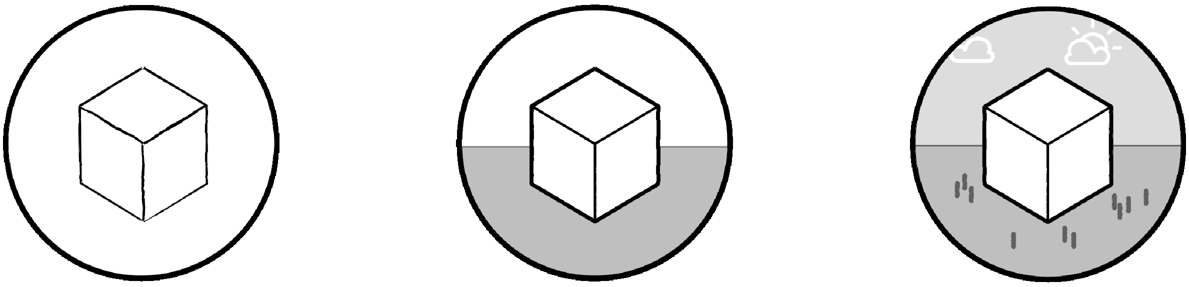
The Impact of Architectural Representations on Conveying an Intent

A quantitative study



by

Maxime Cunin

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ABSTRACT

Architects have to express themselves graphically in order to communicate ideas, both to clients they need to convince and to themselves. To do that, they appeal to a variety of representations supposedly faithfully carrying their initial intent. Research to date has demonstrated how "*experts*" designers and "*non-expert*" lay-people differently perceive, or on the other hand share, visual understanding (*Alcantara et al., 2005; Bates-Brkljac, 2007*). It is yet unclear how architects *themselves* use different types of representations to express different intentions, and how their expected audience more or less successfully captures those intentions. The purpose of the present study is consequently to refine understanding of how differently a non-expert public captures the initial message of an architect, and what role representations do play in this understanding process. This study presents the results of a survey including roughly 700 lay-people's responses to different forms of architectural representations, i.e. hand-drawings, CAD models and computer renderings. Results show that the computer representations are mostly perceived as conveying the same intents by the lay-people. Yet, renderings convey slightly more faithfully the intentions as intended by the architect than the CAD model. Our results suggest that low-end representations constitute the most efficient mean of architectural visual communication, being the best balance between success of conveyance of the architectural intent and time commitment. These findings can be used as guidelines to maximize the value of the feedback architects receive from the lay-people during the decision making process.

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father
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step-mother
sister
brother
...

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1. CONTEXT

During the decision making process, architectural representations constitute the principal support of communication between architects and stakeholders. People's understanding and assessment of design proposals are evaluated throughout the visual representations provided by the architects. Thus, the representations must convey crucial informations to enable the stakeholders to appreciate the qualities of the design proposed by the architect. The role of the representation in this process cannot be overlooked as it provides the necessary information to judge the worth of a design proposal (*Bates-Brkljac, 2008*).

It has been noticed that traditional forms of architectural representations limit the full understanding of architectural proposals. Indeed, plans and elevations are abstract and symbolically encoded, so they require a certain level of education to be interpreted (*Pietsch, 2000*). Around the decision making table, the stakeholders lack of trust and understanding. These two factors combined lead to a loss of efficiency of lay-people involvement in the design process. Research identified the visual language as having a role to play to facilitate the communication between experts and non-experts, and to encouraging everyone's participation by using a commonly understood language (*Bates-Brkljac, 2008*).

Back in its early development in planning practice, computer visualization was seen as promising way to improve the decision making quality as it appeared to avoid misunderstanding in the negotiation (*Hall, 1992*). By improving a share understanding, computer images made communication easier and more efficient, which finally facilitates joint decisions making (*Kalay, 1998*). Computer simulation moreover provided a mean of communication to lay-people lay-people. «*Members of planning committees, applicants for planning permission and the public at large could make an informed judgement on the issues by looking at realistic views of the proposed development*» (*Hall, 1992, p.13*). The new technology promised an increasing involvement of users in the design process. It could potentially extend the scope of good design by proposing an architecture more attuned to clients' or users' needs (*Groak, 1998*).

Since then, computer simulation has been suggested as a better mean of expression to communicate with the lay-people in a commonly understood language (*Pietsch, 2000*). Some others claim that the digital techniques must be complementary to the traditional tools, as all the requirements for an appropriate communication are not satisfied by a unique representation (*Day, 2002*). Although, there is still no agreement within the research on which form of representation has to be used during at each step of the decision making process (*Mahdjoubi & Wiltshire, 2001*).

Indeed, production of representations constitutes a really important part of the design process, and it requires often non-negligible time and costs. Therefore it is primordial that these representations expressed faithfully architect's thoughts in order to convey the client of the worth of his design.

As the involvement in the design process of the public at large and non-professionals increases, there is a need for comprehensive analysis on ways of representing architectural proposals which answers to the needs of the different stakeholders (*Bates-Brkljac, 2008*). Moreover each stakeholder finds crucial very different qualities of representations. Appleyard already stated back in 1977, it is not certain what are the qualities of a representation that are considered by various populations as more important (*Appleyard, 1977*).

The present study aims to at further discussing the relation between architectural intents - and the choice of a representation, based on a quantitative methodological approach. It starts with research perspectives on representations, how they are perceived, how to use them to depict an intent, and how the present work fits with the existing knowledge. Then it describes the proper research: the methodology specifically built, the results and analysis, and lastly the discussion of the findings within the existing research models. Finally, the concluding section suggests future directions potentially interesting or lacking of knowledge about architectural representations.

2. LITERATURE REVIEW

2.1 **Representing architecture**

rep• re• sen• ta• tion /rɛprɪzɛnˈteɪʃ(ə)n/ ***noun***

The description or portrayal of someone or something in a particular way.

source: Oxford American College Dictionary

During the decision making process architectural representations constitute the principal support of communication between architects and stakeholders. People's understanding and assessment of design proposals are evaluated throughout the visual representations (*Bates-Brkljac, 2008*). This visual communication can take various shapes and each of these form convey different informations.

To convey information about an artifact from a designer to a viewer is the fundamental objective for a representation (*Sheppard & Meitner, 2005*). Representations are never really complete, they rather convey critical aspects of the reality following a purpose (*Appleyard, 1977*). In representations, reality is substituted by symbolism (*Summers & Shah, 2004*). For example, the objectives of sketches is to simplify the reality in order to illustrate the subjacent intent, by doing a form of selection of the information to represent (*Leclercq, 2005*). The producer of a representation is therefore strongly relying on the ability of the viewers' ability to read the symbolized representation and to picture the potential result in reality (*Wergles & Muhar, 2009*). Architects' expectations to convey a message is depending on the form of the representation they are using. The following section aims of defining representation in its functions and its forms, this way further defining the scope of the present study.

