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REASONING BEFORE TESTING THE HYPOTHESIS: HOW TO PRESERVE THE REALITY OF THE INDUSTRIAL CONTEXT

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ABSTRACT
The paper discusses the challenges encountered defining suitable methods to test the hypothesis for research investigating inclusive design in the industry. It outlines the outcomes of an exploratory study with designers and clients in order to describe how the research hypothesis was formulated. The hypothesis considers the impact of information about inclusivity into the design decisions made by clients and designers during design meetings. The paper reflects on ways in which the hypothesis could be tested in order to preserve the scenario as closed as possible to the reality of the industrial process. It considers the advantages and the disadvantages of industrial and laboratory settings. The overall focus is to identify the setting and methods that would result in realistic answer to the research question. The paper concludes by proposing a scenario which could benefit from the current research context without affecting their applicability to design practice in industry.

Keywords: inclusive design, industrial design, industry, design process

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1 INTRODUCTION

Since the last decade, developed countries have faced the challenges of ageing populations. The fact that people are living longer on the one hand means that the society has improved living standards; on the other hand, it means the emergence of new challenges that naturally result from the ageing process, some of which are the loss of physical, sensorial and cognitive capabilities. These capability losses should be considered in new product development if the intention is to promote independent living among the elderly population. In fact, the adoption of inclusive design in industrial contexts seems to be compatible with the current scenario of ageing society. However, previous studies indicate that it does not result in a direct application and; as a result, the adoption of inclusive design in industry is very disappointing. (Goodman-Deane et al, 2010; Heylighen, 2008; Choi et al, 2006; Dong et al, 2004; Vanderheiden and Tobias, 2000).

This paper is based on ongoing research project that responds to the main question of '*How to promote greater inclusivity into the design process in industrial context?*' In other words, the research should clarify ways to accommodate inclusive design into the industry. Therefore, in order to answer this question, an exploratory study (detailed on section 2) was conducted. The study underlined the complexity of industrial projects and the role of designers and clients in making design decisions. The outcomes were the basis to develop a conceptual tool and the research hypothesis.

The focus of the paper however, is to reflect on the current stage of the research, where a theoretical validation has to take place. The importance of the right approach to test the research hypothesis is taken from DRM – Design Research Methodology (Blessing and Chakrabarti, 2009). Section 3 analyses the implications of testing the hypothesis in laboratory settings or industrial settings, as well as the use of experiments in industrial contexts. The paper is driven by the need to preserve the reality of industry in order to answer to the research question, and thus, it is proposed as a method to test the hypothesis within the current context of the research.

2 UNDERSTANDING THE ROLE OF CLIENTS IN INDUSTRIAL CONTEXT

The paper is based on ongoing research project that started by reviewing the tools and techniques available that support inclusive design adoption (Zitkus et al, 2011). The literature review indicated the need for better understanding of the design context, including the tools designers use in their work routine as well as the role that they have to make decisions related to the end-user. An exploratory study that initially was seeking for data related to the differences among design domains and the hindrances to user-centred design (Zitkus et al, 2012; Zitkus et al, 2013a), turned to understand the influence of another actor responsible for feeding the process with user requirements – here called the client. This section discusses the exploratory study and some of its findings which has driven the research to the current stage.

The study was conducted with designers, and project stakeholders to recognize the reasons for non-adoption of inclusive design and how inclusivity could be accommodated into the design process in order to promote accessibility and usability in new product development. It was carried out within seven different companies in order to understand the design practice and contextualise the client-designer dynamic when defining user needs.

2.1 Sample size

A total of 18 industrial designers and six project stakeholders participated in the study. The industrial designers were from five United Kingdom-based design agencies and internal designers of two large companies; the stakeholders were also from the same two large companies. Among the six stakeholders, two people were responsible for commissioning the design to external design agencies, who in this paper are named clients and represented the interests of the company that owned the final product.

