A mixed methods approach to identify and predict people's perception of the design in healthcare waiting environments

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Abstract: Waiting for a healthcare appointment is part of the overall experience of a healthcare service. Therefore, healthcare waiting environments should incorporate design attributes which make this as pleasant as possible. The challenge is firstly to identify which design features contribute towards a pleasant waiting experience. This paper presents an approach to identify users' key design needs using a mixed methods research design. First, in-depth interviews were conducted to explore user perspectives of healthcare waiting environments in order to identify relevant design attributes. In the second stage, selected combinations of design attributes were converted into three-dimensional (3D) renderings. Subsequently, a survey was carried out to evaluate the pleasantness of the designs on a 7-point perceptual scale. Conjoint analysis was then applied to quantify the relative importance of each design attribute and to estimate utility scores of the design levels. With these measures, the perception of untested design concepts can also be predicted. Healthcare designers and researchers can use the presented method to understand user perspectives of healthcare waiting environment designs. This will help them focusing on the design attributes that are relevant to users, which in turn will contribute to an overall more pleasant experience of the healthcare service.

Key words: Conjoint Analysis, Preference, Emotion, Perception, Healthcare, Interior, Waiting Room

1. Introduction

The body of evidence showing a relationship between healthcare built-environment and end-user outcomes has grown rapidly in recent years [4, 21]. However, the cause-effect relationship between design variables and their impact remains unclear [2]. Asking people to express the importance of individual design features by means of distinctive values can be challenging. This is because they tend to think of the design as an overall concept and evaluate it as such rather than as a set of separate design features. According to Gestalt psychology, which was formed by a group of 18th century German psychologists, individuals assess their environment based on grouping elements with regard to their symmetry, similarity, movement etc. [12].

Conjoint analysis is an established method that is frequently used in consumer research to understand buyers' decision-making [8]. Due to its capability of revealing user perception of individual product or service features, the method has been popular in both academic research and industry [24]. Increasing trends of using mediums other than verbal description such as visual images and physical prototypes in conjoint experiments have been observed [9]. The use of visual methods in conjoint analysis can often be found in the context of testing the aesthetic dimension of a new product [22]. However, this application has not been carried out for the interior design of built-environments, therefore it has potential to be used to understand preferred design attributes in healthcare waiting environments. There is need for concise directions on how to perform these types of experiments in a rigorous and systematic manner.

The objectives of this paper are to present a) A systematic approach to identify key design attributes of healthcare waiting environments that are most valued by users and b) Using preliminary empirical data to demonstrate the type of outcome achieved by using this method and to validate the conjoint model.

2. Methodology

A conjoint analysis using visual stimuli was performed to estimate how design attributes contribute to user perceptions of the pleasantness of healthcare waiting environments. To do this, a three stage research design was developed that includes a qualitative interview study to identify relevant design attributes, followed by their conversion into photo-realistic 3D renderings. A survey was then conducted to gather user perceptions of the pleasantness of healthcare waiting environments. Finally, this empirical data was used to perform conjoint analysis to show the relative importance of individual design attributes and levels. An overview of the research design is illustrated in Figure 1.

