Behavior mapping and urban design: graphic versus non-graphic information about environment-behavior relations.

Cartes de comportement et conception urbaine: information graphique et non-graphique sur les relations environnement-comportement

Joost van Andel

La visualisation et l'information graphique jouent un rôle important dans le processus de conception. Cela pourrait aussi être le cas dans le transfert de connaissances entre concepteurs et chercheurs. Les "cartes de comportement" relient le comportement (observé) des utilisateurs à une carte de l'environnement. Ceci peut être une technique de valeur pour rendre les résultats de recherches en environnement-comportement accessibles et utiles aux concepteurs.

Cette étude exploratoire porte sur les effets de différentes formes de présentation de données relatives aux cartes de comportement. Plus spécifiquement nous avons comparé trois groupes d'étudiants en architecture travaillant sur un problème de conception et utilisant des cartes, des tableaux ou une combinaison de ces deux formes. Pendant la période de recherche d'informations les données étaient présentées sur un logiciel qui permettait aux étudiants de parcourir les différentes parties de l'information. Les variables dépendantes étaient le temps passé dans les différentes parties du système d'information et la qualité de l'information extraite.

Dans la condition tableaux-seuls, les étudiants utilisaient moins d'écrans et passaient moins de temps à la consultation de l'information. Le fait que les étudiants étaient les cartes individuelles plus souvent mais pour une durée plus courte que les tableaux, suggère une façon plus globale de traiter l'information. Dans la combinaison tableaux-cartes, les étudiants utilisaient plus d'écrans et passaient plus de temps que dans les conditions tableaux-seuls et cartes-seules. Ils semblaient aussi obtenir plus d'informations et des données plus détaillées, suite à leur consultation du système.

Notre communication finit par une discussion des résultats et présente des suggestions pour des recherches futures.

Mots clés: transfert de connaissances, conception urbaine, cartes de comportement, présentation d'information graphique, formation à la conception urbaine.
Keywords: knowledge transfer; urban design; behavior mapping; graphic information display; urban design education

Communication is a key issue in the collaboration of designers and social science researchers. Several differences between designers and researchers in method and approach of problems seem to account for communication problems between the two groups. Researchers and designers seem to differ on point of view (behavior vs. environments); method (analytical vs. synthetic); presentation (words vs. images); pattern of values (theoretical vs. ideological) and role conception (advisor vs. integrator) (van Andel, 1988). In their review of the transfer of (technical) information to designers and architects, Lera, Cooper, and Powell (1984) mention the need for well-structured, relevant, and well-presented information. But they doubt if the presentation and organization of the information are the essential elements of successful information transfer. "They may be essential but they are not sufficient. It is necessary to stress that decisions are rather complex, emotionally demanding human processes, not just individualized intellectual analyses" (op. cit., p. 119). Newland, Powell, and Creed (1987) focus on the effect of learning styles, perception, and cultural biases on information transfer. These factors cause individual differences in the communication with architectural designers.

Given this more general framework, the form and structure of information are important elements in many studies of architectural design processes. Oxman (1990), for instance, explores the role of prior knowledge in design, which might be organized as integrated prototypes. These prototypes could organize design knowledge at a high abstraction level. It is not yet clear whether semantic or graphic modes play a role in this representation. Christiaans and van Andel (1993) found indications of a fixation effect using visual examples of design principles with industrial design students working in the information gathering phase.

Based on the assumption that visual information is an important aspect in the design process, several computer tools have been developed such as the visual problem-solving environment GISMO by Pracht (1986). Although Gross, Ervin, Anderson, and Fleisher (1988) focus on "constraint programming" as a way to computerize design processes, they also mention diagrams as powerful tools in conceptual design. Diagrams combine advantages such as the expression of important spatial relationships and retaining useful uncertainty and ambiguity.

So in the transfer of knowledge from social science research to architectural designers, visualization of research data appears a promising way to overcome at least part of the communication problems between social scientists and designers. General guidelines on the visualization of research data are available, such as Tuve (1990). But systematic information about the effects of this type of information in the design process is scarce.