2.2 Data Collection

Data was collected through unstructured interviews, an acknowledged method to conduct exploratory studies in qualitative research (Hiller and DiLuzio, 2004). The method supported in-depth investigation of the design activity through opinions, knowledge, behaviour and experience of the participants (Patton, 1987).The participants were encouraged to talk about their background and experience in the field, as well as to give a broad picture of their role in the consultancy or in the

company. The designers and stakeholders were asked to talk about the design process as it occurs in their work routine. Whenever a participant mentioned the end-user or the consumers of the final product, they were asked about the way they understand the end-users' needs. The main topics covered in all interviews were: the design process; the techniques used to assess end-users needs; the influences received alongside the design process, and; how decisions are made alongside the process. The interviews were audio recorded and transcribed afterwards. The data was continued analysed and the findings were represented in a framework format to present to the designers and stakeholders. The sessions were called feedback sessions and were important occasions to get the participants appraisal of the framework as well as the understanding of the design activity and how user requirements are dealt during new product development. In addition, a commercial client-designer meeting to assess the design proposal of a live project was followed to pre-test the research hypothesis which is based on the framework generated.

2.3 Data Analysis

The transcripts were coded and categorised using Atlas.ti software, a computer program mainly used for qualitative data analysis. The categorisation was based on patterns of text – utterances – that were related to the same idea. They were analysed following the principle proposed in grounded theory (Glaser, 1965; Corbin and Strauss, 1990). Every time a relevant fact was recognised in a transcript, old transcripts were re-analysed to find out the views of past participants related to that aspect. For example, as the research evolved, the role that clients play in the design process had to be clarified, as a result of which other questions were raised and past transcripts were re-analysed. Care was taken to ensure that the same code was not duplicated for a single participant under the same interview topic. This procedure prevented the reoccurrence of codes only based on single views. Codes and categories were mapped according to the importance given to the concept among all the participants (reoccurrence) and its connection to other sub-categories (co-occurrence). The maps of categories and codes were interpreted and represented in a framework format. The outcomes from the feedback sessions corrected misunderstandings and confirmed some of the results.

2.4 The client-designer dynamic influencing inclusive design adoption

A framework was generated to contextualise the client-designer dynamic (see more details in Zitkus et al, 2013b), mapping where in the process clients and designers explicitly contribute with their inputs. Throughout the design phases designers are influenced by the clients' needs and directions, the project's budget and the clients' understanding of representations.

The influence that clients exert in the design activity is indeed a fact that has to be considered before proposing improvements to the practice. From the very beginning - when a brief is delivered to designers - until the end of the conceptual phase - when an idea is selected for further development - clients influence or even control every stage. In fact, the brief, the research, some evaluations and tests, all seem to be strongly dependent on the clients' views, procedures and funding for the project.

Designers normally translate the needs and views of the client to the product. Therefore, in cases where the clients awareness of their market includes the understanding of end-users needs related to accessibility and usability, they could drive new ideas towards more user-centre design. In fact, if the client is aware of the critical parts of the project, they will then request, while briefing the designer, to conduct research, tests or evaluations. The result of such assessments would be presented back to the client to ensure that there will not be any problem in the final product.

Moreover, the final decision seems to be made by the client who represents the company that owns the final product. A client interviewed mentioned:

"I have control over the brief for the products, I have control over the design, I have control over the cost, the specifications, but I also have control over the marketing messaging that we speak to consumers." (C2 – client)

The quote above about the power that the client exerts in the process illustrates a common response among the designers from different agencies and companies that took part in the study. However, according to the study, designers also exert power into the design process through their interpretation of the brief. As a result, the design proposals (new design concepts) created by them can be powerful influences towards more inclusive products. Therefore, both, the designer and the client exert power during the very beginning of the design process and thus the provision of inclusive design information could occur in two ways: to designers and clients separately, or for both together.

2.5 Design decisions

Briefly presented, it was found that the designer's decisions are the result of the prioritisation of the design requirements based on the following:

- The key requirements established on the brief that the client commissions.
- The evaluations, tests and research carried out by the designers.
- The knowledge and experience of the designer.

