

# Decision making processes in groups in uncertain situations – An experimental study

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**Short Abstract.** In everyday life, we often encounter unclear situations that require quick action but do not provide a clear basis for decision-making. Especially in traffic environments such as railway stations, crowd motion can become dangerous in confined spaces such as tunnels or platforms. Therefore, a better understanding of the decision-making mechanisms in such situations is essential. The aim of this experimental study was to provide a first empirical approximation of spatial decision-making processes in anonymous situations. It was hypothesized that direct communication, group size and shared social identity have an influence on the duration and homogeneity of group-level decisions. The results show that decisions are more homogeneous in smaller groups than in larger ones, while communication does not directly influence the homogeneity of decisions. Further studies are needed to systematically investigate behavioural patterns in such situations.

## 1 Introduction

In our daily routines within urban traffic scenarios—whether commuting to work, navigating a train station, or shopping at a bustling mall—decision-making rarely demands our full attention. Actions like selecting the correct platform at a train station feel almost automatic, guided by years of experience and familiarity. This smooth flow relies on the structured predictability of the environment and the shared understanding among individuals and the familiar situations of daily routine.

However, this seamless coordination can falter when uncertainty arises. Situations that deviate from the norm—such as unclear signage, unexpected disruptions, or conflicting movement cues—can challenge the routine-based behaviour of individuals. When faced with ambiguity, people must pause to assess and decide, which can ripple through the crowd, leading to congestion and unforeseen movement patterns. These moments of hesitation and their collective impact reveal how critical clarity and coordination are in maintaining the fluidity of urban pedestrian dynamics. Moreover, stationary crowds can create hazardous situations by leading to congestion and obstructing clear escape routes. For this reason, it is crucial to understand what happens in crowds when the routine handling of a situation is no longer possible. Furthermore, in urban traffic scenarios the right decision very often cannot be completely clear for the people present in the situation, e.g. when the information signs do not work or the technical infrastructure is not enough improved for giving immediate information about changes. From the perspective of pedestrian dynamics, it is important to clarify how quickly the people present in the situation decide and how homogeneous these decisions are. Therefore, the main research question of this study is how different communicative and social settings affect the speed and homogeneity of decisions in ambiguous situation in random crowds on the aggregate level.

From the social theoretical perspective, these questions cover three main areas. First, the specific context of decision making. In real-life scenarios in traffic infrastructure, the information is often not sufficiently detailed or available, as described above. Therefore, decision making is primarily about reducing uncertainty regarding the specific situation. According to Festinger[1], two basic mechanisms are relevant in this context. Firstly, an attempt is made to check the physical reality, i.e. to search for information which could validate the decision. If this is not possible, the opinions of others are taken into consideration, i.e. social influence comes into play.

The second pillar that must be taken into account for the theoretical considerations is the context of anonymous situations. Gatherings in public space without an event character (like visiting a concert) lack normally the presence of a strong (and salient) social identity which could be the basis for strong mechanisms for social influence [2–4]. Much more they can be seen as gatherings of strangers who have different backgrounds, intentions and goals. However, even if we do not know each other personally, we act in public space in a coordinated way [5]. As Goffman pointed it out [6–8], when we encounter strangers in urban space, we adhere to culturally encoded behavioural norms. These rules are designed to help maintain both mental and physical distance from others, such as avoiding direct eye contact and ensuring consistent physical spacing with those in our immediate vicinity. In addition, verbal communication and direct contact with others is also very limited in these situations. Expressing neutrality by not communicating is associated with a neutral atmosphere. This setting belongs to the normal maintenance of daily routine encounters. However, it can be challenging in case of unexpected changes in the routine and/or in uncertain situation when a decision has to be done. Communication

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plays in this context a crucial rule. An anonymous atmosphere can lead to a perception of limited communicative possibilities. This can be illustrated most easily by the example of the difference in behaviour between social groups. Among friends or acquaintances, an unclear situation would be addressed and the apparent conflict resolved through communication. This is much less likely to happen in anonymous situations, for the reasons mentioned above.

The third theoretical consideration concerns the relationship between social influence and perceived social identity. The stronger the feeling of belonging to a group, the more likely it is that others will influence one's own behaviour [3,4]. Unexpected situations can basically raise the awareness for similarities among the people present. In principle, social identity can be built on two different bases. According to the interactive model of social identity, direct communication promotes the emergence of a special form of group identity [9,10]. So, if those present decide to communicate with each other, it can lead to the development of a shared social identity in anonymous situations. Additionally, clear distinguishing features of a group and a salient outgroup lead to self-categorization as part of the same group [11,12]. Thus, in a crowd where self-categorization as part of a distinct group is possible, shared social identity can become relevant. While self-categorization is also possible in larger groups, the process of identity formation through interaction is more typical of smaller groups [13].