Behavior mapping is a specific technique, developed within environment-behavior studies to register, analyze and present data about the behavior of people in
direct relation with their physical environment. Usually some kind of map of the environment represents the observed behavior of people (see for instance Ineke & Zeisel, 1987). Behavior mapping seems to be a useful technique in communicating the results of environment-behavior studies to environmental designers. But it is not clear in what exact form this information should be presented. An important dimension in this respect is: graphic versus numeric/tabular representation. Is it preferable to present only graphic maps of the data, losing exact, numeric information? Or should the "traditional" way of tables be used as a condensed but not always easy to read mode of presentation? Or is it more helpful to present the same data both in graphic and in tabular form, to give both a maximum of information and more freedom to use both forms of data presentation?

Therefore, the main research question of this study was:

"What are the effects of type of presentation on the transfer of information about environment-behavior relations to designers?"

These presentation effects are studied in different fields. For instance Larkin and Simon (1987) and Koslowsky (1989) focus on the differences between diagrams and text. Koslowsky presents a detailed scheme to evaluate charts and graphs, based on both principles of human visual information processing and on the interpretation of symbols. He distinguishes three levels of analysis: syntactic (how is the chart perceived?), semantic (how are the elements understood?) and pragmatic (what information does the chart convey?). The evaluation study by Pracht (1986) shows that a graphic presentation of a complex problem makes it easier to "see" the different elements and relations of the total problem, which might help problem solving. This effect was mainly found for highly analytic problem solvers. Levine and Lentz (1982) reviewed research on the effects of text illustrations. They found that illustrations facilitate the learning of information in the written text. The positive learning effects of illustrated text over non-illustrated text were stronger if the illustrations were specific and closely related to the text.

Only a few studies focus on spatial information or on the specific differences between maps and tables. For instance Bartram (1980) compared different methods of presenting information about bus routes. Spatial information, in a schematic, color-coded map, appeared to help the task of finding a route between two places better than textual lists of bus stops. Anoskey and Catravonne (1992) compared textual, graphic, and combined instructions in a hypertext related task. They expected subjects in the graphics only condition, to perform faster than in the text only condition, but with more errors. In the combination condition the researchers expected both faster and more accurate performance. The experiment did not show significant differences between the conditions, which the authors attribute to the small number of subjects and the difficulty of the task. Hoadley (1990) studied primarily the effects of color in information presentation. She also compared tabular presentation with several types of graphs, such as pie-, bar-, and line-graphs. Subjects using graphs performed better as to the speed, and worse as to accuracy of information extraction. While the use of
colors improved performance on the graphs, it confused the situation more for tables.

These results suggest a trade-off between speed and accuracy in the use of either graphic or textual modes of presentation. The aim of the present study is to explore if these effects exist also with architectural design problems. Compared to the tasks used in most studies, design tasks are more complex, involving the analysis of many different aspects, which is typical of the early stages of design.

Based on the above-mentioned studies, the following expectations for the effects of the form of presentation of behavior mapping data were formulated:

- Maps will be viewed during a shorter time, and will generate more global and less correct answers than tables.
- An information system with a combination of maps and tables will be used longer than the maps-only or tables-only condition, but not as long as the sum of their individual usage times. The combination version will generate more correct answers. And the combination version will lead to both global and detailed answers.

**METHOD**

**Subjects**

Three groups of 15 architecture students participated in this experiment. Most of them were graduate students of the College of Environmental Design, UC Berkeley.

**Procedure**

Each student worked individually on the following assignment: “Suppose you have to redesign this playground for a school for physically disabled children. [The students received some introductory information such as a map with legend, photos, information about size, number of pupils etc. to clarify the problem and to make the situation as realistic as possible]. In the initial phase of the design analysis you can consult information from a study on the use of the present playground by the children. This information is presented through a computer system. Try to find out as much as possible about these users. Make a summary or annotations for future use, as if you were going to use this in a realistic design].

All groups received behavior mapping information about the (play) behavior of children using the school playground that had to be redesigned. Information was available about four aspects of the children’s behavior: sex-, age-, mobility- and activity-related differences. These differences were focused on the use of different places, either in a table or on a map.

The students were free to take as much time for the task as they thought was necessary to get their information. They were allowed (and encouraged) to take notes during their consultation with the system. After several pilot-sessions it was decided
to give each student the following set of five questions to be answered while consulting the information system. This was done mainly to focus the search for information and to make the answers mutually comparable.