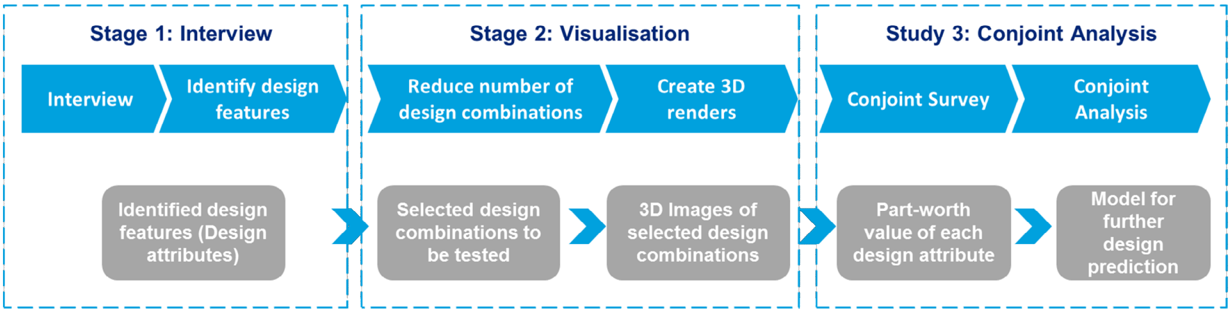

Figure.1 Overview of the research design

2.1 First stage – Identifying the most important design aspects to be studied

In this first stage, twenty-four in-depth interviews were carried out to explore user perspectives of healthcare waiting environments where participants were encouraged to share their perceptions of the design as well as personal experiences. Images of various healthcare waiting environments were used as visual stimuli. Content analysis of the interview data resulted in a large number of design attributes that participants used to describe their perspective of the design of healthcare waiting environments [23]. All design variables were extracted and their frequencies ranked. The most frequently mentioned design descriptors forming cumulatively 80% of the overall count were then considered for further selection. This cut off point was based on the Pareto Principles, where 20% of causes are suggested to explain 80% of the overall problem [11]. Design attributes were defined further based on their properties, characteristics or intensity (design level) such as 'Rows' and 'Groups' were defined design levels for the design attribute 'Seating Arrangement'. The final selection of design attributes and levels was made based on the guidelines in literature [7, 13]. Further considerations included a) design aspects mentioned in literature, b) how suitable design aspects were to be used as visual stimuli in this specific method and c) time constraints in order to avoid participants' fatigue and cognitive overload. Table 1 below gives an overview of the final selection of design attributes and levels for this study.

Table 1. Overview of Design Attributes and Design Levels

Number of Attributes	Design Attributes	Design Levels
1	Arrangement (Seat arrangement)	Groups Rows
2	Padding (Seat padding)	Hard (Without Padding) Soft (With Padding) With and Without Padding
3	Capacity (Seat capacity)	Multiple Seaters (Bench / Sofa) Single Seaters (Chairs) Both Seat Types
4	Reception (Reception desk)	Closed, against the wall Open, against the wall Closed, in the wall
5	Flooring	Wood / Laminate Vinyl / Shiny floor Carpet
6	Additional features (Set of TV, reading material, vending machine, green plants)	With additional features (Yes) Without additional features (No)
7	Signage (set of signs showing time, waiting time, consultation rooms, exit signs etc.)	With signage (Yes) Without signage (No)

2.2 Second stage – Reducing the number of design combinations and visualising design concepts

The number of design attributes and levels created in the previous stage resulted in a total of 648 design variations due to the 2x3x3x3x3x2x2 design. Empirically, it is not possible to test all variations due to time restrictions and participants' cognitive capacity.

An orthogonal design was therefore applied to reduce the number of profiles in order to generate an empirically feasible number of design variations. A fractional factorial design which is a subset of all possible combinations of design levels was produced. This subset of data, also called orthogonal array or Taguchi Methods [1, 18] ensured that the main effects of design levels were recorded. A number of additional design profiles called 'Holdout cards' were also produced as a control, to test the internal validity of the predicted model. They are design profiles that were rated in the experiment, yet, not included in the estimation procedures. The selected design combinations generated by the orthogonal design are shown in Table 2.

Different conjoint methods were compared and the full-profile conjoint approach was selected as the most appropriate for the purpose of the study. This was due to the smaller sample size required and its flexibility with regard to data collection using a computerised or paper-based survey.

