I-191 HUMAN BEHAVIOR DURING EVACUATION : EXPERIMENT IN MAZE

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Introduction : Nowadays, concern about disaster mitigation is growing and one feature of this subject is elaboration of emergency evacuation routes in buildings. The aim of this study is first to observe evacuation behavior of human being during a fire (due to an earthquake for example). Then this behavior will be modelled and eventually simulation on computer will be performed. The basis of this study is the experiment described in the following.

Setting of the experiment : The experiment was carried out at Ikebukuro Life Safety Hall (which is managed by Tokyo Fire Department). The facilities kindly provided by Ikebukuro Center consists of a maze (cf Fig.1) with many doors (among which some can be opened and others cannot). Examinees were sent one by one in the maze with the aim of finding the exit.

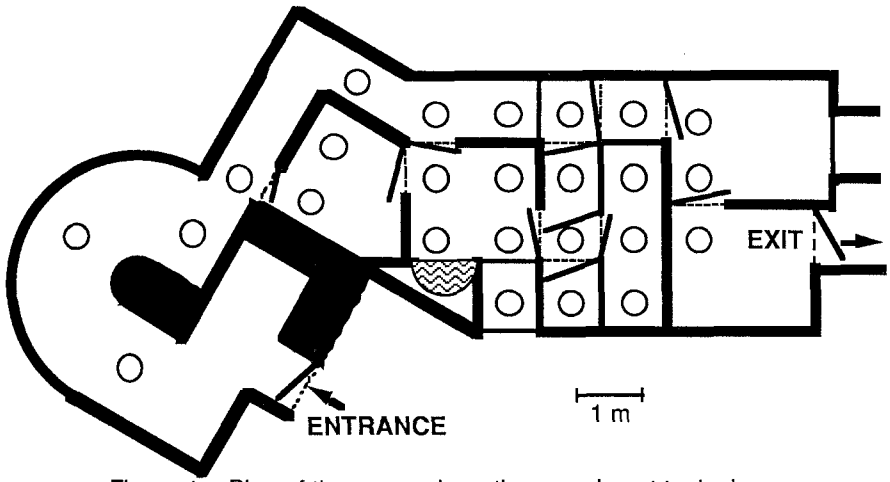

Figure 1 : Plan of the maze where the experiment took place

The input parameters of this experiment were the following.

Brightness in the maze could be controlled from outside with three possible states : completely light, moderately light and completely dark. Smoke could be introduced in the maze from outside and its amount could be controlled. The configuration of the maze could be changed but this possibility has not been used yet. Using different initial states of light and smoke, three different experimental cases have been worked out (cf Table 1). In each case, the light was then turned on and off according to a predefined pattern.

The other set of input parameters were the age and sex of examinees. So far, this experiment has been performed with 12 examinees, 7 men and 5 women, their age ranging from 23 to 50 (cf Table 2).

The output parameters of this experiment were the following.

The maze being equiped with sensors enabling to know where the person is (they are symbolized by circles on Fig. 1), the position of the examinee as a function of time could be displayed on the control board and then recorded using a video camera.

A questionnaire was also devised to know the motivations and feelings of the examinees better. An example of questions and answers of this questionnaire is shown on Figure 2.

General remarks concerning the behavior of the examinees in the maze: When confronted with the situation of this experiment, one can choose either a logical behavior — which leads without fail to the exit but can be time consuming — or an instinctive behavior — which can be quick, with the help of luck, but is far from infallible.

What was actually observed during the experiment is the following. First, when the light was on, the examinee seemed to adopt the above mentioned "logical behavior", trying the different possible ways and going back only when there was dead end. Then, when the light went off, the

Table 1 : Conditions of experiment

	Case 1	Case 2	Case 3
Initial degree of brightness	Completely light	Moderately light	Moderately light
Amount of smoke	None	Moderate amount	Moderate amount
Light leaking from outside	Some	Some	None

Table 2 : List of examinees

Person Nº	Sex	Age	Time Case 1	Time Case 2	Time Case 3
1	M	32	1'35"	1'03"	36" (*)
2	F	26	3'50"	7' (**)	47" (*)
3	M	26	2'30"	1'50"	2'50"
4	F	23	2'50"	3'32"	57"
5	M	50	2'02"	4'07"	2'46"
6	M	28	1'05"	3'12"	5'15"
7	F	28	3'29"	2'20"	2'50"
8	M	45	4'00"	2'00"	4'19"
9	F	37	1'50"	5'00"	1'58"
10	M	42	2'33"	3'13"	1'21"
11	F	27	4'05"	3'10"	5'12"
12	M	31	2'20"	1'13"	5'55"
Mean			2'41"	2'47"	3'20"
Coefficient of Variation			35%	42%	49%

Notes:
(*) Actually the light was not completely turned off in these particular cases.
(**) Actually the examinee could not get out of the maze on her own.

Question : In the following cases , how restless did you feel ?
How restless do you think you would feel in real situation ?

In the experiment

In real situation

(The height of the bars is proportional to the number of answers)

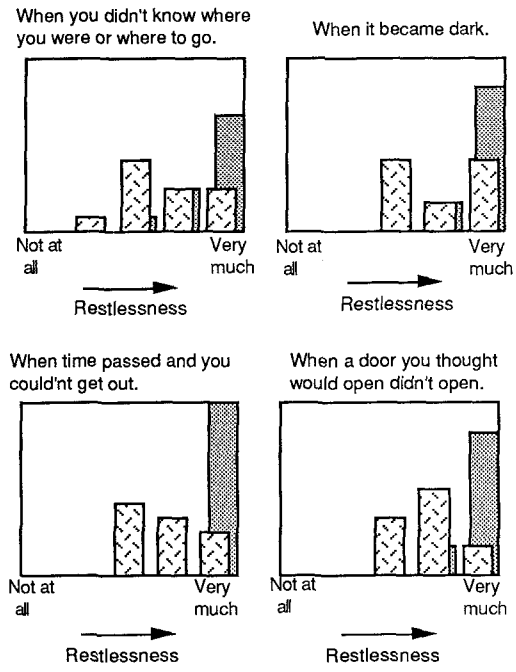

Figure 2 : Results of questionnaire

behavior of the examinee seemed more random, with a lot of going back. When the light came back, the behavior of the examinee did not improve noticeably, which seems to imply that, once you have lost your reference points, it is difficult to find your way.

It is interesting to notice that it seemed very difficult for the examinees to memorize places. This is shown by the fact that there was generally no improvement of the performance of examinees for their 2nd or 3rd try (cf Table 2). Also, several people (5 out of 12) went back to the entrance, obviously without recognizing it, although it is the only part of the maze with curved walls. This difficulty in remembering places can be due to the state of restlessness of the examinee, but more likely to the fact that our brain is not trained to record places we cannot see (except in the case of blind people).

It seems that the results of this experiment can be used reliably to infer behavior of human being in a state of panic. As a matter of fact, there is no visible correlation between the performance of the examinees (for example the time spent in the maze) and their age or sex (which often define hierarchical status). This means that each individual reacted according to his own personality (as it is likely to occur in real situation) rather than to his feeling of his social status.

Utilization of the results : Future modelling using the results of this experiment may have to rely on fuzzy theory, which is particularly appropriate to deal with impreciseness of human vocabulary. The results of the experiment, and especially the answers to the questionnaire, will be used for example to build relevant membership functions. It will then be possible to perform computer simulation of evacuation.