Function

Architects use different types of representation according to the architectural project life cycle, going from the creation to the final presentation, including the technical description. During this process, representations are not all produced with the same purpose.

During the design process, the architect goes through multiple phases and very often concurrently. Several representations are used during this process. It is important to notice that the design process is not linear but a succession of loops, going from one phase to another, and from one representation to another. Summarizing research in design representations, four main functions that representations play in architecture has been identified: [1] as ideation tool, [2] as collaboration media, [3] as mean of illustration, and [4] as technical representation (*Leclercq & Elsen, 2007*; *Pei et al., 2011*).

[1] During the ideation phase, representations are used as an reflection tool supporting the creative process of an architectural project. Architects need to develop ideas on a support and inspect them. As they are inspecting their own ideas they find ways to refine and revise the concepts (*Suwa & Tversky, 1997*). It is like having a conversation with one's self, similarly to the process «*see-transform-see*» as defined by Schön (*1983*).

[2] Some representations are used in a collaborative context, in order to communicate and refine ideas and design proposal collaboratively (*Detienne et al., 2007*).

[3] Further, architects use illustrative representations to show how a building will look like to potential stakeholders. Representations convey these stakeholders with information that will enable them to appreciate the qualities of the design proposed by the architect (*Bates-Brkljac, 2008*).

[4] The architect has to define how precisely the proposal should be built, what it is made of, etc. Technical representations serve the practice of the construction industry (*Bates-Brkljac, 2012*).

Representations that play different functions constitute a junction layer between different groups of people. On one side, the first and the third category are mostly joining professionals. Representations in the ideation process is a mean of communication either between several architects or an architect with one's self, while technical representations join architects with other construction professionals. On the other side, representations in the second group act as a communication tool between architects and stakeholders during the decision making process.

The present study is focusing on representations as an interface between architects and clients, and more precisely on means of communication adopted by the designer to convey an idea around the negotiation table.

Form

Over the years, architects have developed an extensive and various range of representations used for communication, collaboration and decision-making, such as and sketches, drawings, computer simulations, renderings, photographs and physical models.

Developed over the time, traditional form of architectural representations, such as cross-sections and elevations, are abstract and symbolically encoded. They require specific knowledge from the viewer to be interpreted and, for this reason, they don't communicate design proposals effectively to the non-expert public (*Pietsch, 2000*). During their education process, design community members acquire the specific knowledge to translate encoded representations, which enable them to extract information and picture the potentiality of the design proposition (*Healey, 1985*).

While, conventional representation methods, such as hand-drawings and sketches, are still common use, recent times, more particularly, have seen significant changes in architectural representation methods. The fast development of computer technology and visualization softwares lead very quickly to the widespread use of computer generated representations (*Mahdjoubi & Wiltshire, 2001*). The evolutions in the architecture practice brought by the introduction of computer in the design process has been explored. (*Estevez, 2001*) According to Sheppard (*2001*), the nowadays widespread use of photorealistic representation is due to its effectiveness to communicate design proposals (*Sheppard, 2001*).

Obviously, to enable the participation of lay-people in the decision-making process, the comprehension of the visual representation used by the architect is a prerequisite (*Sheppard & Meitner, 2005*). By sharing the understanding of the representation brought by computer visualization, non-experts are enabled to assess the visual and spatial impact of development proposals (*Hall, 1992, p.1*). The new technology was promising a potential increasing involvement of clients and users in the design process. In the end, it could potentially extend the scope of good design by proposing an architecture more attuned to clients' or users' needs (*Groak, 1998*). Since then, researches suggest computer simulation as a better mean of expression to communicate with the lay-people in a commonly understood language (*Pietsch, 2001*).

Nevertheless, the choice of one or another method to represent a proposal is not taken without consequences on people's expectations. Indeed, hand-drawings are known by everyone as an abstract representation. People know that end product will be different than represented. Whereas the built artifact is expected to match the information shown on photorealistic images, seen similarly to genuine photographs (*Harrilchak, 1993*). Some researchers claim that the digital techniques must be a complementary to the traditional tools (*Day, 2002*). One of the argument is the that free-hand sketches leave doors open to further refinements, as the design doesn't seem to be over, while renderings seem to crystallize states, as the user see a proposal closer to reality.

As a witness of common use back in 2011, a large scale survey including 629 Belgian architects shows that two and three dimensional CAD softwares are used by a majority of architecture practice actors. Moreover, it seemed that «*CAD softwares and sketches are roughly of equal importance for both modeling and presentation of the design, and have a secondary role as communication design support tool.*» (*Verdonck et al., 2011, p.774*)

In the nowadays common practice, we summarized previous literature by identifying three main categories of representations used during the decision making process in order to convey an intent to the client :

[-] hand-drawn representations, such as hand-drawings and sketches,
[-] low quality computer simulations, as directly produced from CAD softwares, and
[-] high quality computer simulations, such as photorenderings and photomontages.

It is important to notice that one of the main criteria to distinguish the last two categories is the time of production required for each image. The **low quality computer simulations** are the representations with no, or very little, post-production process after the image has been taken from the CAD softwares. The architect has then very little to communicate the design proposal from the software to the client. The **high quality computer simulations** are including more heavy post-process such as photo-realistic simulations and photo-collages.

Interestingly, video records of architects at work appeared on the web in 2012 (*see Ref.1*), showing how four famous architects present their proposal to clients in the context of an architectural design competition. As a witness of the nowadays common practice, the videos show the architects doing a fundamental part of the practice of the architecture practice, the communication of the proposal. Using several means of representation they communicate their intents to the clients. It has to be noticed that the representations used by the architects includes all the three categories previously enumerated. Although, they also include a fourth group, physical models, even if they don't constitute the core of the presentations.

Physical model is a very particular mean of communication of a design proposal. It is not part of every sets of representations used by the architects during the communication phase of the project, for instance during certain architectural competitions. As a physical object, it cannot be contained on a sheet of paper contrary to the other three categories. Moreover, as it will be explained later, the design of the present study is based on a web survey. Therefore we can only show digital images to the participants. Scott and Canter (*1997*) found that «*people conceptualize the content of a photograph in a different way to how they conceptualize the places represented in the same photographs*» (*Scott & Canter, 1997*). It can therefore reasonably be concluded that the image of a physical model won't be as equally perceived as the actual physical model. For these reasons, this mean of communication is not included in the following analyzes.

