Wayfinding architectural criteria for the design of complex environments in emergency scenarios

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ABSTRACT

This study analyzes human wayfinding strategies in emergencies in relation to the perception of the building’s environment. Wayfinding strategies in complex buildings (by floor plan complexity, type of users, etc. ...) are put in relation to the user’s behavior and the quality of the environment around her/him, especially in emergency situations. The results of case studies concerning wayfinding in two supermarkets and a shopping mall in northern Italy are presented and compared in order to understand efficient wayfinding design criteria, especially in emergency situations. The studies concerned a cognitive mapping test in which customers and workers had to recall emergency exits landmarks inside the building, otherwise indicate how she/he would have exited the supermarket in case of emergency. In all three cases, almost 80% of elderly and adults (who are routine clients of these places) were unable to recall exits or identified themselves as behaving ineffectively in an emergency. This is an important consideration when properly designing wayfinding systems and highlights the importance of understanding human behavior, and how people perceive the environment, in order to design safer buildings.

1.0 INTRODUCTION

Weisman [1] found that the most serious disorientation problems occurred in buildings judged as being the most complex and difficult to describe. In 1981 he found that visual spatial features of the environment such as simplicity, good form, visual access, signs and proper architectural features (in addition to familiarity with the building) are the most important key elements for good human wayfinding performance. Nowadays, many buildings are very complex and most of the designers think that signs are a sufficient solution for poorly designed buildings. It has been argued several times (Arthur and Passini [2]) that signs do not fix the problems related to the bad design of a building (fig. 1).

Fig. 1. Centro Culturale Candiani in Mestre (Venice). The long staircase implicitly suggests to move down straight. The emergency EXIT sign tells, instead, to turn right.

In addition it is important to notice that people are naturally inclined to filter out information about signs, especially the ones related to emergency exits, in order not to overload their processing system.
McClintock et al. [3] have highlighted that under everyday conditions occupants tend not to notice or recall the location of emergency exit signs: in their experiment in a Marks & Spencer retail store they found out that only 17.6% of the occupants said that they did notice one or more emergency exit sign inside the building. People frequently prefer to move intuitively towards the familiar exits, even in emergencies, because they do not have an overall idea of the location of emergency exits. This intuitive egress behavior is not always problematical but in some cases it could prove lethal, when the familiar route is untenable [4].

An experiment in an IKEA retail store has also showed that the tested subjects prefer a familiar ordinary cash exit even if the distance is longer to that exit than to the nearest emergency exit. However, if the emergency exit is open and the subject can see the outside, the attractiveness becomes much higher for the emergency exit, and most of the subjects choose the emergency exit [5].

In addition, most of the early researchers of human behavior in fire have demonstrated that the difficulty of wayfinding tasks increases significantly in emergency scenarios, due to stress, time limitations and the difficulty to catch environmental information caused by the fire scenario [4,6,7,8]. As suggested by Ozel [9], in order to understand how to design efficient wayfinding especially in emergency situations, it is important to know how people perceive the environment. Cognitive factors are a key element in influencing wayfinding performance. If information regarding a specific location, and the spatial relationships among locations, are stored in one’s cognitive map, it is easy for the user to spot the exact location of an alternate exit, for example in case of low visibility due to smoke or layout of the building. People develop cognitive maps by choosing specific landmarks, depending on their salience in the environment, that can be structural, visual or semantic [10].

In this paper, the author turned the attention to the cognitive salience of the building’s exits as an important performance factor in predicting human behavior in emergencies and designing safer buildings. It was decided to conduct cognitive mapping tests on emergency exits in complex environments, as these architectural settings are too extensive to be perceived in their entirety from any one location. The settings chosen for the case studies were two supermarkets and a single-storey shopping mall.