All the feedback received from the client become part of the designer's reasoning process to make design decision. Meanwhile, the client decisions are results of the prioritisation of the company requirements based on the following:

- The company priorities or company strategies.
- The legal obligations of the company.
- The project's resources.

Figure 1 presents a framework based on the findings, which was developed to illustrate the client-designer dynamic and the design and company requirements influencing this dynamic.

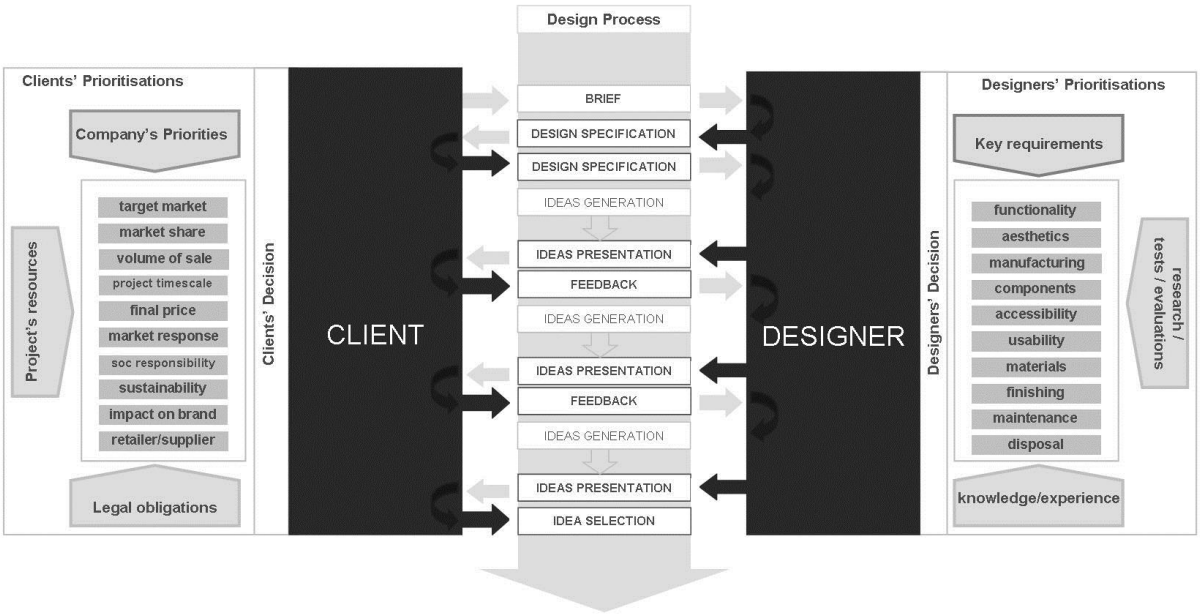


Figure 1.The client-designer dynamic and the prioritizations that influence design decision

It was identified in the study that design meetings represent occasions where design decisions happen. The meetings are used to specify the project, to discuss the project and to present and discuss the ideas. In fact, it is in the meetings where many decisions are made to progress with new product development. Therefore, to support the development of more inclusive designs, one possibility is to inform both - designers and clients - about inclusivity while design decisions are made. In other words, the design meetings were identified as the strategic phases to provide inclusive design information. Independently of the stage of the design process in which the design meeting is held, it is possible to supply the participants with information about inclusivity.

Meetings to specify or discuss the project

The meeting(s) used to deliver the design brief and develop the design specification (in some cases called product design specification - PDS) are important occasions to introduce information about accessibility and inclusion if that has not been considered before.

Meetings to present and discuss ideas

Initial ideas are embodied into presentations and delivered to clients in their meetings. Clients give feedback and directions according to their priorities, but clients also rely on designers' interpretations of better solutions. Interventions that inform about the accessibility and inclusivity of the proposals being presented in such meetings could direct the project towards more inclusive products.