In order to adopt the most appropriate styles and techniques of representations, a practical guide (*Meeda et. al., 2006*) to producing graphics for urban design projects and planning has been published. The most appropriate styles and techniques of representations are identified for different purposes by using good practice examples. While in architectural design, there is not such representations guidelines for integrating the different professions involved in a project development.

In order to extend the scope of good design by including final users or clients, it becomes then necessary to define requirements of the different stakeholders regarding to architectural representation of design proposals (*Bates-Brkljac, 2008*). Despite the three categories of representations described have been studied following very various purposes, there is still no agreement within the research on which form of representation has to be used during the decision making process (*Mahdjoubi & Wiltshire, 2001*).

2.2 **Perception of architectural representations**

per• cep• tion /pəˈsɛpʃ(ə)n/ ***noun***

The way in which something is regarded, understood, or interpreted.

source: Oxford American College Dictionary

Back in the early development of computer simulations, the importance of determinate aspects of human cognition was emphasized to avoid misuse of the representations conveying non-assessed information (*Steinitz, 1991; Zube et al., 1987*). Since then, the tool has incredibly evolved while the understanding of the viewer's perceptual response is still lagging behind (*Wergles & Muhar, 2009*). Despite numerous research dealing with architectural computer simulation, there is no clearly established analytical framework defining the perception of architectural representations. Existing research are centered on two main characteristics of simulations, their credibility and their fidelity.

Credibility

As a visual communication mean, computer generated visualization was acclaimed to act as a highly reliable representation of the real world (*Day, 2002*). The validity of a simulated object was defined then by its ability to produce equivalent cognitive, affective and behavioral responses between the simulated and the actual environment to the observer (*Appleyard, 1977*).

But the real world is complex and an exact and error-free representation of it has been acknowledged as being neither possible nor worthwhile (*Ervin & Hasbrouck, 2001*). In representations, there is a need to simplify and to abstract part of the reality. That leads to the question of what is really required to make a representation look real, which finally results in a balance between high realism level versus time and efforts involvement. The need to find predictive indicators to optimally simulate an environment with the most appropriate credibility is consequently expressed (*Sheppard, 2001*).

While the development of computer technologies lead to new representations methods in architectural design, Appleyard (*1977*) claimed that there had been few attempts to conceptualize the work in the field and there was a need for theoretical framework to assess the credibility of a representation.

Along the time, predictive parameters of credibility of architectural representations has been conceptualized by different authors. In their work, Appleyard (*1977*), Sheppard (*1989, 2001*) and Radford et al. (1997) proposed theoretical frameworks to conceptualize the loss of credibility of representations. They developed criteria to assess visual representations, aiming at guiding both future research and practitioners dealing with architectural representations.

Appleyard (1977)	**Sheppard (1989)**	**Radford et al. (1997)**
Accuracy	Accuracy	Accuracy
Realism	Representativeness	Realism
Comprehensibility	Visual Clarity	Abstraction
Evaluability	Interest	
Engagement	Legitimacy	

Tab.1 - *Criteria proposed by different authors for the assessment of visual representations.*

As a critique of the contemporary practice, Appleyard (*1989*) defined criteria for assessing simulation quality

- **[-] *Realism*** and ***accuracy*** - as the reflection of how the project is experienced,
- **[-] *Comprehensibility*** and ***evaluability*** - as the ease of access to the lay-people to understand the content of the simulation and evaluate it for their own purposes, the main content assed mostly being technical informations such as the length of a sidewalk, and
- **[-] *Engagement*** - as the ability to keep the viewers focused on the message conveyed by the simulation, which can be reword as the ability to please the viewer and not discourage to be read.

Based on this theoretical framework, Sheppard (*1989*) proposed refined criteria for improved comprehension, credibility and bias-free visual simulations :

- **[-] *Representativeness*** - as the degree to which it represents typical views of the project, the ability of the image to represent the project as a whole,
- **[-] *Accuracy*** - as the similarity between the simulated and the actual scene,
- **[-] *Visual clarity*** - as the degree to which content can be easily understood by the viewer, which is interesting to assess if we want to study the ability of a representation to convey an architectural intent,
- **[-] *Interest*** - as the degree to which simulations hold the interest of the audience, and
- **[-] *Legitimacy*** - as the degree of correctness of the simulation.

Later, Radford et al. (*1997*) refined the criteria and conceptualized a theoretical model to assess computer visualization. He identified three distinct qualities to evaluate computer visualization :

- **[-] *Abstraction*** - as the amount of detail included within the model,
- **[-] *Accuracy*** - as the the level of dimensional accuracy achieved, and
- **[-] *Realism*** - as the overall realism of the visualization, such as colors and details.

According to Radford's theory, observers' perceptual responses is influenced by the collective effect of the abstraction, the accuracy and the realism of the representation (*Bates-Brkljac, 2008*). Each visualization is represented by a balance of these three criteria. Depending on the purpose followed by the visualization, the most appropriate balance between the three criteria has to be defined by the producer of the representations (*Day, 2002*).

Bates-Brkljac (*2008*) assessed the credibility of architectural representations from the lay-people perspective. The theoretical framework used was based on Radford's definition of credibility, based on the three qualities *abstraction*, *accuracy* and *realism*. Six bipolar adjectives were determined internally to assess each of these criteria. Note that the question raised of the choice of theses particular adjectives in order to assess a meta-characteristics. By comparing responses collected from computer and hand-drawn representations, it seems that computer generated representations appear as a more credible architectural representation than traditional hand-drawn perspectives.

With her studies, Bates-Brkljac aims to improve the decision making process by defining more credible representations. Nevertheless, most of the studies dealing with architectural representations are not focusing on that issue. It seems that the main concern of scientists is how to reduce the distance between perceptual responses of the simulated and the real environment by determining images characteristics to obtain equivalent responses.

Fidelity

In order to understand the adequacy of computer visualizations in their representation of future real environment, computer simulations have been compared to their real homologue. In this context the concept of *fidelity* is defined as the degree of exactness of the representation, or in other words the degree of equivalence between perceptual responses during confrontation to the simulated and the real environment.

By comparing computer model of a real urban environment to the correspondent real environment, it has been acknowledged that the same responses are not necessarily generated, even through very detailed and time-consuming computer simulations (*Bishop & Rohrmann, 2003*). The generated environments seem to be assessed less positive appreciation of the study area, and retention of informations is less detailed. Nevertheless, additional research based on the same methodology nuanced the results. Computer visualizations could be employed successfully in design communication but every aspects of the reality cannot be replicated within the simulation. Indeed, Wergles and Muhar (*2009*) compared computer model and real urban environment perception by lay-people. Computer simulations seems to convey more difficultly *texture*, *movement* and *interaction* than the exposure to the real environment. Nevertheless, they have the advantage to focus more directly people's attention to centered or foreground pictorial elements. Moreover they acknowledged that more emphasis should to be placed on matching visualizations with the communication needs for reaching the targeted viewers (*Wergles & Muhar, 2009*).