Supermarkets, as reported by Norman [11], are known as being complex environments, above all because of visual merchandising techniques that tend to easily disorient customers. In shopping malls the overload of environmental cues (store windows, lighting etc.) and the limited time to process them can make it hard to identify relevant cues [12]. In a study conducted in a Marks & Spencer retail store, Boyce [13,14] showed that the longest pre-movement times occurred in areas that had low visual accessibility because of the height of the display units. In addition, clients in a supermarket are never involved in fire drills and may not be aware of emergency exits location, or how to behave efficiently in emergency. From a designer point of view, as regards the Italian building codes (Decreto Ministeriale 27 luglio 2010 “Approvazione della regola tecnica di prevenzione incendi per la progettazione, costruzione ed esercizio delle attività commerciali con superficie superiore a 400 mq”) the only information given to the designer relates only on the widths of the emergency exits (at least modules of 120cm) and their location (at least two in every floor and “reasonably opposed”), without giving any information regarding people’s efficient wayfinding strategies.

Research on cognitive maps and cognitive mapping is by now quite extensive. The bulk of research has focused on people’s memory representations from large-scale environments [15] to buildings facades [16] to interiors [1,17]. As a result of the work by the American urban planner Lynch [15], many of these studies, have tried to determine what people remember about the environment in order to design efficient wayfinding environments. No studies, to the knowledge of the author, have
analyzed the type of landmarks used by people to recall emergency exits in supermarkets or malls. Understanding how people perceive the environment is the most important thing in order to predict human wayfinding behavior and consequently design safer buildings.

2.0 METHODS

The research method involved case studies to test human wayfinding, in ordinary and emergency scenarios, in two supermarkets and a shopping mall in northern Italy.

The three stores participating in the study were chosen to represent environments characterized by increasing levels of environmental complexity. The settings were:
• a supermarket with a lower environmental complexity: case study 1
• a supermarket and shopping mall with a higher environmental complexity: case studies 2 and 3.

The data collection technique used was post-occupancy verbal interviews with a set of pre-defined questions with single individuals. Participants were both clients and workers who did not have prior knowledge of the test. They were interviewed, while egressing the building, by a team of interviewers positioned outside. The tests were conducted on Saturdays, to represent relatively busy periods in each of the stores. Participants were asked to:
• indicate a certain route to a person who had never been inside the supermarket/shopping mall
• recall emergency exits, otherwise indicate what evacuation procedures he/she would have followed in the event of a real emergency.
• they were finally invited to draw the route and mark the exits on the building’s map

3.0 RESULTS

In this paper, we report findings (Table 1, 2, 3) on a cognitive mapping ability test about recalling emergency exits, as the emergency scenario is considered to be the most difficult one for wayfinding.

3.1 Case study 1. IperCoop Meduna supermarket: lower environmental complexity

3.1.1 Customers responses

The study was conducted on Saturday, February 27th 2010 inside the IperCoop Meduna supermarket in Pordenone, a small town in north-east Italy. There were 106 customers interviewed:
• 51 males: 48%
• 55 females: 52%

The layout of the supermarket is quite simple: it is a typical grid patterned floor, ending with an open space layout which allows good visibility (fig.2). This shopping setting is considered as a small dimension one, according to Cncc (Consiglio Nazionale dei Centri Commercali, i.e. the Italian National Shopping Mall Council) [25]. The Ipercoop supermarket has an area of 6,200 square meters: it is collocated inside Meduna shopping mall which has a total area of 14,000 square meters and includes 35 shops. This supermarket has a lower level of environmental complexity when compared to the one used in case study 2. According to the designers, the commercial advertisements are designed in order not to overlap with emergency devices: emergency exits are clearly marked and visible to the occupants (fig. 3).
This supermarket is not far from Pordenone city center: customers can be considered very familiar and to have a high level of affiliation. The first consideration (table 1) relates to the identification of a vivid distinction of responses related to the different age groups: particularly important, also, the fact that only 18% of all respondents were able to give an effective indication of the location of at least one emergency exit.