2 Hypotheses

These theoretical considerations allow us to emphasize three aspects that are relevant to the research question. Firstly, there is the role of communication. It can be assumed that an interactional context in which communication appears to be permitted/usual results in a more uniform decision at group level than a context in which those present cannot talk to each other, as opinions and considerations can be harmonized. However, it can also be assumed that communication delays the decision-making process because the opinions have to be presented and negotiated against each other.

Secondly, it can be assumed that the number of people (referred to below as group size) has an effect on the homogeneity and duration of the decision. It was hypothesized for this study that a smaller number of people would result in a more uniform decision at group level. The assumption was based on other research results that have shown that smaller groups solve problems more effectively than larger groups, while larger groups can develop a broader variance and diversity of solutions [14,15]. It was also assumed that the duration of the decision is shorter in this case since there are less actors in the process.

Thirdly, the role of shared social identity must be considered. In this regard, it is assumed that the perception of group membership leads to a more homogeneous decision at the overall level. On the other hand, it is assumed that the perceived similarities favour a faster decision.

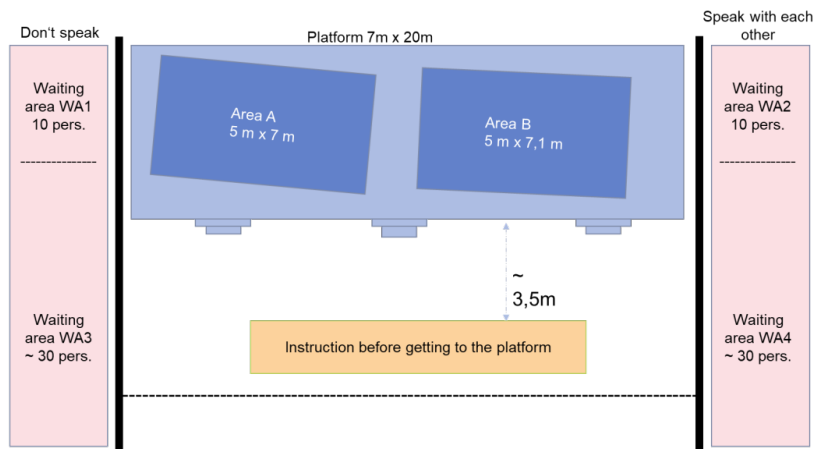
Table 1 Modifications and independent variables

Modification binary/Independent variables	Communication no/yes	Group size small/big	Social identity low/high
Duration to decision	Shorter/longer	Shorter/longer	Longer/shorter
Homogeneity of decision	Lower/higher	Higher/lower	Lower/higher

3 Study design

The study presented here was part of a series of experiments conducted as part of a joint project at the Mitsubishi Electric Hall in Düsseldorf. The aim of the large-scale experiments was to investigate pedestrian dynamics in various experimental settings and with different specific questions, while being able to deploy the recruited participants in an optimal capacity plan in several experiments over the course of the day. The experiments lasted a total of four days, and the study presented here is based on the experimental setup of three consecutive days with the same structure. The exact design of the whole experiment was presented in a methodological paper [16], but the structure of this specific experiment has to be briefly outlined in order to present the experimental design in a comprehensible way.

In a separate area of the hall, a 7x20 m stage was set up, which was accessed via a three-step staircase and was located in the middle of the area (see Fig. 1). The entire experimental area was recorded with two overhead cameras and two side cameras. The video recordings were then used to calculate the participants' walking trajectories.



**Figure 1** Experimental area

In the instructions, participants were asked to imagine the stage as a platform at a railway station from where they would like to leave by train. In this experiment two areas of almost the same size were stuck to the platform with yellow adhesive strips; it was impossible to determine the exact size of the areas with the naked eye. The participants had to choose the larger area during an imaginary stop at the station so that they could leave on the planned train. This task served to create a barely resolvable ambiguity in the crowd and thus depict a decision-making situation that primarily triggers uncertainty in the participants and offers no clear-cut solutions. The exact wording of the instruction was (translated from German): « Imagine you are at the railway station and you see a platform. There are white stripes on the long sides, these are the safety stripes on the platform. There are two waiting areas from where you can board the train, they are marked in yellow: two areas, one on the left and one on the right. You will only be able to board the train from the larger of the two areas, so please go to the larger of the two areas on the platform. »

All three modifiers were binary coded, see Table 1. In order to generate the two communicative modifications, it was noted at the respective instruction whether the participants could communicate with each other ('you can discuss with other participants, if you want'), or whether communication with each other was prohibited ('during this experiment, please do not have any verbal contact to the others present'). In terms of group size, the participants were divided into groups of 10 persons and into larger groups, whereby the number of participants in larger groups had to be based on the respective slot sizes of the overall experiment design. The larger groups comprised therefore 24 to 41 participants (see Tab. 2).

