Studying Wayfinding in Healthcare Facilities Using Two Different MCDA Approaches

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ABSTRACT: Wayfinding in complex public buildings is an interesting and well-researched area, which discusses elements as static signage, use of apps and architectural elements of the environments. This research focuses on a specific area, namely designing an inclusive hospital wayfinding system for patients (and their visitors). Challenges here are not only the complexity of the built environment and the stress patients usually have when visiting a hospital but also the large variety of patients. Some patients have functional disabilities, limited mobility or suffer from cognitive disorders. Although this is generally recognized, not much work has been done so far to integrate all these different requirements – criteria for optimizing wayfinding systems – in a single model. The present research work provides a comprehensive explanation of the set of aspects collected in the available literature that are linked to the wayfinding performance in complex buildings and specially in healthcare facilities. In order to evaluate the role that these factors play in the wayfinding performance of individuals inserted in one of the user groups here explored, two Multi-Criteria Decision Analysis (MCDA) approaches were selected. The use of MCDA in the current problem allowed to break down its complexity towards an intuitive and transparent process to access the priorities and values of the different users. The approaches used were adapted to the problem under study and an assessment session was conducted with elderly individuals from a retirement home facility. The obtained results contributed to a thorough understanding to which extent the inherent aspects of healthcare facilities affect users while trying to reach their destination.

KEYWORDS: Wayfinding; Healthcare Facilities; User Groups; MCDA

1. INTRODUCTION

1.1 BACKGROUND

The hospital's framework poses several additional challenges to the already complex problem of wayfinding, namely the complexity of the building itself, the large variety of patients, and the fact that when visiting these environments patients may already be under stress, which combined with their navigation to multiple locations increases wayfinding difficulty [1]. Furthermore, when considering patients within a hospital, one has to remember that there are those with functional disabilities (e.g. visual impairment), limited mobility or that are in wheelchairs or the ones who suffer from dementia or autism and need special attention [1]. Hence, wayfinding systems in hospitals should be inclusive in the sense that every single patient “with the widest range of abilities within the widest range of situations without the need for special adaptation or design” should be able to find his/her way [2]. This means that when considering the hospital architecture, designers should consider the wide range of users with varying abilities instead of trying to adopt a preconceived design to include them. Although the importance of well-designed wayfinding systems in healthcare facilities like hospitals and clinics is always present, it is often underappreciated, overlooked and rarely included in the healthcare environment planning and design process [3][4]. At the Hospital level the consequences of a wayfinding system that lacks in design quality are related with: lost of time by the staff members, as they have to interrupt their activities to provide directions; delayed and missing appointments when patients don’t reach the departments where they are scheduled to attend on time or because they already left the hospital due to dissatisfaction and frustration or even potential lawsuits as a result of users wandering into spaces that are not part of the hospital’s public sphere [1][5][6].

The present work aims to develop and apply a methodology to determine the relative importance of the environmental factors that influence the different user groups of healthcare facilities. In order to meet this overall objective, the following research plan was adopted (from objectives to methods):

1. Ascertaining the environmental factors affecting the complexity of wayfinding tasks in healthcare facilities and the different groups of users that need to be considered when appraising this topic, by conducting an analysis of the available literature for this problematic together with the consultation of an expert panel on the topic.
2. Structuring a MCDA model by combining the environmental factors retrieved from the literature with the knowledge provided by the expert panel.
3. Obtaining the relative importance of the different environmental factors selected to be part of the model with different individuals belonging to one of the user groups predefined in earlier stages of the research, by exploring two MCDA methods. The idea behind the use of these two methods is superficially exploring which would be the most appropriate one to pursue with a conclusive study on the topic, by comparing their outcome and understanding which is the most intuitive according to the selected sample of users.

1.2. ENVIRONMENTAL FACTORS

The existing literature points out the morphological complexity of the facility's layout, also referred to plan configuration, as the most important architectural characteristic on wayfinding performance, followed by visual access, spatial differentiation and signage [7][8]. However, others argue that the traditional use of signage has failed to succeed in dealing with the wayfinding problem in hospitals, and it is being used as a remedy to overcome the poorly designed buildings [9][10]. Wayfinding is also considered a multi-sensory exercise, as users make use of four of their senses (sight, sound, touch and smell), while performing a wayfinding task [11]. Therefore, another important contribution to the effectiveness of wayfinding systems is the extent to which healthcare facilities account for how the different users use their senses while walking around and trying to find their way [11].The expansion and modernization of hospitals due do the increasing demand for healthcare, specialized care and diagnostic techniques, tends to increase the complexity of the routes that patients must follow to reach their destinations [12]. The complexity of these routes is intrinsically related with the morphological complexity of the facility's layout. Zijlstra et al. (2016), enumerate other factors such as building interchanges and floor changes as attributes to increase the complexity of patients' route. The literature also commonly refers to the Inter-Connection Density (ICD), as an objective measure of spatial complexity [13][14]. The ICD can be expressed as the average number of directional choices at each decision point [14][15]. The availability of more options at every decision point (i.e., environments with higher values of ICD), increases the number of spatial relationships to be remembered, makes the user take more time to reach the destination, to take more wrong turns along the path and to backtrack his/her route more often [14].

The degree of architectural differentiation in a building intends to quantify to which extent different areas of the building appear to be unique or confusing due to symmetry and repetition of similar elements. Differentiation of the architectural elements present in the various spaces of a facility can be introduced by varying their size, shape, colour or architecture style [8]. According to Baskaya et al. (2004), the more distinct a place tends to be, the more easily it will serve as a cue to guide human experience and decision-making behaviour. Therefore, the monotony of architectural elements and the lack of reference points or landmarks tend to increase the complexity of wayfinding in hospital leaving each space less distinct and memorable from others. Nevertheless, facilities should present a balanced degree of differentiation within spaces, as the presence of extreme differentiation can lead to users' disorientation and frustration [8].

