant differences were found between male and female subjects.

Those subjects who indicated that they were somewhat (or very) familiar with the city for which the trip was planned did little better than the remainder of the group in any category. It appears that for this particular problem the stated familiarity was not a factor. It can be anticipated that this might be a more important consideration during the actual trip where landmarks could be used for navigation.

Only six of the subjects reported that they actually traveled on this particular bus system more often than once a month. Their responses did not vary significantly from the responses of the remaining subjects.

Subjects who reported their hometown size to be greater than 500,000 were considered to possibly have a greater familiarity with city transit systems. They should have been exposed to transit system advertising, and they certainly had had opportunities to have been city bus passengers. Seventeen subjects were in this category. Their trip planning data, however, was not significantly different from the data of the remaining subjects.

DISCUSSION

The results of this experiment indicate clearly that transit map characteristics can have a significant effect on a

number of different variables related to trip planning. Specifically, it was found that the map variations used in this experiment significantly affected trip planning accuracy, reported difficulty in selecting the proper buses, amount of frustration experienced, and level of confidence in planned trips. Any of these variables might have an impact on attitudes toward public transportation as well as on decisions to use or not use public transit in making some trips within a city.

Excluding bus and automobile time estimates, a comparison without regard to statistical significance can be made between the relative merits of the four experimental maps across the seven remaining dependent variables in Table 1. This comparison reveals that the OTC map was superior to all of the other maps for six of the seven variables, and that the OTB map was inferior to all of the others on six of the seven variables. Furthermore, a comparison of the two less detailed maps places the MJR ahead of the SMR on six of the seven variables. Without further testing, it would seem that the official color coded transit map (OTC) used in the experiment was superior for purposes of trip planning to any of the experimental variations of this map. On the other hand, the MJR map which cut down considerably on street detail and eliminated color coding ran a close second to the OTC. Given the cost considerations of reproducing a color coded map, the MJR or something like the MJR might be a viable alternative for transit systems which must operate on a limited budget.

This experiment had a number of limitations which might be more carefully considered in future research. First, the subject sample was not representative of a typical population of public transit users. It might be expected that a representative sample would be made up primarily of less educated individuals. With this in mind, it is possible that the overall degree of difficulty experienced among the subjects in planning trips, which was considerable, would be still greater in a less educated sample group. It is also possible that the effects of transit map variations observed

in the experiment might be different with a different population of subjects.

A second limitation of this experiment had to do with the manipulations of map characteristics. One does not know, for instance, from this experiment whether a map like the MJR would be significantly better than the OTC if color coding of transit routes were included. In subsequent research, it would be useful to investigate trip planning using four maps, two colored and two black and white with one of each pair having a high degree of street detail and another having a low order of street detail. With this kind of design one could see whether color coding and street detail combine in an additive or multiplicative fashion.

Finally, the results of this experiment suggest that there are probably a great number of individuals in this society who cannot effectively comprehend or utilize transit system maps in trip planning. It is significant that in our college student sample slightly more than six errors on the average were made during trip planning. Had a less selected sample been studied in this experiment, one might anticipate an even greater number of average errors. One potential remedy for this problem might involve the introduction of map reading into our public education curriculum, especially in our urban centers.

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