**Table 2** Distribution of participants due to modifications

	small	large		no-speak	speak
N groups	12	10		11	11
N participants	120	324		220	224

For the operationalization of the perceived social identity, it was assumed that participants who had to complete the experiment in the morning did not yet know each other in the group (the social relations of the participants were recorded and care was taken to ensure that the groups remained heterogeneous when assigning them to different experiment groups), while experiment groups that went through several experiments together throughout the day and into the afternoon were assumed to develop a shared social identity. This assumption was also supported by the fact that the individual groups were given a specific colour coding, which enabled them to distinguish their own group from the other two overall groups. In this sense, an ingroup-outgroup distinction could be expected. In order to test the modification, the test subjects not only had to answer a questionnaire after, but also before the experiment. This made it possible to compare the perception of togetherness between the morning and afternoon groups, but also the perception in the distinct runs before and after the experiment. The aim of the questionnaire study was therefore, first, to record the perception of sociality. Shared social identity was operationalized on the basis of feelings of belonging, similarity and connectedness [17], but questions were also included about the perception of anonymity and atmosphere. Questions that were only asked after the experiment related to the participants' uncertainty regarding the correct area and their self-confidence when making a decision. All questions were formulated as statements that the participants were asked to rate on a 7-point Likert scale (1: strongly disagree, 7: strongly agree). However, as the evaluations showed, there was no

significant difference in the perception of the feeling of bonding and the identification with the others in the comparison between the morning groups and the afternoon groups. In addition, participants rated the statements very neutrally to negative. Only with regard to the statement ‘I am like the others who are present in the waiting area’ was there a significant, but negative correlation in this respect: in the afternoon, the participants agreed with this statement significantly less often than in the morning ( $p < 0.05$ ,  $r = -0.1$ , paired Wilcoxon-Mann-Whitney test). For this reason, this modification could not be included in the evaluation of the results.

The operationalisation of the decision duration at group level was carried out in two ways. Firstly, the time was measured until all participants had taken their final position (P.D.). Secondly, initial video analyses showed that individual positioning was not the only form of behaviour during the experiment. Observing the movements of others as well as visually measuring spaces was part of the individual decision-making process. For this reason, the recordings were subjected to systematic video analysis [18]. As a result, four different forms of behaviour were observed in relation to the decision-making process.

- 1. actively measuring the two areas
- 2. visually measuring the areas (participants remained standing but tried to visually determine the size of the areas and compare them)
- 3. no visible effort to measure, but following the events on the platform
- 4. Explicit inactivity, sitting down, fiddling with a mobile phone

A second measure of the duration of the decision-making process was derived from this differentiation: the time from instruction to the point where no more participants were actively or visually measuring the areas and interactive movement on the platform had stopped. This measure is referred to here as interaction duration (I.D.). The question regarding the homogeneity of the decision was based on the participants' uniform final position. A 50%/50% distribution was assumed to be the maximum degree of inconsistency, and a 100%/0% distribution between the areas was assumed to be the maximum homogeneous distribution. The homogeneity measure (H.M) was determined as follows based on the distribution in one of the areas:

- 1. Homogeneous: 0-10%
- 2. Mixed: 11-40%
- 3. Strongly divided: 41-50%.

Due to the uneven distribution, the group comparisons were carried out using the Wilcoxon-Mann-Whitney tests.

4 Results

First and foremost, the qualitative analysis, based on the video analysis of the experimental footage, showed that the participants tended to rely on immobile/passive measurement techniques when determining the size of the two areas. As Fig. 2 shows, active measurement was only practiced by a few participants and only for a very short time in relation to the total duration of the decision-making process. This applies to all modifications, but as the figure shows, the possibility of communication seems to have a positive influence on the measuring activity. Likewise, active measuring seems to occur proportionally more often in smaller groups. However, this finding can also be assigned to the proportionality of activities depending on group size and thus indicates the complex structure of decision-making in anonymous situations: The fact that some actively take care of measuring the areas dissuades the others from this explicit activity, since the role of measurer is already occupied. In smaller groups, one person can already account for 10% of the participants, while in larger groups, one person who takes on the role is represented with a smaller proportion in the evaluation.