3. METHODOLOGICAL APPROACH

3.1. MCDA STEPS

Reviewing the goals of the present research, one can highlight the structuring of a model containing the environmental factors that affect users' wayfinding performance and its further use to assess users' preferences and determine the relative importance of the different elements present in the model. The steps described are typical activities used in the MCDA framework. Three main stages were identified as being part of the methodology designed and presented in Figure 2. 1) Problem Formulation, 2) Problem Structuring and 3) Model Building, with this last stage being divided between the structuring of the model and its further evaluation. A Working Group (WG) of four experts in the wayfinding domain and in the architectural features of built environments was brought together to collaborate in the different stages of the process. This collaboration allowed to explore individual perspectives, but also share different points of view and knowledge that would enrich the quality of the work developed.

Two specific MCDA methodologies, the AHP and the MACBETH were selected to obtain the relative importance of the criteria present in the model. Experts have identified a growth trend in the application of MCDA within the healthcare framework and these two different methodological approaches are widely used in prioritization and decision-making problems when dealing with multicriteria [17]. However, both techniques substantially differ in their questioning protocol. MACBETH makes use of qualitative or semantic judgments to express the difference in attractiveness between pairs of options whereas AHP uses qualitative judgments to express the same difference but regarding its importance for the user. The difference in terms of questioning is the following: for each pair of criteria (x,y), such that x is preferred to y from the standpoint of the user, in AHP the evaluator is asked to judge how many times x is preferred to y – a ratio judgment – whereas in MACBETH the user is asked what is the difference in preference between x and y. Hence, the AHP approach is characterized by obtaining ratio scales derived from quantitative pairwise comparisons of hierarchical levels, whereas in MACBETH interval scales are derived by qualitative pairwise comparison judgments [18].

After the definition of the evaluation criteria and their hierarchical structuring in a value tree (Figure 2), each criterion was operationalized by constructing descriptors of performance. Such construction was based on the available literature and then presented to the WG for further adjustments and approval. Two reference levels were defined for each evaluation criterion (one neutral and one good). The definition of the different reference levels was carefully performed to ensure a clear and unambiguous interpretation of their meaning. Although the operationalization of the evaluation criteria is not part of the AHP approach (only the MACBETH one), it ensures that they are compared using references levels. By doing so, all the participants are placed at the same level, as they do not evaluate the model and its different criteria from an unspecified level of performance. Furthermore, without references the participants' judgements might be influenced by their knowledge and experience, which could introduce bias during the assessment.

The conclusion of the model structuring was followed by activities focused on assessing the relative importance of the different environmental factors (selected in the previous

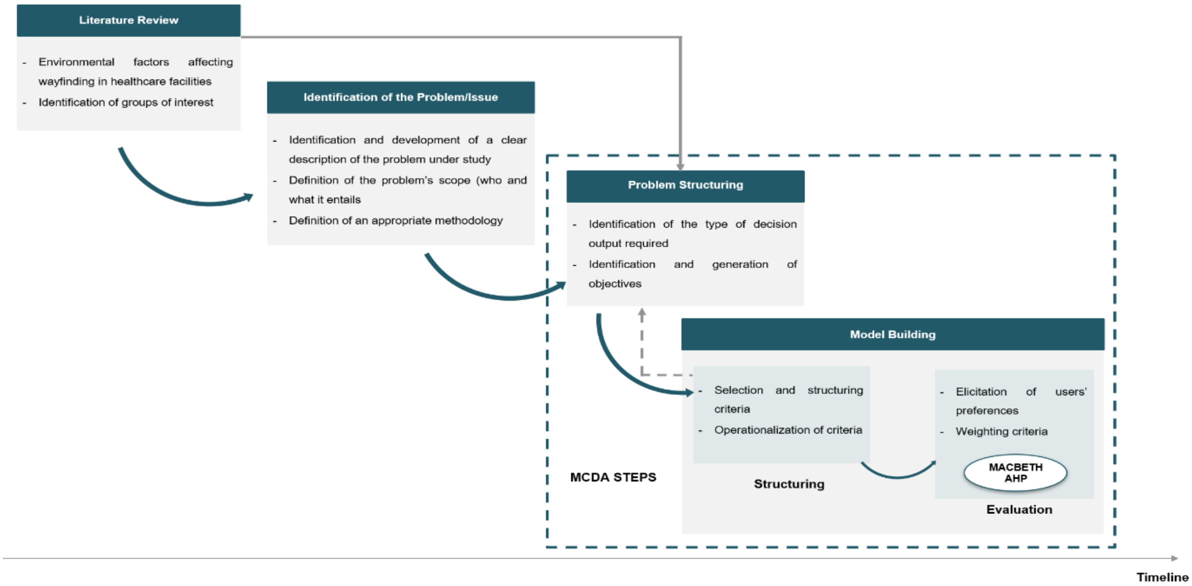


Figure 1: Schematic representation of the proposed methodology. Note: full arrows represent sequential processes whereas the dashed one represents an iterative process.