Researchers focused then on determining images characteristics to obtain equivalent responses. Several characteristics have been studied in order to improve the fidelity of the simulations. Representations with different levels of detail, or degrees of abstraction comparison, has been compared regarding to viewers' perceptual assessment (*Oh, 1994; Lange, 2001*). The visual angle of view was varied in order to compare perceptual judgements based on slides and panoramas (*Meitner, 2004*). Other features have been studied for their influence on the fidelity of the representation, such as day time of the simulation, the presence of shadows, and the weather represented (*Rohrmann & Bishop, 2002*).

While computer programs made communication easier and more efficient (*Kalay, 1998*), it is still not clearly proved it improves shared understanding within the decision making process. Certain critical issues have not yet been addressed and thus «*this gap in our knowledge has persisted and it would appear that intuition and trial-and-error approaches have guided the production of architectural representations of design proposals*» (*Mahdjoubi & Wiltshire, 2001*). One aspect of architectural representations as a mean of communication appeared be untreated : representation form as a parameter of the perception of architectural intents.

Assessments of credibility and fidelity of representations have their limitations. By determining meta-concepts represented by adjectives, such as *abstraction*, *accuracy* and *realism*, it doesn't take into account what the architect wanted to convey in his/her design. Some aspects assessed as being a weakness of a certain representation might be intentional from the architect point of view. For this reason, architectural intent has to be considered in the assessment of architectural representations.

2.3 **Depicting intents**

in• tend /ɪnˈtɛnd/ ***verb***

Design or destine something for a particular purpose.

source: Oxford American College Dictionary

As a mean of visual communication, architectural representations are supposed to faithfully convey the ideas intended by the architects, so that observers should understand underlying intentions the same way than the producer of the representation.

It has to be noticed that architects' predictions of lay-people's perception have been explored. Evidence suggests that architects as a group cannot predict the public's aesthetic evaluations of architecture (*Brown & Gifford, 2001*). Customer's perceptions have also been studied. Researchers asked potential purchasers to describe a specific property in his own words. Attributes were then identified As being highly influent while customers assess a piece of real estate (*Llinares & Page, 2007*).

In this paper the authors propose to analyse the structure of citizen' emotional impressions and determine their influence on the choice of neighbourhood by applying differential semantics. With this technique it is possible to transmit the perceptions experienced by citizens in terms of emotional performance.

While there is no study dealing with the transmission of an intent through different mean of visual communication in architecture, similar methodologies with slightly different objectives have been developed in product design studies.

In product design practice, similar research has been conducted on visual communication and representations. Similarly to the architectural practice, graphic representations are recognized to play a significant role in describing and explaining a future product in the product design field (*Kaulio, 1997*). Assessment of consumers' opinion, judgments and preferences, are not independent of the mean of communication of the artifact. Researchers acknowledged that the representation of the object will shape consumers' responses (*Desmet, 2003; Reid et al., 2012*).

Moreover, it is well known in both fields that visual communication shapes the perception of the message, and in both cases, most of the researches are focusing on influence of representation features. Although, while it stays an important lack of knowledge in architecture, research has been conducted in product design to understand how the meaning of a product can be effectively transmitted to the user. Designers' and users' product form of perception have been studied using semantic differential methods (*Hsu et al., 2000*). Observers were asked to describe subjectively phone designs images, including a group of designers and a group of users. Multivariate analysis were performed and revealed many differences between the perception of the two groups. Among others, it showed that users' preferences are mainly affected by image delicacy while designer's preferences are influenced by delicacy, creativity and maturity.

Based on these observations, numerous studies focused on the representation characteristics regarding to their influence on viewer's perceptions. Only to name a few of the findings: synthetic representation affects colors and textures (*Knill & Saunders, 2003*), perceived depth could be altered as well as information related to size (*Tversky et al., 2002*), material properties and position of the object (*Sharples & Saikayasit, 2006*).

Similarly, Petiot and Yannou (*2004*) measured consumer perceptions in order to better assess product semantics. According to them «*taking the product as a communication media between the designer and the user, product semantics try to explain which messages a product expresses or represents.*»

Finally, while previous researches were using a unique mean of communication, i.e. physical model only or pictures only, in order to understand the behaviors, the influence of the mode of representation on the perception of product aesthetic has been studied in design practice (*Artacho-Ramirez et al., 2008*). Four different visual representations was compared in their ability to transmit product's symbolic to the observer. Pictures, computer models and interactive images of loudspeakers were shown to non-expert design participants, using the *Differential Semantics Method*. Findings suggest that the type of representation has an influence on the perception of a design intent in product design practice, but some concepts were conveyed in the same way independently of the type of representation. Yet, there is no such study dealing with the same topic in architectural representations.

Authors	Purpose	Characteristics evaluated	Media			
			Hand drawing	CAD Model	Photo-montage	Picture
Bates-Brkljac (2007)	Representations effectiveness.	Accuracy, realism, abstraction.	●	●	●	
Day (2002)	Determine best practice.	Accuracy, realism, abstraction.		●	●	
Bishop et al. (2003)	Comparison of reality vs. computer-simulation.	Quality, comprehension, realism, appreciation.		●		●
Wergles & Muhar (2009)	Comparison of reality vs. computer-simulation.	Perceptual impression, perception, retention, comprehension, deduction.		●		●
Oh (1994)	Computer simulations effectiveness in portraying reality: wire frame, surface model, image processing, collage.	Visual attractiveness, confidence, site familiarity, emotional perception.		●	●	●
Lange (2001)	Validity of virtual representation to represent reality.	Realism.			●	●
Meitner (2004)	influence of angle of view.	Scenic beauty.				●
Rohrmann et al. (2002)	Influences of simulation characteristics: day time, shadows, weather.	Quality, readability, realism, appreciation.		●	●	
Brown et al. (2001)	Architects' prediction of lay people's perception.	Emotional perception.				●
Llinares & Page (2007)	Identify main attributes to quantify clients' perception.	Emotional perception.			●	●

Tab.2 - *Summary of previous studies dealing with architectural representations - Purpose, evaluated characteristics, studied media.*

3. RESEARCH GAP

Following up existing literature, we understand that a gap of knowledge exists when it comes to architectural representations and the way architectural intents are conveyed. While credibility and fidelity of representations have been extensively studied, there is still a need of comprehensive analysis on the influence of the representation choice over the perception of architectural intents. The present study aims to advance the discussion about architectural representations as a visual mean of communication to convey an intent from the architect to lay-people through different mean of visual communication (*Fig.1*).