2.6 Preparing a tool to be used in client-designer meetings

A conceptual software tool was created to simultaneously supply designers and clients with information about inclusivity in design meetings. Its development was based on the outcomes from previous observations and interviews with designers, clients and stakeholders involved in industrial design projects. The tool was prepared to be friendly and usable by both designers and clients as it followed what was described by them as a common way to present the design proposals to the client.

It was conceived to estimate the percentile of the adult population in the United Kingdom that would be excluded from using the design under development. The prototype estimates dexterity and visibility exclusion only. Problems related to cognitive, physical or sensorial capabilities are not identified neither are the exclusions estimated. Figure 2 shows the result screen of the tool with an example of 'healthy fryers' under evaluation.

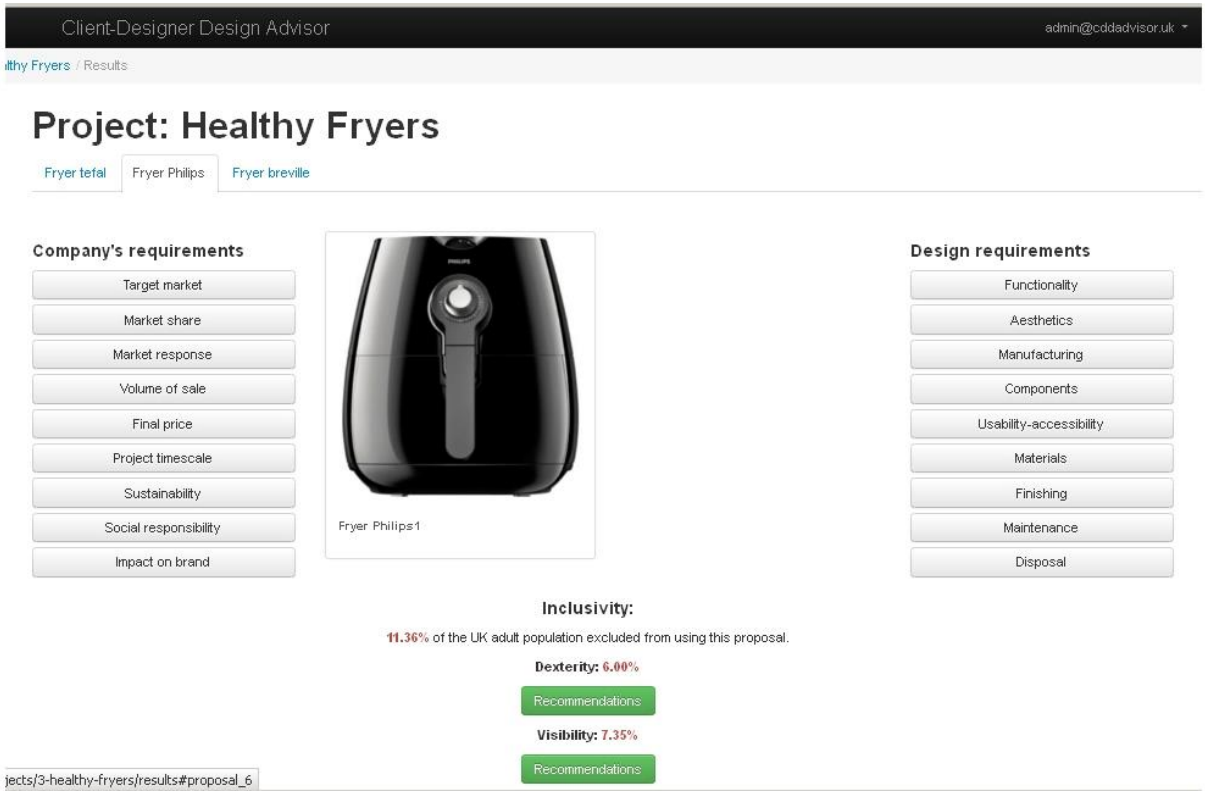


Figure 2.The conceptual tool developed to supply project developers with inclusivity information

The information delivered by the tool – the percentile of the UK adult population and the recommendations given to enhance the accessibility and usability of the design under development are called in this paper 'information about inclusivity', which will be referred to in the next sections.