<table>
<thead>
<tr>
<th>Answers</th>
<th>Young</th>
<th>Adults</th>
<th>Elderly</th>
<th>TOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolutely not</td>
<td>3 (20%)</td>
<td>12 (17,46%)</td>
<td>6 (17,86%)</td>
<td>19 (17,92%)</td>
</tr>
<tr>
<td>Effective response</td>
<td>2 (13,33%)</td>
<td>14 (22,22%)</td>
<td>3 (10,71%)</td>
<td>19 (17,92%)</td>
</tr>
<tr>
<td>Move towards Pay desks/Entrance</td>
<td>5 (33,33%)</td>
<td>18 (28,56%)</td>
<td>11 (39,29%)</td>
<td>34 (32,08%)</td>
</tr>
<tr>
<td>I will follow the flow</td>
<td>2 (13,33%)</td>
<td>9 (14,28%)</td>
<td>3 (10,71%)</td>
<td>14 (13,21%)</td>
</tr>
<tr>
<td>Seek Signs/Exits</td>
<td>3 (20%)</td>
<td>10 (15,87%)</td>
<td>4 (14,29%)</td>
<td>17 (16,04%)</td>
</tr>
<tr>
<td>General information</td>
<td>0</td>
<td>1 (1,59%)</td>
<td>2 (7,14%)</td>
<td>3 (2,03%)</td>
</tr>
</tbody>
</table>

Tab. 1. Answers to the question: “Can you recall emergency exits? Otherwise, how would you exit the supermarket if an emergency occurs?”. Occupants’ age classification. IperCoop Meduna supermarket.

Respondents, who were unable to recall emergency exits (32,08%), have proposed, as an alternative for escaping, to head towards the pay desks or the entrance, simply proposing the paths habitually engaged in ordinary conditions.

Paydesks and entrances are, therefore, critical design elements. In case of an emergency they can impede the rapid flow of people: this is due to the narrowness of paydesks lanes and the presence of crowds in their close proximity. About 16% of participants said that they would seek signs or emergency exits. This is an efficient attitude in emergency situations, but it could be unsuccessful if the sign systems and location of emergency exits are not really effective in that particular situation. Almost 18% of respondents did not recall any emergency exits: this is an important consideration if we consider that customers have a high level of affiliation to this supermarket.

Only 18% were able to recall emergency exits. The most mentioned landmarks, to locate the emergency exits, were relative to the supermarket’s departments, such as: pastry (25.8%), pet foods (12,9%), fruits and vegetables (12,9%).

3.1.2 A comparison between customers and workers response

Appropriate communication during an emergency is essential for guiding occupants out of a building. A wayfinding experiment, held in the early ‘90s by Proulx and Sime in a complex station,
demonstrated that prompt instructions to the public, explaining what is happening, what to do and why, is fundamental for successful evacuation [18]. Later, an evacuation experiment in a retail store, made by Shields et al. [13,14], demonstrated the effectiveness of trained staff in an evacuation, too. It was confirmed by Proulx [19] that the activation of a fire alarm, without any additional cue, may not trigger any particular response from occupants who are visiting assembly buildings, such as supermarkets and shopping malls. As visitors, occupants will possibly continue their activity, particularly if other visitors are also not paying attention to the alarm. Visitors act as visitors; they are waiting to be told and directed by staff if something is expected from them.

Given these assumptions, it is important to find out if the workers would indicate egress routes to customers by sharing the same landmarks. In order to check out if the workers’ landmarks match with the customers’ ones, the authors decided also to test the employees by asking them to recall the location of emergency exits inside the building.

Results (fig. 4) show that the workers frequently tend to use landmarks that do not match the users’ landmarks. Specifically, workers often remember emergency exits that are near offices or particular activities of the supermarket (such as the drop-off area) which are never mentioned by the users. If the workers used these landmarks to indicate emergency exits to the customers, then the customers might be unable to quickly find the exits because they would probably not know the location of these specific areas in the supermarket. Indeed, no visitors indicated offices or drop off area as landmarks for emergency exits: as previously mentioned, they remembered supermarket’s departments (pastry, etc).