Table 2. Overview of design profiles to be tested

Design Profiles

Card ID	Seating Arrangement	Seating Capacity	Padding of Seats	Reception Desk	Flooring	Add-on	Signage
1	Rows	Multiple Seater	With and Without Padding	Closed, Against the Wall	Vinyl	No	Yes
2	Rows	Multiple Seater	Hard	Open, Against the Wall	Carpet	Yes	No
3	Groups	Multiple Seater	Hard	Closed, Against the Wall	Wood	Yes	Yes
4	Rows	Single Seater	Hard	Closed, In the Wall	Wood	No	Yes
5	Groups	Both Seating Types	With and Without Padding	Closed, In the Wall	Carpet	Yes	Yes
6	Rows	Multiple Seater	Padded	Closed, Against the Wall	Carpet	No	Yes
7	Rows	Single Seater	With and Without Padding	Closed, Against the Wall	Wood	Yes	No
8	Groups	Multiple Seater	With and Without Padding	Open, Against the Wall	Wood	No	No
9	Rows	Multiple Seater	Hard	Closed, In the Wall	Vinyl	Yes	No
10	Rows	Both Seating Types	Hard	Open, Against the Wall	Wood	No	Yes
11	Groups	Single Seater	Hard	Closed, Against the Wall	Carpet	No	No
12	Groups	Multiple Seater	Hard	Closed, Against the Wall	Wood	Yes	Yes
13	Groups	Single Seater	Padded	Open, Against the Wall	Vinyl	Yes	Yes
14	Rows	Both Seating Types	Padded	Closed, Against the Wall	Wood	Yes	No
15	Groups	Multiple Seater	Padded	Closed, In the Wall	Wood	No	No
16	Groups	Both Seating Types	Hard	Closed, Against the Wall	Vinyl	No	No
17*	Groups	Single Seater	Padded	Open, Against the Wall	Carpet	No	Yes
18*	Rows	Both Seating Types	Padded	Closed, In the Wall	Vinyl	Yes	No
19*	Groups	Both Seating Types	With and Without Padding	Closed, Against the Wall	Vinyl	No	Yes
20*	Rows	Multiple Seater	With and Without Padding	Open, Against the Wall	Carpet	No	Yes

* Holdout

Based on these profiles, photo-realistic renderings were created using 3DS Max 2012 (Autodesk, San Rafael, USA). This technique was chosen due to a number of factors that served the purposes of the study: high level of flexibility to modify design attributes and levels systematically, control over constant variables, realistic result, in line with existing methods used by the design community to interact with other stakeholders in the early stage of the design process. Before the varying design attributes can be incorporated, a basic 3D Model with fixed design attributes was created. Those untested design attributes included in the basic 3D model such as the colour of seats, room size or type of ceiling were chosen with the intention to keep their effect on people's arousal minimal. An example is the blue colour of seats which was selected based on its neutral position on the colour scales presented by Ou (2004) [14, 15]. Examples of four design profiles that were converted into 3D images are shown in Figure 2.

Design Profile Number 1

Design Profile Number 6

Design Profile Number 7

Design Profile Number 14

Figure.2 Examples of design profiles converted into 3D renderings

2.3 Third stage – Conjoint Survey (Data Collection)

The number of design attributes and levels created in the previous stage resulted in a total of 648 design variations due to the 2x3x3x3x3x2x2 design. Empirically, it is not possible to test all variations due to time restrictions and participants' cognitive capacity.

In the third stage, the images were used to develop an online survey where users from the general public were asked to evaluate the displayed designs based on how pleasant they perceived the design.. Participants were given the scenario of visiting an outpatient healthcare facility for a routine check-up and asked to rate all images on a 7-point scale ranging from *very unpleasant* to *very pleasant*. The survey also included space for free comments and explanations to help interpreting rating scores in later stages. The experiment took 15-20 minutes on average.

Analysis was carried out on preliminary empirical data in order to demonstrate the potential outcome when applying this suggested methodological approach. SPSS 21.0 (IBM Corp., Armonk, USA) was used to calculate the relative importance of design attributes and levels expressed in importance values and utility scores.

The basic conjoint analysis model is described in Eq. (1) as follow:

$$U(X) = \mu + \sum_{i=1}^{m} \sum_{j=1}^{k_i} \alpha_{ij} x_{ij} \qquad (1)$$

Where

U(X) = Overall utility of an alternative *X*, where *X* is a vector with entries x_ij

μ = Constant (base utility)

α_{ij} = the part-worth contribution or utility associated with the *j* th level (*j*, *j* = 1, 2, . . . k_i) of the *i* th attribute (*i*, *i* = 1, 2, . . . *m*)

x_{jj} = 1 if the *j* th level of the *i* th attribute is present (x_{jj} = 0 otherwise)

k_i = number of levels of attribute *i*

m = number of attributes

3. Findings and Validation of the Model

The preliminary analysis was based on scores gathered from 86 participants living in the United Kingdom. All design levels were defined as categorical (discrete) as no other assumptions about the relationship between the design factors and the rating scores were made. Table 3 provides a summary of the chosen discrete model.