3 HOW TO TEST THE RESEARCH HYPOTHESIS

Some methodology books often present the advantages and disadvantages of a range of methods to induce the readers to reflect on the compatibility between the nature of their research, their research philosophy and the research questions that they aim to answer (Saunders et al., 2009; Robson, 2011). Similarly, in design research methodology books, as highlighted by Blessing and Chakrabarti (2009), the right decisions related to sample selection, sample size, settings and methods are highly important to test the research hypothesis (pp 254 to 257). This section discusses the settings and methods available to test the research hypothesis.

The exploratory study described in the previous pages formed the basis of the research hypothesis. The latter was developed to test whether the use of the conceptual tool by clients and designer would increase the industrial uptake of inclusive design:

In industrial design meetings, clients and designers who receive the information about inclusivity provided by the conceptual tool will make more inclusive design decisions.

In this case, the dependent variable (decisions taken = DT) is a function of the independent variables involved in the design process (some of which are illustrated in the framework – figure 1) and the independent variable introduced in the meeting (information about inclusivity provided by the conceptual tool = iv).

$$DT = f(v1, v2, v3, \dots, iv)$$

Decisions Taken is a function of independent variables including inclusivity information (1)

As the research has been conducted in industrial settings, it was always challenged by the access obtained to follow the process. Nevertheless, access to test the research hypothesis is slightly different than access to conduct interviews or observations. Testing the hypothesis requires involving commercial projects in the study, which means the necessity of dealing with confidentiality issues, delays or interruptions. Therefore, other options, such as laboratory settings, were considered as is described in the next section.

3.1 Advantages and disadvantages of laboratory settings

The main advantage of studies conducted in laboratory settings is the control that the researcher has. The control over the variables enables the researcher to obtain an apparent effect that the 'intervention' (independent variable) has in the experiment, which might be a result of a combination of factors highlighted by Blessing and Chakrabarti (2009):

- the design activity is determined by the researcher and thus there is no extra history about the project or the product that needs further considerations;
- low complexity of design brief;
- analysis of the role process;
- the focus of the design can be very functional as the participants determine the design without the interference of other stakeholders;
- the researcher can predetermine the variables and correlations and causalities can be determined.

Not surprisingly many design studies have been conducted in laboratory settings. For instance, the studies of the design activity demonstrated on Cross et al (1996) and the studies conducted by Bilda and Demirkan (2003) and Bilda and Gero (2005) are good example of laboratory studies. The use of laboratory settings was indeed compatible with the nature of these studies, which were investigating the creative process of the design activity.

A remarkable example of laboratory study was the small-scale design experiment conducted by Cash et al (2012). The authors used rigorous methods to test their hypothesis regarding the provision of relevant information to design team in the very early stage of the design process. The authors divided the participants into five groups using Belbin Team Role scores to limit performance variability among the teams. One team was a control group (with no information), another group was given 'placebo' information and the other three were given different types of information. Clearly, the study was well planned and care was taken regarding the use of control group, normalisation and mitigation techniques, which are not always present in design studies. However, despite all the methodological rigour, the selection of participants and the context limited the authors to relate the conclusions to industrial scenarios. The limits to relate the findings of laboratory settings to industrial contexts are part of the issue that calls for discussion and led to the topic of the present paper.

Although there are many advantages in carrying out research based on laboratory setting, there are many variables that are part of real design process that are not captured in a laboratory experiment. In the case of the present investigation, once the research question is '*How can greater inclusivity be promoted into the design process in industrial context?*'; it claims greater understanding about the design process in an industrial context. The idea of setting a representative study inside laboratory is therefore challenged by the complexity of the dependencies between variables.