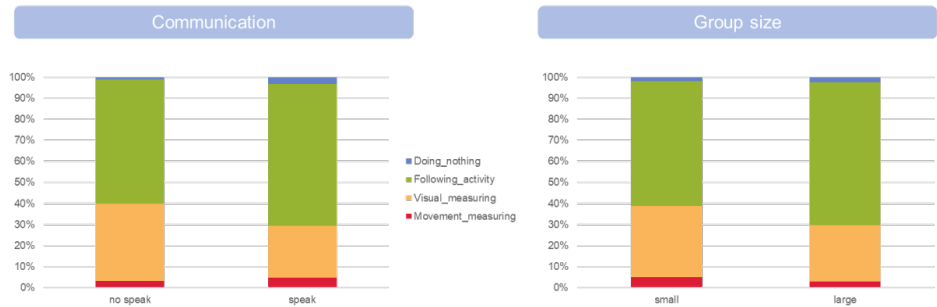


Figure 2 Observed behaviours in the modifications "Communication" and "Group size"

4.1 Time to final decision

The average time until all participants had taken up their final position (P.D.) was 2 minutes and 15 seconds across the modifications. The modification variables group size and communication did not show any significant difference in this respect.

With regard to the interaction duration of the decision-making process (I.D.), communication had a significant effect: when the participants had the opportunity to discuss with each other, they needed a significantly longer time to finally come to rest (MD\_noSpeak=90 sec, SE\_noSpeak = 27.07, MD\_Speak=250 sec, SE\_Speak = 36.01,  $p<0.05$ ,  $r=-0.49$ ). These results suggest that, regardless of the communicative condition and group size, the participants made a relatively quick decision for themselves, which was discussed for longer under communicative conditions, but the discussion did not necessarily contribute to the possibility of convincing a large number of participants to change their minds. Communication itself did not delay the decision, but rather prolonged the interactive process.

On the other hand, the group size couldn't be identified as a significant factor in this regard. Although the average decision-making time was longer in the larger groups (MD\_large = 184.5 sec, SE\_large = 42.65) than in the small groups (MD\_small = 142 sec, SE\_small = 27.4), this difference was not significant.

4.2 Homogeneity

The relatively small number of runs does not allow a statistical comparison of homogeneity between the experiment modifications. Nevertheless, the visualization of the distribution of the individual experiments according to modification shows a pattern that can provide insights into deviations depending on the modification. We assumed that smaller groups are more likely to decide homogeneously than larger groups. As Fig 3 shows, a 100% homogeneous final positioning occurred more often in smaller groups than in larger groups. Furthermore, there was no run in which smaller groups held particularly divided opinions regarding the assessment of the area sizes. In contrast, two larger groups held particularly divided views. These results support our hypothesis.

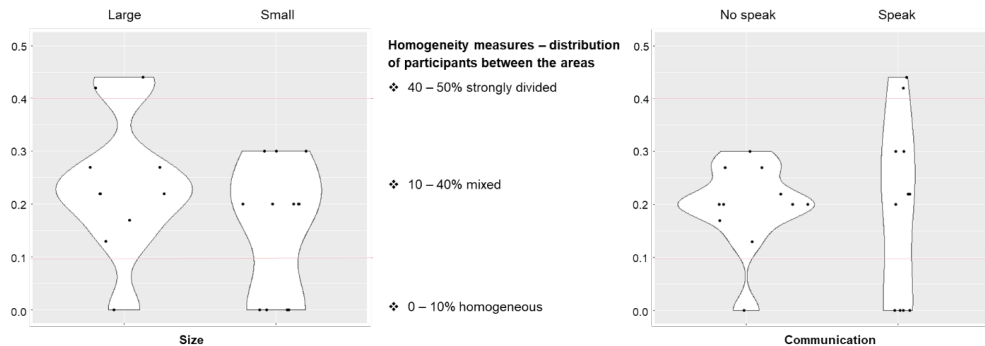


Figure 3 Homogeneity measurement in the modifications "Communication" and "Group size"

In terms of communication, the assumption was that communication can contribute to greater homogeneity, that opinions and other information can be shared and exchanged better than in a communicatively restrictive environment. The data presented here does not necessarily support this assumption. As can be seen in Fig. 3, the runs with a communicative setting are distributed relatively evenly, i.e. communication itself initially causes an exchange, but not a standardizing influence on decision-making. The figure also shows that without communication, a uniform positioning is rather unlikely: in 10 of 11 runs, the homogeneity measure remained in a mixed area.