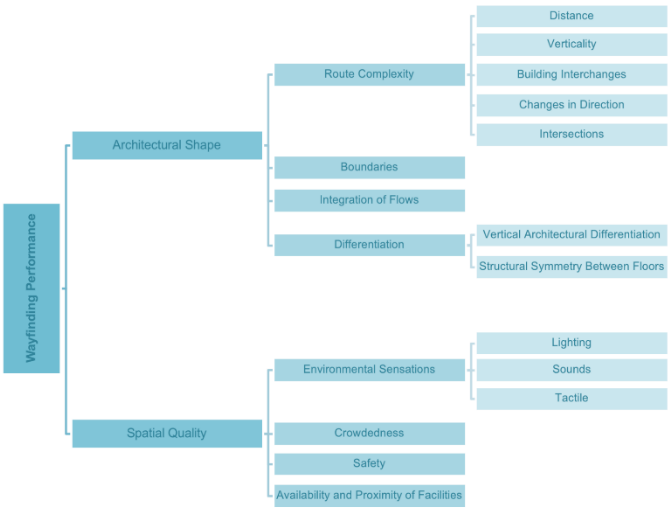


Figure 2: Value tree of evaluation criteria.

stage) affecting the wayfinding performance of healthcare facilities' users.

3.2. PRACTICAL ASSESSMENT

During the last two weeks of July 2019, the researcher tried to establish contact with retirement and nursing homes located within the Flanders region of Belgium, the country where the research was conducted. A positive feedback was received from a facility located within the target region, whose manager was contacted for further details and explanation of the entire project and showed interest in collaborating in this research work by allowing several visits and personal interviews with the patients interested in participating. Prior to the practical assessment, an information sheet and an informed consent were prepared to
distribute among the participants. Two versions of these documents were elaborated, one in English and one in Dutch.

It is important that they develop a full understanding of how the information gathered will be further used and processed but also, of what is expected from their participation. Figure 3 illustrates the three different steps of the methodology intended to be performed by each participant. Five visits took place to the retirement home during the month of August 2019 in order to conduct the study. A preselection of participants was performed by the facility's staff who provided the researcher a preliminary list of 16 patients who demonstrated interest in collaborating in the study. Furthermore, and given the constrains imposed (of not including participants without a full cognitive capacity), one occupational therapist agreed on evaluating the model on behalf of a user with a cognitive impairment. Since these professionals are used to deal with such patients in their daily work, they have a good perception on how the factors present the model contribute to a decline in their reasoning and ability to find their way around healthcare environments. Other two members of the staff (another occupational therapist and one general assistants) also agreed on participating in the study as representatives of users without reported disabilities. Therefore, a total amount of 19 participants was scheduled to participate in the assessment.

- ***Part I – Demographic Assessment***

A demographic assessment took place in the form of a multiple-choice questionnaire, in order to categorize the patients by age, gender and type of impairment. It was composed of eight questions and the ones used to assess users' impairments where adapted from the World Health Survey (WHS) [19]. This survey was conducted worldwide by the World Health Organization aiming to obtain a global picture on the prevalence of disabilities among the population.

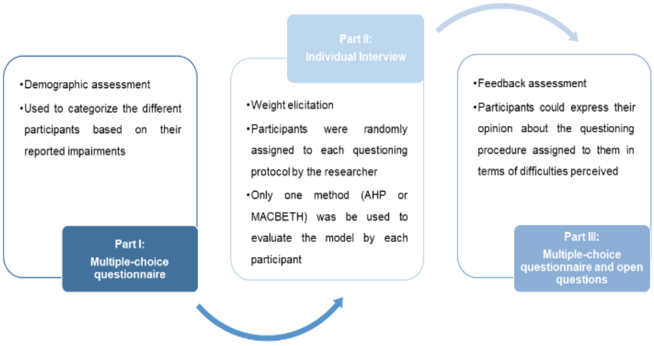


Figure 3: Methodology developed for the pilot study.

- ***Part II – Weight Elicitation***

This part was exclusively dedicated to deriving the criteria weights based on the users' judgements. It was conducted in the form of personal interviews (in English) between each participant and the researcher, which randomly assigned each participant to one of the two questioning protocols, having in mind the need for a balanced sample of participants per method and type of impairment. The interaction with each participant started by providing some context and detailing the objectives of the research work. A list of the criteria included in the model together with all the performance descriptors that operationalize each of them was also provided. The technical steps required at this stage to perform the elicitation of weights in each software were performed by the facilitator. Prior to the completion of each pairwise comparison matrix, the ranking of the swings for each criterion took place in both questioning protocols. Although the swing ranking step is not contemplated in the AHP approach, it was adopted as an attempt to provide valid references for the criteria under comparison and to reduce the inconsistency of the future judgements – given the number of criteria present in the model. A total amount of 15 cards (the number of evaluation criteria) containing each swing being evaluated was distributed to the participants during the interview. An example of such card is presented in Figure 4. In total, 42 pairwise comparisons were requested to each participant. To ease the reasoning behind each pairwise comparison, similar cards to the one presented in Figure 5 were distributed to them. The researcher suggested the consideration of two distinct situations in each criterion: situation A and B. Situation A would represent a neutral level of performance, whereas situation B a good level of performance. The participants would then evaluate the transition from one situation to another in both criteria under comparison (from left to right in Figure 5).

For each pairwise comparison in the MACBETH approach, the participants were asked "What is the difference in attractiveness between the transition from situation A to situation B in (1) and the transition from situation A to situation B in (2)?". Each of these questions was answered using one of the levels of the following scale: (1) no difference, (2) very weak, (3) weak, (4) moderate, (5) strong, (6) very strong, (7) extreme. During the completion of the pairwise comparison matrices, every time the software alerted for the introduction of an inconsistent judgement, the researcher asked the participants to revise it, by proposing the suggestions available on the screen.