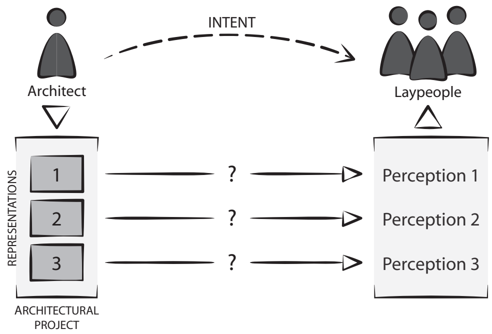


Fig.1 - *Different perceptions of an architect's intent through different modes of representation.*

It is important to remind that design proposals are evaluated throughout the visual representations during the decision making process. It is then crucial to determine whether the representations convey faithfully the architectural intents. But there is a clear lack of comprehensive study dealing with both architects' intentions conveyed through different representations and viewer perceptions of the proposals also as a parameter of the representation.

Methodologically speaking, we base our approach on similar research in product design. The present study will be focusing on three main type of representations : [1] hand-drawings, [2] CAD models, and [3] photororendings and photomontages, given their widespread use in architectural practice as well as the methodological issues described previously. (*see 2.1 Representing architecture*)

Below are the three main research questions this study will investigate :

[-] Is there an influence of the style of representation over lay-people's perceptions of an architectural intent?

[-] Is the style of representation influencing participants' agreement about the perception of an architectural intent?

[-] Are representation styles conveying equally successfully the architectural intents?

METHODOLOGY

4.1 **Overview**

In order to explore the questions previously raised, a specific methodology has been built. Because of time limitation, we used an online based survey strategy, which enable us to obtain numerous answers very easily. The following sections aims to develop the methodology used to build rigorously the survey. We will be following a four steps structure.

The first step is to find projects represented in the three different types of architectural representations, chosen for the reasons previously described (*see 2.1 Representing architecture*). The main purpose of this study being to compare intent perceived through different visual representations, we looked for projects with direct access to the architect(s) who created the representations. Nevertheless, in some situations we had no direct access to the

The second step, once we have the visual material, is to build the structure to collect people's perception of the architectural intent. Based on Osgood's (*1957*) Semantic Differential Method, we build an adjectives data base describing architectural intents of the selected projects.

The combination of the projects representations, the adjectives data base and the Semantic Differential Method eventually form the survey (*Fig.2*). Two categories of participants took place in the study, the lay-people participants reached online and the architects with whom we have a direct contact. For each of them, we developed a specific procedure to go through the survey previously built.

Finally, we explain data analysis methods used to explore the responses from the survey.

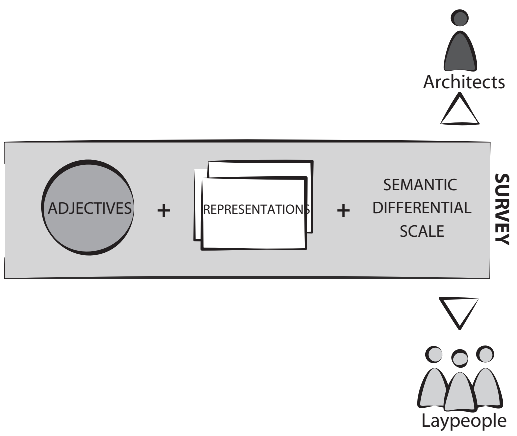


Fig.2 - *Structure of the survey built for two different populations.*

4.2 **Selection of projects**

The first step our methodology is to find the visual material. The objective we follow is to get insights from both students and professionals, and not to limit our research on academic assignments. We justify this decision with two main reasons. First, it brings validity and representativeness of the representations used, by leaning the research closer to the professional community than the students in their learning process. And second, we ensure a reproducibility of the study, by avoiding particular pedagogical styles in terms of representations.

Dozens of architects and students have been reached to provide projects representations that follow our criteria, along with a short description of the architectural intents. An email campaign has been conducted mostly targeting professionals, while few dozens of posters (*see Appendix 1*) have been placed in universities, at the *University of Liège* (*Belgium*) and at the *MIT* (*United States*).

As our study is focusing on three main types of representations, each project provided must be illustrated by each of them: (*e.g. in Tab.3*)

[-] one **sketch** or **hand-drawing**,
[-] one **basic computer model** (e.g. *Sketchup* model), and
[-] one **computer rendering** (e.g. *Photoshop* image).

Moreover, while each of these representations must represent a unique architectural project, they have to show the artifact with the same point of view. This precaution is taken as we know that the angle of view has an impact on people's perception of an object (*Meitner, 2004*). (*see 2.2 Perception of architectural representations*)

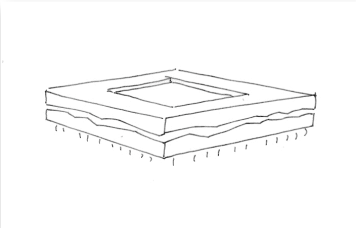
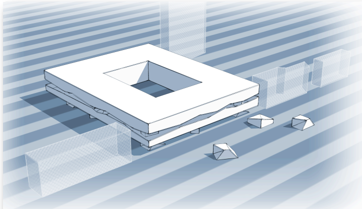
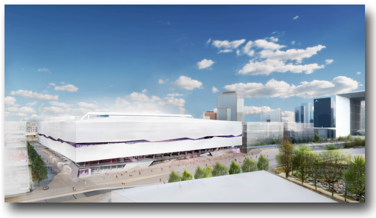
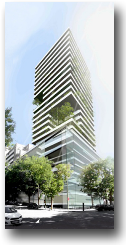
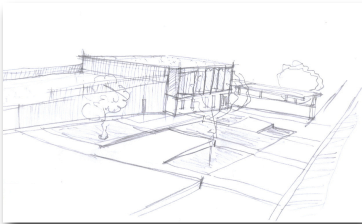
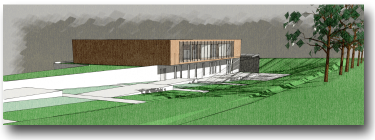
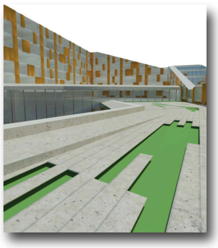
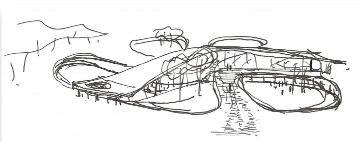
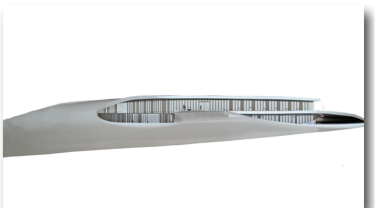
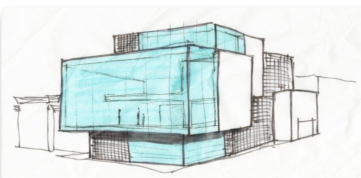
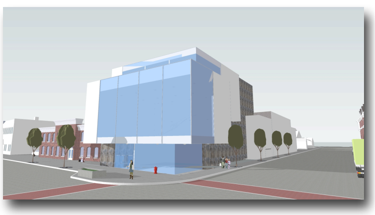
The original set of representations included 11 projects from 8 architects and students, that is a total of 33 distinct representations. This number has been reduced to 6 projects from 6 architects and students for two main reasons. First, some representations weren't even approximatively depicting the same point of view from one representation to another. Second, from one project to another we noticed very various images within a type of representation. So, in order to maintain a relative consistency within a type of representation, it has been decided not to include all the projects received. The 6 projects for which we have direct and personal access to the architect constitute the **primary projects** data set. An overview of the representations is showed below (*Tab.3*).