1. What is the over-all pattern of use of the playground?
2. What places are used, by whom and for what?
3. What are differences in use between boys and girls?
4. What are differences in use between younger and older children?
5. What are differences in use between mobile and disabled children?

Conditions and materials

The three conditions in the experiment were: tables-only, maps-only, and a combination of tables and maps.

In all conditions the information was available through a computer system. Using a GIS-program (MapInfo) and a hypermedia-program (Guide), three versions of an information system were built, with a simple menu-structure and icons to navigate among the four different behavior maps and tables respectively. Figure 1 and 2 show examples from the combination version of map-related information as a table and a map respectively.

The program logged the time the students spent with different screens.

The dependent variables in this study were the time in seconds spent at each screen, and an evaluation (on a 3-point scale) of the answers on each of the five questions. This evaluation concerned the following three aspects: amount, correctness, and detail of the answers.

RESULTS

Screens and viewing times

The general results for the number of screens visited, and viewing times are presented in table 40.1. The differences among the three conditions are significant on both number of screens visited ($F=23.18$, $p < .001$) and total time ($F=19.20$, $p < .001$).

In the table-condition students visited both a smaller number of screens ($t=8.14$, $p < .001$), and spent less time in total consulting the system ($t=3.06$, $p < .005$) than in the map-condition. This difference between tables and maps is not as expected. Probably the maps used in this task are rather complicated and need more time to be understood. As expected, the total task in the combination condition took a longer total time both compared to the tables-only ($t=6.88$, $p < .001$) and to the maps-only ($t=2.84$, $p < .001$), but definitely not as much time as the sum of table and map condition. The average time per screen shows a, non-significant, reversed effect.
Figure 45.1  Table of sex by place.

Figure 45.2  Map of sex by place.
In other words, the students see the different maps more often but look at them for a shorter time than the tables, which might suggest a more global way of information handling. The combination-version appears the most complicated in use, because students use both many screens and they need the longest time for the total task.

Tables 45.2 and 45.3 give more detailed information about the use of the different screens per condition. Except for activity, the general trend of tables being viewed longer than maps, can be found in the combination version as well.

Combining maps and tables appears to have complicated effects: Compared to the 'singular' versions, the number of times a particular screen is viewed, decreases; the average viewing time increases for sex and age, and decreases for mobility and activity.

Table 45.2 shows on which subjects the students spent their time as a percentage of the total session time. Table 45.5 gives more details about the average time spent on different screens, accounting for the fact that students do not return to the same screen several times during a session. Tables 45.2 and 45.3 indicate that the complexity of the table or map is a relevant factor. In the material used in this study, sex and mobility are variables with only two classes, generating relatively simple tables and maps. Age and activity have more classes (resp. 4 and 12), and consequently lead to more complicated tables and maps. Especially the average time per screen (table 45.3) is higher for more complicated subjects and lower for more simple ones. The combination version does not show these effects.

Another noteworthy result is that the average time spent in the main menu appears to increase from table, via map to combination version (F = 9.33, p < .001).

Comparison of the first, the middle, and the last period of information gathering shows that in the last period always fewer screens are viewed and consequently for a longer time. In the earlier periods of the task students seem to explore the information and come back later in a more focussed way.

Content

Table 45.4 shows the average scores of the five content-related questions. The answers to each question are judged on a 3-point scale for amount, correctness, and level of detail.

Only the differences between the three conditions for detailed answers was found to be marginally significant (F = 2.61, p < 0.10). Against the expectation, the answers in the map condition show higher scores than those in the table condition. As expected, there seems to be a trend for higher scores in the combination version.
Table 45.1  
Mean number of screens visited and viewing times

<table>
<thead>
<tr>
<th>Condition</th>
<th>Table</th>
<th>Map</th>
<th>Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Mean number of screens visited</td>
<td>17.80</td>
<td>27.93</td>
<td>24.20</td>
</tr>
<tr>
<td>Mean total time in sec.</td>
<td>1525</td>
<td>2035</td>
<td>2509</td>
</tr>
<tr>
<td>Average time per screen</td>
<td>90.14</td>
<td>79.47</td>
<td>78.39</td>
</tr>
</tbody>
</table>