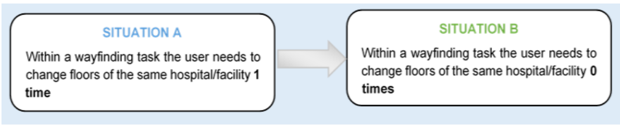


Figure 4: Example of one of the 15 cards distributed to the participants for the swing raking procedure.

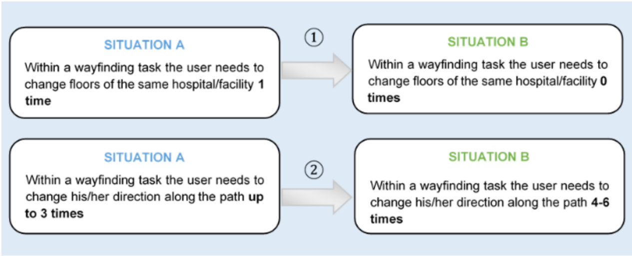


Figure 5: Example of pairwise comparison card given to the participants.

After the completion of each pairwise comparison matrix, the software generated the correspondent interval scale for the criteria being evaluated. These figures were shown to the participants in order to obtain their validation for the criteria weights derived from their judgements. It was also given the opportunity to them to adjust the values if they intended so, without violating the consistency of the judgements.

In contrast to the MACBETH approach, the participants to whom the AHP questioning protocol was assigned to were asked "How important is the transition from situation A to situation B in (1) in comparison to the transition from situation A to situation B in (2)?". In other words, each user was asked to indicate the transition – (1) or (2) – that he/she considered more important and by how much in comparison to the other transition. To quantify this importance, the nine-point scale of Table 1 was used. For this questioning protocol, the consistency of the judgements was only performed after the determination of the vector of weights for each matrix. If the Consistency Ratio (CR) for each matrix was equal or higher than 0.10, the participants would be asked to revise their judgements. Suggestions on how to reduce the CR were given to the participants, by indicating examples of modifications proposed by the software. The modification of the initial judgments was performed with a close follow up from the researcher, ensuring that fair comparison was made between the elements avoiding the manipulation of the pairwise comparisons' values in order to get rid of the inconsistency.

Moreover, and aiming to ensure that the ranking of the swings previously completed was respected, the researcher also alerted the participants for inconsistencies detected during the weight elicitation that would infringe this ranking. Similar to the procedure described for the MACBETH questioning protocol, the participants were also confronted with the histograms of weights derived from their judgements in order to validate them. Adjustments in the weighting vectors were performed upon request, always ensuring that the condition of the CR falling below 0.10 was being respected.

A_{ij}'s value	Subjacent Interpretation
1	Criterion i and j are equally important
3	Criterion i is moderately more important than j
5	Criterion i is strongly more important than j
7	Criterion i is very strongly more important than j
9	Criterion i is extremely more important than j
2,4,6,8	Intermediate values
Reciprocal Values	If criterion i has one of the above importance levels assigned to it regarding its comparison with criteria j, then j has the reciprocal value when compared with i

Table 1: Nine-point scale used to perform pairwise comparisons between the criteria in the AHP protocol [20]

- ***Part III – Feedback Assessment***

The final part of the practical assessment consisted of a feedback questionnaire where the participants had the opportunity to express their opinion about the questioning procedure used to assess their preferences by answering simple multiple-choice questions about its difficulty and overall satisfaction. They were also submitted to a hypothetical questioning protocol different from the one used in the part II of their assessment, i.e., the one they were not assigned to. The idea behind was trying to perceive which would be the most intuitive questioning protocol to use with a larger sample if the results were robust enough to draw such conclusion. It was asked the difficulty perceived in performing pairwise comparisons using the new questioning protocol and if the participants would rather prefer the new questioning protocol over the one they were assigned to, or if they were indifferent to it.

4. RESULTS

4.1 CHARACTERIZATION OF THE SAMPLE

The sample used to test the model was considered well balanced concerning the number of participants assigned to each questioning protocol (47.1% for the AHP and 52.9% for the MACBETH), although slightly unbalanced if one considers only the patients subsample (42.9 and 57.1%, respectively). In the participants' subsample, 64.3% of the individuals were aged 70 or higher, with the female gender being the most representative (57.1%). Regarding the three providers who participated in the study, all of them were aged between 20 and 29 years old and no impairments were reported for this group. All the patients reported at least one type of impairment in the demographic questionnaire filled in, with some participants reporting more than one type of difficulties. Given the inherent characteristics of this subsample, especially the age of the group and the fact that all of them were inhabitants of a retirement home facility, this was somehow expected. However, it is important to highlight that the evaluation of their health status in what regards the degree of perception of the impairments was performed by the participants themselves. Therefore, it might not correspond to the full veracity of their condition or differ from a hypothetical standard evaluation performed by a medical doctor or other type of healthcare professional. In order to categorize the patients into one or more user groups UGj (j = 1, 2, 3, 4) included in the problem scope, it was necessary to analyse their answers to the questionnaire. In a scale from none to extreme concerning the extent to which each impairment affects their ability to perform daily routine tasks, only participants who reported at least a moderate restriction were integrated in the respective user group UGj (j = 1, 2, 3, 4). The result of the integration of the participants into one of the user groups predefined in the problem's scope – per assigned questioning protocol – is presented in Table 2.

Table 2: Integration of the participants into one of the user groups predefined in the problem scope per assigned questioning protocol.

User Group	Questioning Protocol	
	AHP	MACBETH
UG_1 – Unimpaired User Group	1	1
UG_2 – Perception (Sensory) Impaired User Group	3**	2**
UG_3 – Mobility Impaired User Group	4****	4
UG_4 – Cognitive Impaired User Group	1*	2***

Notes: * – Provider who evaluated the model on behalf of a cognitive impaired user. ** – One of the patients reported both vision and hearing impairments. *** – Both patients reported difficulties in concentrating and remembering things and learning a new task. **** – One of the patients in this group is also categorized under UG2.