In an emergency, workers could direct visitors to move towards cashier desks or entrances: as previously shown in case 1. These areas are susceptible to crowds of people (almost 32% of users indicated that they would select a familiar route).
3.2 Case study 2. Unicomm supermarket: higher environmental complexity

3.2.1 Customers responses
This other test has been made to validate the results of the previous one and to test the customers’ emergency exits landmarks in a more complex environment.

The layout of this supermarket (Fig. 5) is similar to case 1 but is bigger and has a higher level of environmental complexity. The design of the interiors is not hierarchically structured, there are no relevant landmarks and the environment’s overall appearance is quite homogeneous.

The supermarket, which is a medium dimension one, has an area of 6,500 square meters and is located inside the Emisfero mall (fig. 6), comprises 65 shops and has a total area of 27,288 square meters. In addition, this supermarket is an out-of-town one: this means that customers are attracted from a wider catchment area. They are used to visiting different malls in order to save money, and are less routine and affiliated than the ones in case 1. The fact that the supermarket is inside a shopping mall means that customers do not come only to buy food but probably wander around different shops: this leads to increasing difficulty in creating an accurate cognitive map of the overall environment.

The study was conducted on June 26th 2010 in the Unicomm supermarket in Fiume Veneto, a small town near Pordenone. There were 67 customers interviewed:

- 29 males: 41.8%,
- 38 females: 56.7%

In this case (see table 2), less than 20% of the population were able to recall at least one emergency exit. Of particular importance is the fact that only 6.1% of adults (who are the most frequent users and the most present inside) were able to recall emergency exits.

Note that a lower percentage (24% compared to 33% of case 1) of people would egress by a familiar route. The higher levels of environmental complexity and interior homogeneity probably leads users to form a weak cognitive map of the setting. In addition, this is an out-of-city center store so users are considered to be less familiar and affiliated. Unfamiliarity is also lowered by the size and complexity of the environment: people who go into the supermarket are supposed to wander around the mall before and after their shopping.

In case of an emergency, 31.3% of the interviewed would prefer to look for signs or emergency exits. This could be caused by higher levels of alertness induced by lower familiarity with the building and the by the presence of bigger crowds of people.

<table>
<thead>
<tr>
<th>Answers</th>
<th>Young 12 (17.9%)</th>
<th>Adults 33 (49.3%)</th>
<th>Elderly 22 (32.8%)</th>
<th>TOT 67 (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolutely not</td>
<td>1 (8,3%)</td>
<td>2 (6,1%)</td>
<td>3 (13,6%)</td>
<td>6 (9%)</td>
</tr>
<tr>
<td>Effective response</td>
<td>5 (41,7%)</td>
<td>2 (6,1%)</td>
<td>4 (18,2%)</td>
<td>11 (16,4%)</td>
</tr>
<tr>
<td>Move towards Pay desks/Entrance</td>
<td>2 (16,7%)</td>
<td>11 (33,3%)</td>
<td>3 (13,6%)</td>
<td>16 (23,9%)</td>
</tr>
<tr>
<td>I will follow the flow</td>
<td>1 (8,3 %)</td>
<td>3 (9,1 %)</td>
<td>3 (13,6 %)</td>
<td>7 (10,4 %)</td>
</tr>
<tr>
<td>Seek for signs/Exits</td>
<td>2 (16,7%)</td>
<td>11 (33,3%)</td>
<td>8 (36,4%)</td>
<td>21 (31,3%)</td>
</tr>
<tr>
<td>General information</td>
<td>1 (8,3%)</td>
<td>4 (12,1%)</td>
<td>1 (4,5%)</td>
<td>6 (9,0%)</td>
</tr>
</tbody>
</table>

Tab. 2. Answers the question: “Can you recall emergency exits? Otherwise, how would you exit the supermarket if an emergency occurs?”. Occupants’ age classification. Unicomm Supermarket.