5 Discussion

The aim of this study was to provide a first empirical approximation of spatial decision-making processes in anonymous situations. It was hypothesised that direct communication, group size and shared social identity have an influence on the duration and homogeneity of group-level decisions. The results show a mixed picture and point to further research that is necessary for a better understanding of decision-making mechanisms in ambiguous situations. An interesting finding regarding the framework for anonymous situations in crowds is the failure to modify shared social identity. This shows that self-categorisation as part of a distinct group can very rarely be regarded as a relevant category under anonymous conditions. However, further analyses of the

questionnaire data showed that solving the task that concerned all group members had a positive effect on the perception of identification and connectedness with others. This significant effect was even similarly pronounced regardless of the communication condition or group size (MD\_ident\_before = 4, SE\_ident\_before = 0.9, MD\_ident\_after = 5, SE\_ident\_after = 0.9,  $p < 0.05$ ,  $r = -0.11$ , MD\_affil\_before = 3, SE\_affil\_before = 0.8, MD\_affil\_after = 4, SE\_affil\_after = 0.8,  $p < 0.001$ ,  $r = -0.14$ ). This finding supports the assumptions of the Interactive Model of Identity Formation [9,13], according to which the shared interactive setting reinforces the perception of belonging to the situational group through the division of tasks in the situational context.

The distribution of roles in the situational context also appears to be of the utmost importance when analysing the decision-making mechanisms under anonymous conditions. A particularly striking result of this study is the short measurement time and the quick individual decision in favour of one of the areas. The task was designed in such a way that the decision remained the individual responsibility of all participants despite the joint instruction. The participants had to decide for themselves which area they considered suitable. Nevertheless, the task was solved at group level, which is best illustrated by the lack of individual measurement activities. As the video analysis showed, the measurement activities of the individuals (which were sometimes carried out in dyads) were followed with interest by most of the other participants, and the conclusions of the active participants were sometimes confirmed by nodding their heads or other approving gestures if they led to the same result as their own considerations, or they even caused the participants to reconsider their position. The verification of physical reality [1] was thus often outsourced by delegation to individual others and used as additional information to one's own judgement. The quick individual decision in favour of one of the areas also showed that, despite the challenging task (the size of the areas was difficult to distinguish), there was no lengthy reality check, but instead a simplified comparison took place for most of those present (usually a comparison of the nearest area boundaries). This shows the endeavour to reduce uncertainty as quickly as possible by making a decision, but without excluding further considerations. This is reflected in the varying duration of the interaction process and the final individual positioning.

The distribution of activities and the clear assumption of roles could not yet be sufficiently considered in this study, but is an important key element in understanding the exact decision-making mechanisms in crowds and the emergence of leadership roles. How these mechanisms relate to spatial conditions should also be investigated in more detail. Further qualitative analysis of the experimental data could provide interesting insights here. Particular attention should be paid to the differences between interaction under communicative and non-communicative conditions.

Finally, the limitations of this study should be mentioned. Firstly, the group sizes were not uniform (the larger groups had different numbers of participants), which can be attributed to the overall design of the experiment. The comparison between groups of 10 and 30 could be questioned, particularly from the perspective of crowd research, as in real-life situations even larger crowds are often exposed to the conditions simulated here. However, it can be assumed that the interaction context relevant to the decision-making situation can only reach a level that remains perceptible to the participants' senses. [19]. Even in a crowd of 200 people, the influence of others is limited to what the individual can perceive in their immediate vicinity. Another point of criticism is the manipulation of the participants' motivation. The instruction was relatively short, and as the participants had taken part in various experiments throughout the day, the actual motivation to choose the larger area in this experiment may have been lower than would have been the case in a real situation at a railway station. In addition, the two areas in this experiment were very close to each other. This circumstance could also be introduced as a modification in a follow-up experiment: In real-life situations, e.g. at a railway station, the choice options are often further apart, e.g. two different platforms. In this case, the options would have to be weighed up more thoroughly, as switching between the areas would involve higher costs. In such a decision-making situation, the spatial aspect would be even more pronounced.

To summarise, the present study has provided initial indications of the influence of ambiguities on decision-making mechanisms in anonymous crowd situations. The modification variables introduced provided an initial orientation. However, further studies are needed that take into account the special circumstance of anonymous sociality and the associated interactional rules and that analyse and evaluate the behavioural rules in a systematic manner.

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