4.2 CRITERIA WEIGHTS

This section comprises the analysis of the criteria weights obtained using the AHP and MACBETH approaches where an aggregation of the individual judgements for each approach within the same user group (when applicable) took place. According to Ramanathan and Ganesh (1994), the weighted average mean is the most appropriate statistical measure to reflect the priorities of the group as a whole. In this approach, all the individuals assigned to participate in the assessment perform their individual pairwise comparisons and once this step is concluded, the individual outcomes are aggregated using the arithmetic mean [22]. After this aggregation, the weight obtained for each criterion could be interpreted as the relative importance of having a similar experience to situation (1) rather than situation (2) – following the reasoning depicted in Figure 5 – in that criterion during the completion of wayfinding tasks (from the standpoint of the user group).

- ***AHP***

The result of a similar analysis to the one conducted by Danner et al. (2017) is presented in Figure 6. It was conducted in order to evaluate the overall inconsistency of the judgements performed by the participants who used the AHP approach in the weight elicitation step. Therefore, an average of the CR for the individual judgements performed by the patients' subsample regarding each node was calculated. Since the CR is only calculated when three or more pairwise comparisons are performed, the differentiation node was not considered for this analysis (as only one pairwise comparison was required). By analysing Figure 6 one can depict that the average value of the CR progressively increased with the number of pairwise comparisons required in each node (3, 10 and 28, respectively). Regarding the obtained CR values for the provider included in the AHP subsample (8.25, 8.20 and 11.16%), they are considerably lower than the averaged ones presented in Figure 6, with only the last CR value requiring a review of the judgements. Although, a comparative analysis between the CR values obtained for the two subsamples would be desirable here, in order to determine if the inherent characteristics of the patients' subsample influenced the outcome, the size of the providers' subsample (n=1) does not allow so.

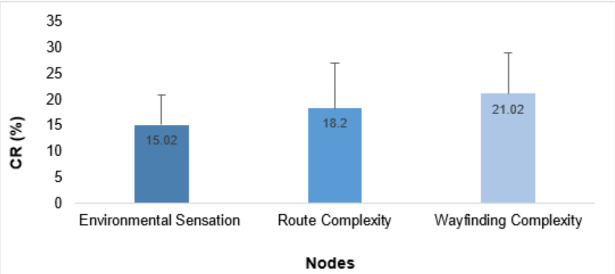


Figure 6: Averaged CR for the individual judgements performed by the patient's subsample (n=7) using the AHP approach for the different nodes.

Table 3 presents the obtained weights for the Spatial Quality and Architectural Shape nodes. These weights were calculated based on the sum of the weights of their respective children nodes (according to the properties of an additive value model). The results obtained and here presented need to be interpreted as reflecting the amendments made in the original AHP questioning protocol to implement in the current study. In the traditional approach, the higher the weight, the more important the respective criterion is for the user. Here the weight attributed to the different factors regards the importance that the users give to the transition from a neutral to a good performance level in each of them.

Table 3: Weights obtained for the spatial quality and architectural shape nodes in AHP protocol.

User Group	Weights	
	Spatial Quality	Architectural Shape
UG_1 – Unimpaired User Group	28.97	71.03
UG_2 – Perception (Sensory) Impaired User Group	51.35	48.65
UG_3 – Mobility Impaired User Group	43.88	56.12
UG_4 – Cognitive Impaired User Group	39.05	60.95

Note: The weights displayed for UG_2 and UG_3 are aggregated values.

For the UG_3, the route complexity seems to be the factor to which the participants would value the most in obtaining an improve from a neutral to a good level of performance (31.38%), followed by the availability and proximity of facilities (16.00%), the crowdedness (13.77%) and the differentiation of the spaces (13.07%). In the route complexity node, this subsample considered expressed preference for the verticality and building interchanges aspects, where aggregated criteria weights of 35.04% and 32.81% were respectively obtained. In the environmental sensation node, all the participants gave more importance to the lighting aspect (which obtained an aggregated weight of 69.50%), whereas in the differentiation node, both factors appeared to show similar importance to the participants (54.17% and 45.83% for the structural symmetry of floors and vertical architectural differentiation). The UG_2 tended to attribute similar value to some of the factors mentioned above for the wayfinding complexity node, but also recognized as highly important aspects like the own safety of the users (with a weight of 22.37%). Major differences between these two user groups were detected in the environmental sensation and differentiation nodes. In the former, the aggregated weights showed that the UG_2 would preferer an improve from a neutral to a good level of performance in the sounds' criterion (which obtained a weight of 50.71%), followed by the lighting aspect (with a weight of 35.36%). In the latter node, the participants gave considerably more importance to the transition from situation A to B in the structural symmetry of the floors (77.78%) in comparison to the same transition in the vertical architectural differentiation present in the building. In the route complexity node, the building interchanges and the verticality were also the factors which obtained the higher weights (36.70 and 25.96%, respectively), similar to what was observed in UG_3. The participant who performed the weight elicitation exercise on the behalf of a cognitive impaired user assigned the complexity of the route as the factor that most influences the wayfinding complexity in a healthcare environment (32.36%), followed by the availability and proximity of facilities (20.24%), the boundaries (12.60%) and the differentiation (12.26%). In the route complexity node, in opposition to the results obtained for the other user groups, the changes in direction (with a weight of 43.68%) and the intersections (27.67%) seem to be the factors that assume more relevance when considering an individual with such disabilities, from the perspective of the occupational therapist. In the environmental sensation node, the sounds and lighting obtained similar weights of 46.92 and 44.68%, respectively, whereas in the differentiation node, the vertical architectural differentiation was the subcriterion with the highest weight (75.0%). Finally, for the unimpaired user included in the AHP questioning protocol, the route complexity was also assigned as the factor with the highest weight in the wayfinding complexity (35.45%), followed by the differentiation (18.07%) and the availability and proximity of facilities (18.02%). In the route complexity node, the ranking of the criteria was quite similar to the one obtained for the UG_2, with the exception of the first two factors, where verticality was assigned to the highest weight (47.86%), followed by the building interchanges (25.86%). The criteria weights obtained for the environmental sensation node were very similar to the aggregated weights of UG_3, whereas in the differentiation node were the same as the ones obtained for UG_1. Finally, by observing Table 3, one can denote that the architectural shape node was identified by three of the four user groups – UG_j (j = 1, 3, 4) as being the one with the highest importance in the wayfinding complexity (in comparison to the spatial quality). Only for the UG_2 the sum of the criteria weights for the spatial quality node was slightly higher than for the architectural shape, with respective weights of 51.35 and 48.65%. The most pronounced difference between the weights of the two nodes was observed in the unimpaired user group, where the sum of the criteria weights was 28.97% for the spatial quality node and 71.03% for the architectural shape node.