Nevertheless, with only 6 items collected for each type of representation, we had to raise the question of their representativeness. It was then necessary to look at a larger set of representations. On-line portfolios and professionals' websites were reviewed in order to find complementary representations. A **secondary projects** data set complete the previous primary set.

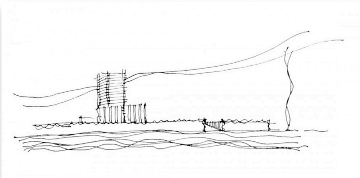
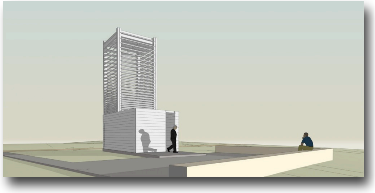
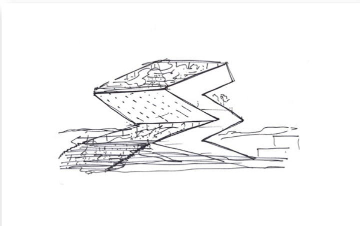
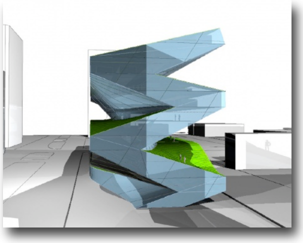
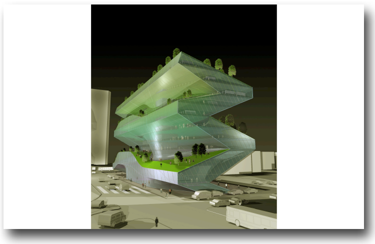
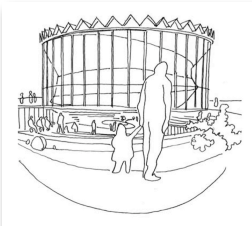
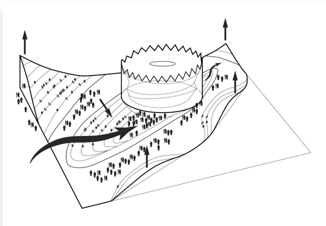
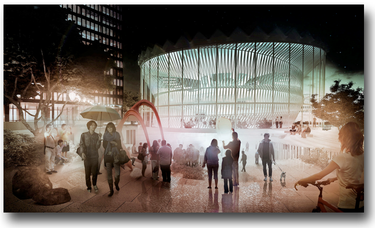
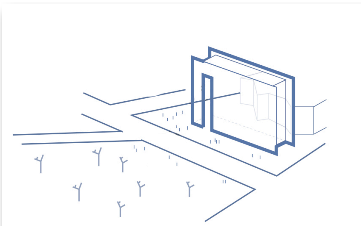
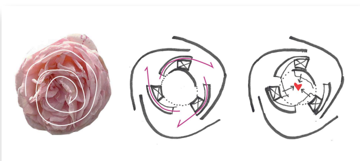
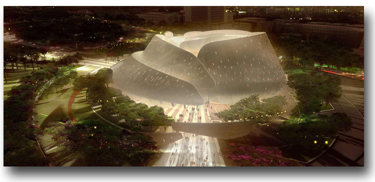
While the conditions of the unique point of view and the relative consistency within a type of representation had still to be met, other criteria were considered. For reasons explained further, there is a need to have access to a descriptive text of the project and the intentions of the architects. Moreover, diverse typologies and sizes of projects were researched, in order to form a diversified representations set. The secondary projects data finally counted 11 additional sets of representations from 9 architects or groups of architects. An overview of the representations is also showed below (*Tab.4*).

Moreover, we decided to include an additional project made by myself, the project *P16*. The purpose was to have access to a return on experience. In order not to biased the results by knowing the survey in advance, this project had been included in the secondary projects and so nothing had to be completed by the architect.

Eventually we obtain a set of 16 projects, 6 primary projects and 12 secondary projects, illustrated by three representations each, that represents 48 unique images. Larger illustrations of the representations sets are presented in the appendix for a closer look (*see Appendix 2*). Representativeness and statistical significance will be brought by containing a sufficiently large number of similar images (*Bell, 2001*), and it will consist as «*a reliable source of factual evidence*» (*Van Leeuwen & Jewitt, 2001*).

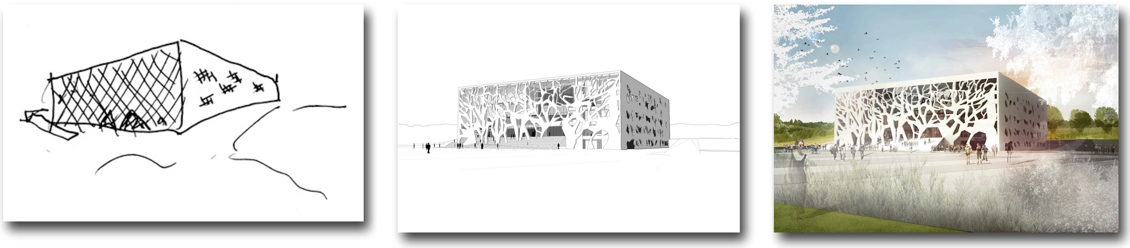
	HAND-DRAWING	COMPUTER MODEL	RENDERING
P1			
P2			
P3			
P4			
P5			
P6			

Tab.3 - *Representations sets of the primary projects, with access to the architects.*