Of particular importance is that the people who were able to recall at least one emergency exit mentioned only the one that was located in the drinks department (see fig. 7). This means that this exit is the only one designed in a proper way: it is easily recognizable and visible. In addition, cognitive salience of this exit could probably be enhanced because of its diffused use. Drinks, are an item that are used by client of all ages. Would have it been different if there were something more aged-oriented as, for example, candy or denture adhesives?

![Fig. 7. Interior view of Unicomm Supermarket. Drinks were the only landmark mentioned to identify emergency exit.](image)

3.3 Case study 3. Centro Commerciale Emisfero shopping mall: higher environmental complexity

3.3.1 Customers responses

We are now considering the responses taken from the survey in the big shopping mall. As can be seen in the picture (fig. 8), this is a one-floor shopping mall. This is an out-of-city-center mall with medium dimension (it is the one which includes the Unicomm supermarket inside) and is visited by people who come from different nearby areas. It comprises 65 shops (including Unicomm supermarket) and has a total surface 27,288 square meters. The floor layout is quite complex as has no perpendicular intersections. We know from the literature on wayfinding [2] that is very difficult to figure out a proper and accurate cognitive map when there are no regular or perpendicular intersections of paths.
This leads to inaccurate cognitive mapping and the consequences are the disorientation of the users and problems in wayfinding. This shopping mall has been designed by the same designer who designed the Unicomm supermarket, so it has a similar architectural appearance. The interiors are uniform and the environmental communication is not a hierarchically structured. This makes it harder to discriminate between environmental cues during everyday wayfinding and, particularly, in case of a fire incident. Smoke levels will also contribute to the difficulty in discrimination. The study was conducted on Saturday July 1st 2010 in the Centro commerciale Emisfero in Fiume Veneto, a small town near Pordenone. There were 87 customers interviewed:

- 42 males: 48.3%,
- 44 females: 50.6%

In this case (table 3), less than 20% of people who were able to recall emergency exits. We reported similar results, compared to case study 2, regarding people who would egress by familiar routes (10.3%), 16.14% in case 2, and who would look for signs or emergency exits (41.4%), 31.3% in case 2. As can be seen, these results are quite similar to case study 2: this could be explained in terms of design similarities with Unicomm supermarket.

<table>
<thead>
<tr>
<th>Answers</th>
<th>Young</th>
<th>Adults</th>
<th>Elderly</th>
<th>TOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolutely not</td>
<td>0</td>
<td>1 (2%)</td>
<td>2 (9.5%)</td>
<td>3 (3.4%)</td>
</tr>
<tr>
<td>Effective response</td>
<td>4 (23.5%)</td>
<td>10 (20.4%)</td>
<td>3 (14.3%)</td>
<td>17 (19.5%)</td>
</tr>
<tr>
<td>Move towards Entrance</td>
<td>0</td>
<td>7 (14.3%)</td>
<td>2 (9.5%)</td>
<td>9 (10.3%)</td>
</tr>
<tr>
<td>I will follow the flow</td>
<td>5 (29.4%)</td>
<td>3 (6.1%)</td>
<td>4 (19%)</td>
<td>12 (13.8%)</td>
</tr>
<tr>
<td>Seek for Signs/Exits</td>
<td>7 (41.2%)</td>
<td>22 (44.9%)</td>
<td>7 (33.3%)</td>
<td>36 (41.4%)</td>
</tr>
<tr>
<td>General information</td>
<td>1 (5.9%)</td>
<td>6 (12.2%)</td>
<td>3 (14.3%)</td>
<td>10 (11.4%)</td>
</tr>
</tbody>
</table>

Table 3. Answers the question: “Can you recall emergency exits? Otherwise, how would you exit the supermarket if an emergency occurs?”. Occupants’ age classification. Emisfero Mall.