- ***MACBETH***

For the individual (UG_1) and aggregated criteria weights (UG_2, UG_3 and UG_4), the route complexity seems to be the factor where these users would prefer the most to have an improvement from a neutral to a good level of performance in the wayfinding complexity node. Similar weights for this criterion were obtained for UG_1-UG_3 (22.22, 21.99 and 23.81%, respectively), with the UG_4 assigning an aggregated weight of 31.74% to this factor. For the UG_1 and UG_3 other factors revealed to be highly attractive as well, like the differentiation (19.44 and 15.85%, respectively), safety (16.64 and 19.54%, respectively) and the availability and proximity of facilities (13.89 and 16.43%, respectively). The UG_2, besides the route complexity in the global node, also considered similar attractive the availability and proximity of facilities and the safety (19.99 and 19.45%, respectively), whereas the UG_4 ranked the safety and the boundaries as the second (16.34%) and third (14.84%) most attractive criteria in the global node. Two user groups (UG_1 and UG_3) ranked the environmental sensation criterion as least attractive (1.39 and 1.46%, respectively), whereas the two others (UG_2 and UG_4) considered the integration of flows as the least attractive criterion (3.58 and 1.85%). In the environmental sensation node, the tactile was considered the least attractive criterion for the four user groups. The weights ranged from 7.14 to 8.89% for UG_1, UG_3 and UG_4, with a more expressive weight of 22.22% being obtained for UG_2. The lighting was considered the most attractive criterion in this node for UG_1, UG_3 and UG_4 with weights ranging from 57.15 to 60.59%, whereas UG_2 ranked it as the second most attractive, preceded by the sounds with a weight of 45.83%. In the route complexity node, similar weights were obtained to the verticality and the building interchanges in all the user groups, with these two factors being listed as the two most attractive ones. In the UG_4 it is important to highlight that the criteria weights are more uniformly distributed among the five factors under comparison in the route complexity node, as no criterion seems to be extremely less or more attractive than others as observed for other user groups. In the differentiation node, similar weights were obtained for both factors for UG_3 and UG_4. For the differentiation node, UG_3 and UG_4 attributed similar weights to both factors, whereas noticeable differences were observed for UG_2 and specially for UG_1. The participant included in the latter user group considered that an improvement from a neutral to a good level of performance was considerably more attractive for the vertical architectural differentiation (with a weight of 69.27%).

Finally, by observing Table 4, one can denote that the architectural shape node was also identified by three of the four user groups – UG_j (j = 1, 3, 4) as being the one with the highest importance in the wayfinding complexity (in comparison to the spatial quality), similar to what was previously presented in the previous section for the participants assigned to the AHP questioning protocol. Only for the UG_2 the sum of the criteria weights for the spatial quality node was slightly higher than for the architectural shape, with respective weights of 54.36 and 45.64%.

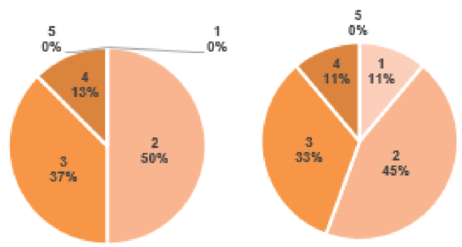
Table 4: Weights obtained for the spatial quality and architectural shape nodes.

User Group	Weights	
	Spatial Quality	Architectural Shape
UG_1 – Unimpaired User Group	38.89	61.11
UG_2 – Perception (Sensory) Impaired User Group	54.36	45.64
UG_3 – Mobility Impaired User Group	48.35	51.65
UG_4 – Cognitive Impaired User Group	42.40	57.60

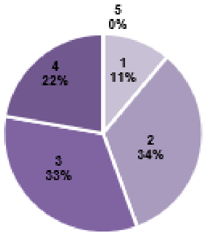
Note: The weights displayed for UG_2, UG_3 and UG_4 are aggregated values.