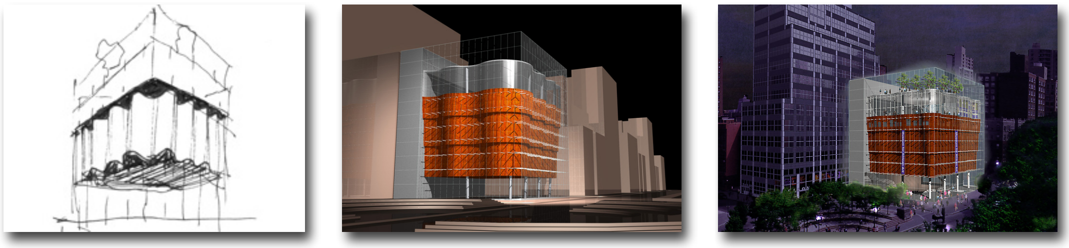
	HAND-DRAWING	COMPUTER MODEL	RENDERING
P7			
P8			
P9			
P10			
P11			
P12			

Tab.4 (part I) - *Representations sets of the secondary projects, without access to the architects.*

P13

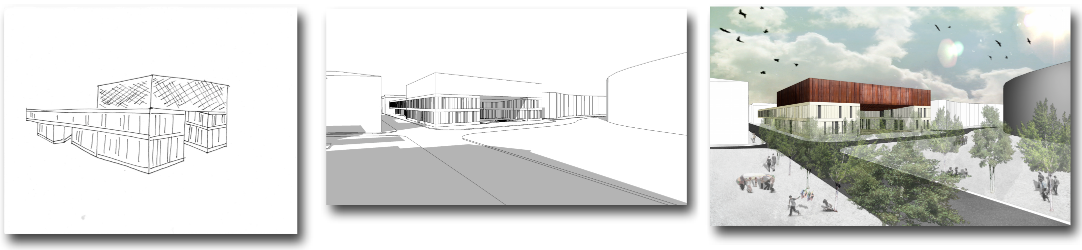


P14



P15

P16



Tab.4 (part II) - *Representations sets of the secondary projects, without access to the architects.*

4.3 **Adjectives data base**

Now than we have the necessary visual material for the study, we need to build the framework to catch architects' intents and people's perception of these representations. Descriptions accompanying the projects, either obtained directly from the architect or from their website and portfolios, constitute the primary base to describe the architectural intent of each project (*see Appendix 3*).

A quick scan of the descriptions accompanying the projects reveals that intentions extensively rely on adjectives, such as "*verticality*", "*enclosed*" or "*elegant*". Architects describe their intents using adjectives, so it becomes logical to research lay-people's perception using similar semantics, in order to be able to compare responses from the two different populations.

We then considered the Semantic Differential Method and Scale (*Osgood et al.,1957*) in order to assess architects' intents and people's perception. This method consist to rate a set of attributes on a scale of two bipolar adjectives, as showed below (*Fig.3*). As explained earlier (*see 2.3 Depicting intents*), several studies employed this method in order to assess several attributes adapted to their specific purpose. In our case the attributes relate to the architectural intent and its perception.

SEMANTIC DIFFERENTIAL SCALE

	very	somewhat	neutral	somewhat	very	
'A' side	x	x	x	x	x	**'B' side**

Fig.3 - *Semantic differential scale.*

It has to be noticed that another method had been considered. Instead of asking people to rate a pair of adjectives, we could also ask them to rate with which degree they agree or disagree with a single statement, for instance «*this building is vertical*» (*Alcantara et al., 2005*). Nevertheless, with this method the results would be very sensible to the understanding of the wording. For instance, light could be understood as the opposite of *dark, bright* and *heavy*, which are very different intents. Moreover, the fact that you clearly disagree with a statement does not necessarily mean that you clearly agree with the opposite statement. For these reasons, we chose the Semantic Differential Method as defined by Osgood.

Then, we need to determine the semantic scales for the evaluation of the projects. The protocol we developed is inspired by the method defined by Artacho-Ramirez (*2008*) and following the guidelines given by Alcantara et al. (*2005*). The protocol is composed of four main steps to determine the attributes to be rated (*Fig.4*) : **[1]** formation of the *Initial Semantic Spaces*, **[2]** passage to the *Reduced Semantic Spaces*, **[3]** determination of the *Final Semantic Space*, and finally **[4]** choice of the bipolar adjectives to form the *Survey Semantic Space.*

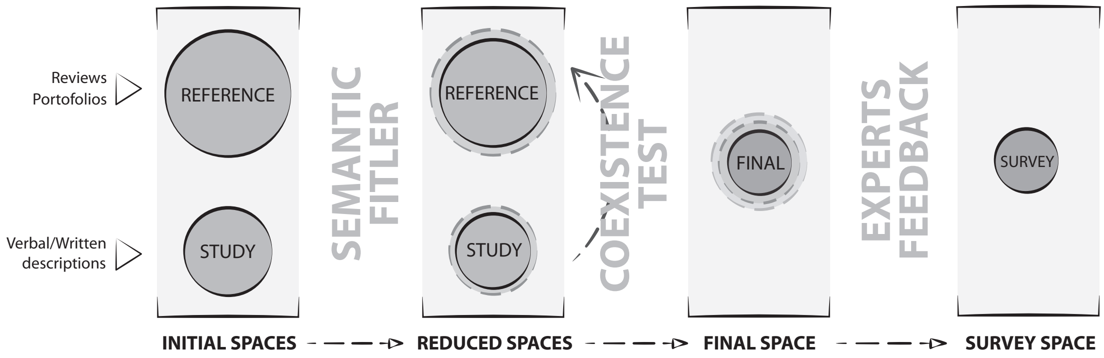


Fig.4 - *Steps to determinate the Survey Semantic Space.*

[1] **Initial Semantic Spaces**

The first step is to analyse the descriptions of the 16 architectural projects - 6 primary and 10 secondary projects - collected either from architects' websites and portfolios or from the descriptions collected (*see Appendix 3.1 and 3.2*). Note that some of them had to be translated from French or Spanish into English, with the help from translator interns. For the 6 students' projects and 10 professionals' projects, adjectives used in the descriptions are gathered to form the ***Initial Study Space***, which includes 90 adjectives (*Tab.6*).

The question of representativeness of these adjectives is naturally raised. Those adjectives might not reflect the only way to express intents in the practice. Consequently there is a need for more projects, even without personal contact with the architects. Magazines and available portfolios provided us with 421 students' and 39 professionals' additional reference projects (*see Appendix 3.3*), totalizing 287 adjectives into the ***Initial Reference Space*** (*Tab.7*).