The difference between the present study and the ones mentioned above is precisely the nature and scope of the research. Firstly, the research question that drives the present study is related to the industrial context. Secondly, the findings from the exploratory research outlined the complexity of the design process regarding the decisions made from the very beginning. These findings are the essence of the hypothesis. Therefore, testing the hypothesis outside the scenario where it was developed might bias the outcomes regarding the applicability of the results in the real-world.

In other words, testing the impact of information about inclusivity may vary according to designers, clients, companies and projects. Therefore, the variables are too broad to be covered in a laboratory experiment and the results in such setting may not reflect the decisions taken in industry. As already presented on section 2.5, the design decisions are a combination of designers and clients decisions driven by the company priorities, project resources, brief, and so on. Even role-playing sessions would potentially affect the reality of the experiment in terms of all the variables that affects a commercial design process, many of which are illustrated in the framework (Figure1). These are some of the reasons that induced the researcher to insist on getting access to industrial projects, though it was known it would be very difficult.

3.2 The challenges of industrial settings

As well presented by Blessing and Chakrabarti (2009), the main advantage of carrying out studies in industrial settings is that the "results show reality", though they require time to deal with the challenges. Some of them are the interferences of multiple stakeholders, the complexity of the projects and the difficulties to plan and control the research. In fact, the researcher can hardly plan the activities and define dates, and; there is no guarantee that the results will be useful or the observed situation will continue without interruption. Lloyd et al (2007) precisely add to these challenges, the issues related to the confidentiality of commercial projects and the delays or hold-ups which may prevent the researcher from following the project. The above challenges have been experienced whilst this research has been conducted. Although the designers that participated in the study have been keen to support the research, it was necessary to ensure for them that the study would not be conducted to judge the company or design agency, but only to understand how information about inclusivity could affect their process. The initial idea was to follow design meetings alongside the design process of three industrial projects to capture whether information about inclusivity actually resulted in more inclusive design (final product). However, problems related to the confidentiality of live commercial design projects restricted the access to all meetings. In addition, two of the projects assigned to the study were put on hold for commercial reasons

The above challenges imposed by the industrial setting, combined with the time restrictions of the research impacted on the way the research was planned. The fact that only two design agencies and a maximum of four projects (two from each agency) have been assigned to the study already restricted the potential for carrying out experiments in this research.

3.3 A True experiment in industrial settings

An experiment or true experiment is a research method to test the hypothesis and answer its intrinsic cause- and- effect question. According to Salkind (2012) it consists on the following characteristics:

- having at least a control group;
- randomly selecting the participants;
- randomly assigning the participants to groups;
- randomly assigning the independent variable into the groups;
- control of the variables.

To illustrate, in this research, an experiment would be possible in the following scenario:

- if design meetings were occasions in commercial design projects where researchers easily get access;
- if there were a large number of companies keen to collaborate in inclusive design research;
- if among these companies it was possible to select those companies which produce similar products to similar markets;
- if these projects selected from different companies had a similar brief with similar design specifications;
- if the design agencies responsible to develop the new designs have designers with similar background and experience.

In this case, the constraints found in the research context already exclude the possibility of 'randomly selecting the participants' or 'randomly assigning the participants to groups', as a consequence of which it was concluded that a true experiment was not suitable to this context. However, there are variables that can be controlled and there are ways to control the 'experiment' and assign the tool into the groups. Thus, a method that could be used is the quasi-experiment.