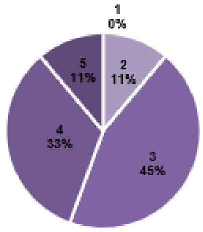
4.3 FEEDBACK OF THE ASSESSMENT

The results obtained for what regards the overall satisfaction and difficulty perceived by the participants in completing the second part of the practical assessment are divided by questioning protocol (Figures 7 – 10). The averaged difficulties perceived in expressing preferences by the participants for both questioning protocols (AHP and MACBETH) were very similar, 2.63 and 2.67 (in a scale from 1-5), respectively. The researcher had quite a similar perception of their performance, as the averaged perceived difficulties obtained were respectively 2.89 and 2.88 (in a scale from 1-5). None of the participants revealed extreme limitations in completing the assessment, although the researcher noticed that the scale used to complete the pairwise comparison matrices in the MACBETH was more straightforward for the participants. In the AHP approach, they were asked to quantify the difference in importance between the transition from one situation to another regarding two different criteria. A scale from 1-9 was used, however the participants were asked to answer these questions having in mind the subjacent interpretation of the values (according to Table 1). Hence, having to look to a similar table to perform their judgements required an extra effort comparing to the MACBETH approach, where no subjacent interpretation of the qualitative judgments was needed. This difference is somehow reflected in the overall satisfaction of the participants after completing their assessment, where averaged satisfaction values of 2.5 (50.0%) and 3.4 (68.9%) were respectively obtained for the participants assigned to the AHP and MACBETH questioning protocols.



Figures 7 and 8: Difficulty perceived in expressing preferences by the participants to whom the AHP questioning protocol was assigned to, using a 1-5 scale – from 1=very easy to 5=very difficult (on the left) and overall satisfaction regarding the questioning protocol assigned using a 1-5 scale – from 1=very dissatisfied to 5=very satisfied (on the right).





Figures 9 and 10: Difficulty perceived in expressing preferences by the participants to whom the MACBETH questioning protocol was assigned to, using a 1-5 scale – from 1=very easy to 5=very difficult (on the left) and overall satisfaction regarding the questioning protocol assigned using a 1-5 scale – from 1=very dissatisfied to 5=very satisfied (on the right).

Regarding the question of the feedback assessment questionnaire – where the participants were supposed to express the difficulty perceived in expressing their preferences using the new questioning protocol – the results were inconclusive. Some participants manifested preference over the new questioning protocol but considered it more difficult than the one assigned to them. Others manifested preference over the questioning protocol assigned to them but still considered it more difficult, so no conclusions can be taken from this question. Regarding the general preference for one of the methods (or the indifference in being assigned to one of them), the results are presented in Table 5.Most of the participants (70.6%) did not express interest in having been assigned to a different questioning protocol, with only 11.8% manifesting a preference over the new approach and 17.6% revealing indifference over the two methods.

Table 5: Preferences manifested by the participants in being assigned to one of the questioning protocols.

Questioning Protocol	Number of Users
AHP	6 (35.3%) *
MACBETH	8 (47.1%) **
Indifferent	3 (17.6%)

Notes: * – Five of them were initially assigned to this questioning protocol. ** – Seven of them were initially assigned to this questioning protocol.

The researcher monitored the time the participants took to complete the weight elicitation step, as contemplated in the fifth question of the feedback assessment questionnaire. 30 minutes was the initial time estimated to complete this task given the number of pairwise comparisons required and the characteristics of the sample. Ten participants (58.8%) were able to do so, while seven others (42.2%) exceeded the estimated time. The average time spent to complete the task was 35.2 min for the overall sample, and 33.3 and 37.4 min for the subsamples assigned to the MACBETH and AHP questioning protocols, respectively.

The difference in time between the two questioning protocols can also be explained by the extra effort associated to the subjacent interpretation of each value in the scale used in the AHP approach. This difference is somehow reflected in the overall satisfaction of the participants after completing their assessment, where averaged satisfaction values of 2.5 (50.0%) and 3.4 (68.9%) were respectively obtained for the participants assigned to the AHP and MACBETH questioning protocols.

Regarding the type of difficulties felt during the study, all the participants point out that the weight elicitation step was too extensive and required too many pairwise comparisons, more than they were expecting in the beginning of the assessment. Overall, most of the participants, especially the patients of the retirement home facility, felt tired by the end of the exercise. In addition, the researcher noted that for some of them, the cognitive overload associated to this assessment exceeded their cognitive capacity, and close to the end of the weight elicitation exercise, they were not fully focused as in the beginning. The large number of factors present in the model and the non-familiarity with the scale used were also aspects mentioned by some of them, while others manifested discomfort with the number of options to choose from in the scales used. This discomfort was more expressive in the AHP approach, were some participants questioned the researcher why the scale was built from 1-9 and not from 1-5, which would have reduced the cognitive burden associated to the number of options to choose from.

During the time the participants had contact with the detailed description of all the factors present in the model, the researcher also noticed that some concepts were not as clear or easy to assimilate as desirable (given the characteristics of the sample), as some participants asked for further clarification.

The final question of the feedback assessment intended to gather suggestions from the participants, that could enhance the quality of a future similar study conducted in the topic. Here the researcher highlights the criticism presented to the number of factors present in the model. This was considered a major drawback of the present study by some of the participants, by arguing that the study should have been focused on a smaller group of factors. One participant also suggested that if the number of factors present in the model would have been lower, a small group of people could have been brought together to perform the weight elicitation exercise, instead of conducting individual interviews with the different participants. Moreover, the individual said that the contact with others during such activity would stimulate the discussion about the topic and would be interesting to collect other points of view.