As can be seen on the floor layout, the mall has several emergency exits located along its paths. It is interesting to notice that the only emergency exits remembered by those interviewed were the ones which had a toilet nearby (fig. 9, 10). This means that all other exits that did not have toilets have been
passed without having been noticed. This means that most of the mall is badly designed: in particular, it gives no environmental communication about emergency devices. The only exits rememberd are the ones which are frequently used (i.e. when people go to the toilet) or which are noticeable because of people moving in close proximity (movement is the most eye-catching mean to get attention).

**CONCLUSIONS**

The cognitive mapping tests were necessary to highlight the critical elements of the architectural design of the supermarkets and the shopping mall and to predict human behavior in the event of a fire. The location of large retail stores, i.e. city centre or out of town urban stores affects the patterns of usage by customers in terms of frequency and affiliation (fig. 11). Frequency of use of a building is often related to the notion of familiarity, i.e. that somehow in an emergency the occupants will have knowledge of and use the fire safety facilities provided, e.g. emergency.

**Fig. 9, 10. Interior view of Emisfero Mall: the emergency exits with toilets nearby were the only ones remembered.**

**Fig. 11. Supermarkets’ catching area analysis. Point 1 refers to IperCoop Meduna. Point 2 refers to Emisfero shopping mall.**
1. The fact that almost 80% of elderly and adults in all three case studies (who are routine clients of the supermarkets) were unable to recall exits or have declared that they would have ineffective behavior in an emergency, is as an important consideration for properly designing wayfinding systems.

2. In case study 1 people are supposed to have a high level of affiliation to the supermarket: this could lead to the consideration that they should know the environment and therefore egress successfully. Results show that almost 32% would egress by a familiar route. In this case, familiarity does not lead to accurate cognitive mapping but to stimulus irrelavence towards emergency exits. Emergency exits should therefore be designed in a more proper way to catch attention. In this case, cashier desks and entrances are critical design elements. In an emergency they can impede the rapid flow of people: this is due to the narrowness of cashier desk lanes and the presence of crowds in their close proximity.

3. As the environment becomes more and more complex there is an increase in people who would look for signs:
   • case 1: 16%
   • case 2: 31.3%
   • case 3: 41.4%
This is probably due to higher levels of alertness related to higher stress and by the presence of bigger crowds of people. There is a relative decrease towards the behavior of egressing by familiar routes, probably due to the inability to form a proper cognize map of the environment, including the simple way back. Between 16-40% of customers would look for signs in case of emergency. This is an effective attitude towards evacuation, but it could be completely ineffective if the signs are not designed properly.

4. Environmental complexity affects the salience of landmarks. In case 1 (low environmental complexity) people remembered a wider range of landmarks associated with emergency exits. In cases 2 and 3 they remembered fewer and fewer landmarks.

5. Workers indicate emergency exits with different landmarks than customers: this could lead to misunderstandings in announcing instructions to evacuate. Workers should be instructed to use landmarks that match those likely to be know by the users.

6. In all cases considered, there is always a 10-14% of respondents who would follow the flow. This percentage could become problematical if they are following those who behave ineffectively.

Given these conclusions the designers’ goal should be to create distinguishable environments (see fig 12,13). Good wayfinding design facilitate users’ navigation and lead the customers to find their way in the building without effort. If information regarding specific locations, and the spatial relationships among locations, are stored in one’s head, then it is easy for the user to spot the exact location of an alternate exit. For example, in case of low visibility due to smoke or layout of the building.

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*Fig. 12, 13. Some architectural devices to improve wayfinding: signs and LED emergency devices*
ACKNOWLEDGEMENTS

The authors would like to thank IperCoop Meduna supermarket (Pordenone), Centro commerciale Emisfero (Fiume Veneto), for permitting the tests.

References