3.4 Quasi-experiment in industrial settings

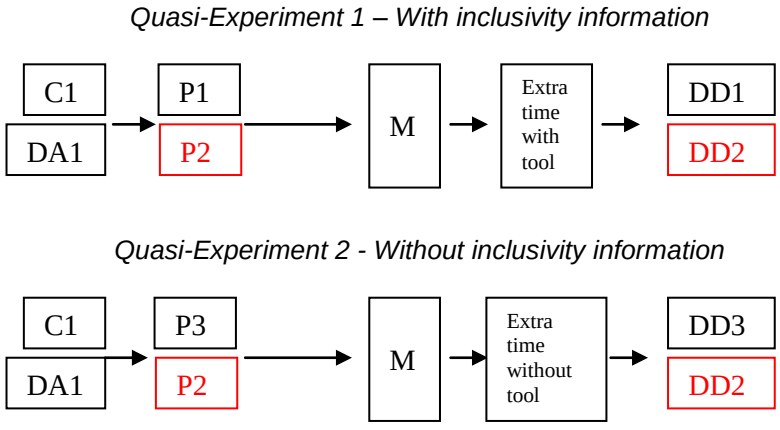
According to Cook and Campbell (1979) quasi-experiments are "experiments that have treatments, outcome measures, and experimental units, but do not use random assignment to create the comparisons from which treatment-caused change is inferred". In this case, quasi-experiments seem to be feasible in industrial settings. Quasi-experiments could be carried out within a real commercial design meeting to follow the design decisions taken by clients and designers in a live project, as designers, clients and projects do not need to be randomly selected and assigned.

Additionally, the fact that only two design agencies, and a maximum of four projects - two from each agency - have been assigned to the study does not restrict the use of quasi-experiments. The following scenario was envisaged to test the hypothesis:

1. Two similar projects from the same design agency and the same client have been assigned to the quasi-experiment;
2. The researcher will follow the meetings as they normally happen (M on figure 3). It is expected that during the meeting the design proposal(s) will be discussed and decisions will be made, including those decisions related to accessibility, usability and inclusivity, as it normally happens. All the design decisions will be documented as they will be used after the experiment to compare with the design decisions made by using the conceptual tool.
3. At the point when the 'normal meeting' would end, there will be extra time to continue the meeting. In one of the projects the designer and the client will be provided with the tool prepared (presented on section 2.6 – figure 2). In the other project the designer and the client will not be provided with the tool.
4. A similar product created by the researcher will be introduced to clients and designers at the beginning of the meetings. This product (P2 on figure 3) will be the same for both projects as part of the experiment, in order to control the differences between projects that could affect the comparison of results of both projects (P1 and P3).
5. The decisions taken at the end of both meetings (DD1, DD2 and DD3) will be rated about their inclusivity by inclusive design experts.

The diagram on figure 3 illustrates how the quasi-experiment has been conceptualised. The quasi-experiments 1 and 2 would be applied in the two different design agencies.

As it is a live project, the quasi-experiment has to be as compact as possible in order to cope with the limited time that the participants will be able to spend on it.



C1=Client1; DA1=Design Agency1; P=Project; P2=Control Project; M=Meeting; DD=Design Decision

Figure 3.The design of a quasi-experiment to test the impact of information about inclusivity in design decisions

Although the paper proposed a quasi-experiment with a control group (quasi-experiment 2) and a control project (P2 - allowed for the removal of project's differences affecting the decisions), the size of the experiment would be small and the results therefore highly dependent on the participants. Therefore, future work should involve a larger study within more industrial projects.

4 CONCLUSION

The paper discussed the challenges that were found to define suitable methods and settings to test the research hypothesis. To describe how the research hypothesis was formulated, the paper presented the outcomes from an exploratory study with designers and clients. The study demonstrated the influence and power that the client and the designer have when design decisions are made alongside the design process. Therefore, in order to answer the research question related to ways to accommodate inclusive design into the industry, it was identified occasions in the process where information about inclusivity could be supplied for client and designer at the same time. These occasions are the design meetings.

The research hypothesis considers the impact of information about inclusivity in the design decisions made during these meetings. To test the research hypothesis therefore all the variables involved in the process of making design decisions that are part of industrial design process have to be considered. Consequently, if the hypothesis is tested in laboratory settings (where true experiments could be conducted), the results in such settings might not reflect the decisions taken in industry.

The paper proposed a quasi-experiment to be conducted in industrial setting that would benefit from the current context of low number of projects assigned to the research. The intention is to preserve the reality of the industry. Although the consistency of the outcomes regarding the applicability of the results in the real-world would be preserved, future work should enlarge the sample of commercial projects to be followed to increase the reliability of the results

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