5. DISCUSSION

5.1 INTERPRETATION OF THE MAIN FINDINGS

- ***Inconsistencies in the judgments for the AHP protocol***

For the AHP questioning protocol, the average value of the

CR (Figure 6) progressively increased with the number of pairwise comparisons required in each node (3, 10 and 28, respectively). This is an expected result as the increase in the number of pairwise comparisons is associated to a higher cognitive burden. Hence, it may lead the users to pay less attention to the judgments previously performed in order to complete the process in the shortest time span, which consequently increments the likelihood of having a higher CR. In Danner et al. (2017) research work, an average inconsistency level of 16.4% was obtained for the global node, which was only composed of five criteria (requiring the completeness of ten pairwise comparisons). The averaged CR for the wayfinding complexity node (21.02%) is not very distant from the previous value, especially if one considers the number of pairwise comparisons required to obtain the weights for this node. In addition, the ranking of the swings for each criterion that preceded the pairwise comparisons performed for each weighting matrix might have contributed to lower the averaged CR values obtained, as the researcher ensured that the ranking previously determined was respected during this exercise. However, no further conclusions can be drawn on this matter as none of the groups who use the AHP approach to determine criteria weights (either patients or providers) perform such exercise without previously ranking the respective swings, which would be required to perform a comparative analysis.

- ***Obtained criteria weights***

Overall the participants assessed considered that the simpler the route, the easiest the wayfinding task becomes in a healthcare facility, but also that having available a set of facilities along their route (elevators and staircases, toilets and emergency exits) have almost similar importance as walking around in crowded places or in spaces where the differentiation pattern is not the highest. Moreover, the participants also demonstrated that feeling that the environment where they perform the wayfinding task provides them a good level of safety (rather than a moderate one) is quite important. Feeling threatened in such crowded environments by walking in a floor with a low slip resistance, encountering disturbing objects in the path or using facilities like elevators or staircases with a questionable level of safety would normally affect the users' ability to find their way around. The participants (especially UG_2-UG_4) also expressed a noticeable preference for a higher number of soft (open) spaces compared to hard spaces in healthcare facilities. Having to pass through a lot of doors along the route might be quite unpleasant for users in wheelchairs or with vision impairments, thus open spaces would ease their ability to freely move around, especially in crowded areas. In the wayfinding complexity node, the integration of flows and the environmental sensation were overall identified as the criteria with the least importance for the different user groups. It seems that these individuals would not mind circulating in corridors and spaces together with healthcare professionals or other type of users, as they believe that this does not affect to a major extent their ability to perform wayfinding tasks. Regarding the environmental sensation perceived while trying to find their way around, the users expressed in the assessment that an improvement from a neutral to a good level of performance would only decrease the wayfinding complexity to a minimal amount. Regarding the route parameters under evaluation, the participants expressed strong preference for not changing between the facility buildings along their route and to circulate in buildings with direct connections between all the floors. For users with cognitive impairments other factors seem to play a major role as well, namely the estimated distance to travel from the onset of the wayfinding tasks to the final destination, the average number of directions to choose from at a decision point and the number of turns taken along the path. In the environmental sensation node, the amount and type of light available in the environment and the sounds users may experience while traveling around the facility were the factors that obtained the highest local weights, with the tactile aspect only obtaining noticeable weights for the users included in UG_2. However, the three criteria weights obtained for this node are not globally significant, giving the low weight of the parental node. In the differentiation node, both factors assumed similar importance for the users, with the vertical architectural differentiation playing a major role for the unimpaired user group. Thus, having striking landmarks across the route and specially in the main circulation spaces was identified as a great differentiation asset that helps the users in locating themselves in the environment. Moreover, having structural symmetric floors considerably helps them in moving between floors and in locating facilities like toilets, elevators or emergency exits.

- ***Preferences Manifested for the Questioning Protocols Used***

Since the participants were only exposed to one of the methods during the weight elicitation step and the second approach was only presented in the feedback questionnaire without requiring any pairwise comparisons, one can denote that the contact that the participants had with the new approach was minimal. This might have influenced the results obtained, as they most likely could not perceive all the potential advantages or disadvantages associated to the new questioning protocol with just a simple question. Moreover, by the end of the exercise, the participants were already quite familiar with the questioning protocol assigned to them, which might also have interfered in their decision of not selecting a different method. The obtained results express this familiarity by a certain extent, as 70.6% of the participants selected the same method assigned to them as the most preferred one. Given the participants performance regarding the two different questioning protocols selected to obtain the criteria weights, one can say that both are adequate to pursue for a large-scale research on the topic. The AHP approach revealed to be slightly more time consuming than the MACBETH one, but the results were not significant enough to state that the latter should be chosen over the former if one would only intend to select one questioning protocol in the future.

6. CONCLUSION

The present research work provides a comprehensive explanation of the set of aspects collected in the available literature that are linked to the wayfinding performance in complex buildings and specially in healthcare facilities. Moreover, it brought together a set of experts that helped in the structuring process of this factors into a value tree of evaluation criteria and provided their contribute to complement what was previously retrieved from the literature. In order to evaluate the role that these factors play in the wayfinding performance of individuals inserted in one of the user groups here explored, two MCDA approaches were selected. The use of MCDA in the current problem allowed to break down its complexity towards an intuitive and transparent process to access the priorities and values of the different users. The approaches used were adapted to the problem under study and an assessment session was conducted with elderly individuals from a retirement home facility. The participation of these users was extremely valuable and the author's knowledge, no similar research has been conducted until now in the topic. The obtained results contributed to a thorough understanding to which extent the inherent aspects of healthcare facilities affect users while trying to reach their destination in clinics and hospitals. Furthermore, they will hopefully be encouraging enough to expand the dimension of the sample used to assess the criteria weights and engage designers, facility planners and other researchers in the wayfinding domain to work together in developing effective wayfinding systems for such complex environments and accounting for the diversity of users.

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