Table 3. Model Description

Model Description

	N^{o} of Levels	Relation to Scores
Arrangement	2	Discrete
Capacity	3	Discrete
Padding	3	Discrete
Reception	3	Discrete
Flooring	3	Discrete
Additional Features	2	Discrete
Signage	2	Discrete

All factors are orthogonal.

Table 4 provides an overview of the calculated importance values shown as percentages. These values reflect the relative importance of a single design attribute in relation to the pleasantness of the overall. With 19.35% of the overall value, ‘Flooring’ impacts most on the perception of pleasantness, followed by ‘Padding’ and ‘Capacity’ of the seats with 18.18% and 17.95% respectively.

Table 4. Importance Values of Design Attributes

Importance Values

Arrangement	10.369
Capacity	17.951
Padding	18.177
Reception	14.380
Flooring	19.345
Additional Features	11.619
Signage	8.158

Averaged Importance Score

For each of the design level associated with the above mentioned attributes, part-worth values in form of ‘Utilities’ were estimated as shown in Table 5. The higher a utility score, the more it contributes to the overall utility of a design profile.

Table 5. Utility scores of design levels

Utilities			
		Utility Estimate	Std. Error
Arrangement	Groups	-.189	.079
	Rows	.189	.079
Capacity	Multiple Seater	-.099	.106
	Single Seater	.137	.124
	Both Seating Types	-.038	.124
Padding	Hard	-.207	.106
	Padded	.325	.124
	With and Without Padding	-.117	.124
Reception	Closed, Against the Wall	.043	.106
	Open, Against the Wall	.088	.124
	Closed, In the Wall	-.130	.124
Flooring	Wood	.093	.106
	Vinyl	-.109	.124
	Carpet	.016	.124
Additional Features	Yes	.179	.079
	No	-.179	.079
Signage	Yes	.189	.079
	No	-.189	.079
(Constant)		3.800	.095

Based on the conjoint model, these standardised, estimated utility scores can be added in order to arrive at the total utility score for any combination of design levels. Example calculation of the overall utility scores for image 1 is shown in Eq. (2).

$$U\ (\text{Image 1}) = 3.8 + (-0.189) + (-0.099) + (-0.117) + 0.043 + (-0.109) + (-0.179) + 0.189 = 3.339 \quad (2)$$

Using this equation (2), utility scores for untested design variations can also be calculated. For example, a design scenario consisting of single, padded chairs, arranged in rows in a room with an open reception desk, wooden flooring, additional design features and signage would be the most favourable design combination.

The correlation coefficients shown in Table 6 were computed to validate the quality of the model. Pearson’s R (0.935) and Kendall’s tau (0.778) reflect the level of agreement between observed and estimated data. This gives confidence with regard to how well the model predicted utility scores compared to the average ratings in the experiment. Both had a statistically significant p-value of < 0.001. Since holdout cards were not used in the estimation procedure, its Kendall’s tau (0.667) was used to check the internal validity and the predictive quality of the model.

Table 6. Correlations between observed and estimated data

Correlations*

	Value	Sig.
Pearson's R	.935	.000
Kendall's tau	.778	.000
Kendall's tau for Holdouts	.667	.087

* Correlations between observed and estimated data

4. Discussion

In order to help designers and researchers understanding which design attributes of healthcare waiting environments are most valued by users, this paper presented a systematic and replicable methodological approach to do so. The objectives of this paper were to present a) A systematic approach to identify key design attributes of healthcare waiting environments that are most valued by users and b) Using preliminary empirical data to demonstrate the type of outcome achieved by using this method and to validate the conjoint model.