Table 45.2  
Mean percentage of time spent on different screens / subjects.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Table</th>
<th>Map</th>
<th>Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of screen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Menu</td>
<td>3%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Sex</td>
<td>19%</td>
<td>19%</td>
<td>11/14%</td>
</tr>
<tr>
<td>Age</td>
<td>28%</td>
<td>20%</td>
<td>18/16%</td>
</tr>
<tr>
<td>Mobility</td>
<td>25%</td>
<td>22%</td>
<td>10/10%</td>
</tr>
<tr>
<td>Activity</td>
<td>24%</td>
<td>36%</td>
<td>12/8%</td>
</tr>
<tr>
<td>Total (ave. # sec.)</td>
<td>1525</td>
<td>2035</td>
<td>2509</td>
</tr>
</tbody>
</table>
Table 45.3
Average time per screen as function of screen condition.

<table>
<thead>
<tr>
<th>Type of screen</th>
<th>Table</th>
<th>Map</th>
<th>Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Table / Map</td>
</tr>
<tr>
<td>Menu</td>
<td>20.90</td>
<td>25.39</td>
<td>29.19</td>
</tr>
<tr>
<td>Sex</td>
<td>76.56</td>
<td>58.38</td>
<td>100.57 / 74.97</td>
</tr>
<tr>
<td>Age</td>
<td>104.74</td>
<td>91.80</td>
<td>121.15 / 113.35</td>
</tr>
<tr>
<td>Mobility</td>
<td>94.85</td>
<td>68.02</td>
<td>61.57 / 53.42</td>
</tr>
<tr>
<td>Activity</td>
<td>121.23</td>
<td>96.77</td>
<td>55.35 / 80.28</td>
</tr>
</tbody>
</table>

Table 45.4
Evaluation of answers, average over five questions.

<table>
<thead>
<tr>
<th>Feature of answer</th>
<th>Table</th>
<th>Map</th>
<th>Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Table / Map</td>
</tr>
<tr>
<td>Amount</td>
<td>1.68</td>
<td>1.90</td>
<td>2.01</td>
</tr>
<tr>
<td>Correctness</td>
<td>1.81</td>
<td>1.97</td>
<td>1.81</td>
</tr>
<tr>
<td>Detail</td>
<td>1.47</td>
<td>1.76</td>
<td>1.91</td>
</tr>
</tbody>
</table>
CONCLUSION AND DISCUSSION

The results of this study show that graphic and non-graphic modes of information presentation certainly have different effects when used in the preliminary phase of a design task. Tables with numeric information allow students to work faster, with fewer repetitions than maps with a graphic representation of the same information. Students consult maps more often but for a shorter time than the tables, which could indicate a more global way of information handling. But the content of the information collected by the students from the tables appears to be less detailed compared with information based on the maps. The combination of the two modes of presentation, tables and maps of the same information, appears to have interesting effects. Although the number of screens doubles from four to eight, both the total usage time and the amount of screens used do increase also as expected, but by a much smaller amount of about 45%. The combination has positive effects on the content as well: students' answers based on the combined version are more detailed and slightly more elaborate.

Especially the longer total time for the map version was not as expected. A possible explanation is the high complexity of the behavior maps used. Interpretation of this kind of maps might be more difficult than expected. Another unexpected result was the lack of detail in the answers of the students working with the tables in comparison with the other conditions. Here the translation from numerical, detailed information in the tables to the solution of a spatial design might have caused the differences. Another clue for the importance of the complexity of the tables and maps comes from the comparison of the four separate tables and maps respectively. The students look at longer at tables and maps representing complex information, for instance comparing many different subgroups, than at the simpler ones.

Therefore, in further research the exact influence of the complexity of the information material should be examined and controlled more precisely. A distinction in abstraction level as proposed by Goel & Pratit (1992) and used by de Vries (1994) is useful in this respect. Repeating a similar study with other design tasks and/or in other design domains seems necessary to account for the large variety in situations and for the differences with more 'standard' problem solving tasks usually found in cognitive studies. Finally it seems of interest to explore the role of other presentation modes such as animation, realistic images, and video that are more available and therefore used more frequently in architectural design practice.

References