4.1 Discussion on the Approach – Visual Stimuli and Conjoint Analysis

The main objective of this paper was to provide a systematic approach to help healthcare designers and researchers understanding user perspectives of healthcare waiting environment designs. This was achieved by presenting the research path from preliminary preparations, data collection through survey and visual stimuli through to conjoint analysis to quantify the relative importance of design attributes and levels.

Furthermore, findings from the preliminary analysis gave readers a precise picture of the format of the outcome when using the methodological approach. Also, it shows how the quality and validity of the estimated data can be assessed using Pearson and Kendall's tau correlation coefficient. Further data collection is currently being carried out, so that the model as well as the findings will be re-assessed in future.

Previous research suggests that testing aesthetic dimensions of the product would not be adequate by using verbal descriptors as stimuli [16]. In a comparative study between verbal and pictorial stimuli, Vriens (1998) found that higher accuracy is produced if pictorial stimuli were displayed prior to verbal stimuli [22]. Concluding from this experiment, pictorial stimuli were not only an additional benefit but represent the more superior and appropriate representation of the in-situ environment. The way people experience the built-environment is not through verbal but sensorial means. Since the degree of realism of the product has an effect of the models' validity [10], the use of visual image in this case is more likely to produce better data quality.

Pictorial stimuli created from verbal descriptors help to avoid misunderstandings between the researcher and participants. The researcher has more control over the stimuli presented to participants while the concrete visual design helps avoiding ambiguity of different associations formed through verbal descriptions across individuals.

4.2 Discussion on the Limitations of the Method

Even though visual stimuli give the researcher more control over the studied object and scenario, false visual cues can still create ambiguity. In the design stage, the light setting was kept constant but the brightness in the renders appeared to vary depending on a number of factors e.g. the type of flooring and the amount and arrangement of chairs. The perceived difference was not modified since the brightness of the room would be affected in the same way in reality. However, some qualitative data suggest that people may have perceived brightness or lighting as a design attribute. The interpretation of the results, therefore, needs to be carefully considered to what extent people may have rated the perceived lighting effect instead of the tested design attributes. The effect of lighting on perception, health and well-being is one of the most established and well-documented design factors in literature [20, 6].

Another potential limitation was due to the fact that the arrangement of seats was to a certain extent pre-dictated by their style. The arrangements 'Rows' and 'Groups' were not as exclusive categorical as they were set out to be, especially when sofas and benches were involved. Seat arrangement appears to have high importance in influencing people's perception which is in line with Gestalt theory suggesting that people perceive things based on grouping elements based on their symmetry, movement etc. [12]. Untested design attributes included in the basic 3D model such as the colour of seating or ceiling may also affect people's perception of the other attributes, hence, on the tested attributes. Therefore, other settings of fixed design attributes need to be further tested. Due to the online nature of the survey, no control over the unity of participants' screen size and quality can be granted which also needs to be considered. Previous research suggested that the size of images does not affect the 'task demands' themselves [3].

4.3 Discussion on Future Research

In this experiment, seven design attributes with each containing two to three design levels were tested. Further research needs to be investigated with regards to other design variables that were indicated to have an impact on people's perceptions and well-being such as lighting, colour [19]; increasing number of green plants in the environment, art work display [17] or windows with a view [20].

The methodology provided a systematic and replicable approach for those who are concerned with identifying most relevant design features. As such, it contributes to the methodological development of combining virtual reality technology with traditional consumer research techniques such as conjoint analysis. By simulating a mock real world scenario, not only physical design features can be tested but also the interaction between users and the physical space. Exploratory studies in this area have already been carried out by a few researchers [5] but the area is in need of further investigations.

5. Conclusion

This paper has presented a systematic approach to help healthcare designers and researchers to gain a deeper understanding of user perspectives of healthcare waiting environments. However, limitations were identified which uncover opportunities for future research to investigate those limitations and to further develop the method. Findings to date suggest that flooring, seat padding and seat type (single chair or sofa / bench) are the most important attributes influencing user perception of the healthcare waiting environment. The presented method as well as findings from this paper will benefit all those involved in the design of healthcare and other environments.

6. References

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