Interestingly, during this research we noticed that, in their descriptions, professionals used much more diversified adjectives and flourished language than students did. It might be explained by the fact that students have less space available to describe their projects. More importantly, it proves that professionals become more and more confident with describing architectural projects, and develop more complex language with growing expertise. That may lead to a certain mystification of the architecture practice by using very abstract and complex language that lay-people don't understand. This preliminary observation underlines the importance of analysing descriptions of both students' and professionals' proposals.

[2] **Reduced Semantic Spaces**

All the adjectives gathered so far are not relevant to our study. We need to avoid loss of reliability due to subjects tiredness by using a too large number of attributes. Therefore, we used a *Semantic Filter* on the previously built *Initial Study Space* and *Initial Reference Space*, to obtain ***Reduced Semantic Spaces***, as showed on the previous figure (*Fig.4*).

We considered several criteria to classify and to refine the choice of adjectives to finally introduce in our survey. Some are inspired from other similar studies. The reduction criteria of synonyms and antonyms elimination (*Kuller, 1975*), but also *«adjectives related to materials, specialized terms and adjectives and expressions indicating a purpose or a aim»* (*Jindo et al, 1995*) are for instance considered here for inspiration. Here under is the custom-made semantic filter following the proper purpose of our study :

[-] Synonyms - adjectives conveying similar architectural intents are grouped,
[-] Antonyms - redundant antonyms are grouped with their pair but conserved,
[-] Specific - specific language related to the abstract sphere (e.g. breathing), or specific features of a project (e.g. vaulted) are filtered,
[-] Judgement of valor - irrelevant value judgments to the architectural intent are neglected,
[-] Other dimension - description of qualities that are visually absent of available representations are also identified.

Adjectives meeting each of our filtering criteria are presented on its own layer in the following pages. This semantic filter reduces the list to 28 groups of synonyms-antonyms for the *Study Space*, and to 51 for the *Reference Space*, represented in bold on the tables *Tab.6* and *Tab.7*. The situation is summarized by the next table (*Tab.5*).

	Study	**Reference**
Number of projects studied		
- students'	6	421
- professionals'	10	39
Number of adjectives		
- Initial Semantic Space	90	287
- Reduced Semantic Space	28	51
Purpose	Catch architect's intent and lay-people's perception	Validate the *Final Semantic Space* for intern assessment of representativeness

Tab.5 - *Characteristics of the Comparison and the Final Semantic Spaces.*

abstract	cylindrical	inspired	opposition	sociable
aligned	dazzling	integrated	**original**	**spacious**
amphitheatrical	diaphanous	invisible	platonic	special
beauty	dividing	landmark	**playful**	spectacular
block	**dynamic**	**landscaped**	**powerful**	**square**
central	**elegant**	low	**quiet**	stimulating
collective	emblem	**massive**	**rectangular**	stimulus
combination	enclosed	**metaphorical**	resource	**striking**
combined	**extravagance**	mixed use	round	**strong**
comfortable	fear	mixing	**safe**	sun-seeking
comforting	figurative	**modern**	salient	symbiotic
conceptual	fresh	monolith	scenic	symbolic
contemporary	functional	multi-purpose	**serrated**	traditional
contrast	harmonious	new	shadow-rich	unexpected
conventional	**high**	nice	significant	unique
convoluted	hybrid	old	**simple**	**vertical**
creative	**iconic**	**open**	**small**	verticality
cultural	ideal	opening	**smooth**	visible

Tab.6 - *Study* *Spaces (primary and secondary data sets) - adjectives building the Initial Space and Reduced Space (in bold).*

abstract	conflictive	ended	horizontal	nuanced	respectful	stockade-like
adaptive	**confused**	enfiladed	hybrid	old	revealing	strong
aligned	connected	engaging	iconic	old-fashioned	rigid	structured
ambiguous	connecting	**enigmatic**	illuminating	opaque	**rigorous**	subtle
ancient	contemporary	ephemeral	incredible	**open**	**robust**	succulent
angled	contrasted	eroded	independent	**organic**	romantic	supplanting
angular	contrasting	exciting	indirect	**original**	rotated	surprising
animated	controlled	**expanding**	industrial	ornate	**rough**	surreal
appealing	**conventional**	expansive	informal	ornamental	rugged	surveyable
architectonic	**convivial**	experimental	innovative	orthogonal	rural	**suspended**
artificial	crowded	**expressive**	insensitive	ostensible	rustic	symbiotic
audacious	cultural	extravagant	integrated	**particular**	**rythmic**	tactile
austere	curious	faceted	intense	peaceful	**sculptural**	technological
authentic	curved	familiar	interesting	**perched**	securable	temporal
autonomous	dark	fantastic	interrupted	permeable	seductive	**temporary**
axial	decent	fine	**intimate**	piled	**sensitive**	tense
basic	delicate	fixed	intriguing	plain	sensual	tensional
blocky shape	delight	**flat**	introverted	pleasant	sensuous	theatrical
blurred	dematerialized	flexible	isolated	poetic	sentimental	tight
breathing	dense	floating	landmark	poised	serene	timeless
brutalist	deployed	fragile	layered	polished	serious	traditional
cantilevered	dignified	fragmented	light	porous	severe	tranquil
ceremonial	direct	free-standing	**limitless**	powerful	sharp	translucent
changeable	**disappearing**	fresh	**linear**	precarious	shifted	**transparent**
chic	disconnected	functional	local	prestigious	shimmery	typical
choreographed	disconnecting	furtive	longitudinal	primitive	silent	unambiguous
circular	**discontinuous**	futuristic	**massive**	private	simple	unconstrained
classic	**discreet**	fuzzy	messy	protecting	simplistic	unconventional
classical	dispersed	generic	minimalist	**protective**	sinuous	undulating
closed	dissolved	graceful	**modern**	provocative	**small**	unfinished
clustered	distinguished	great	**modest**	public	smooth	unified
coherent	dramatic	happy	modular	**pure**	sober	uniform
coloured	**dynamic**	hard	modulated	quiet	social	unitised
colourful	eccentric	**harmonious**	monolithic	radical	soft	unsophisticated
combinating	ecological	harmonised	monotone	rational	sophisticated	**varied**
compact	economic	heavy	monotonous	raw	spacious	vaulted
complex	efficient	hectic	monumental	rebellious	spontaneous	vernacular
complicated	**elegant**	hermetic	mysterious	rectangular	sporadic	**vertical**
composite	**elevated**	high	**narrow**	refined	**stable**	volatile
conceptual	emerging	**historical**	neutral	regular	stacked	warm
confined	emotional	homogeneous	noisy	**relaxing**	static	weighted

Tab.7 - ***Reference*** Spaces - *adjectives building the Initial Space and Reduced Space (in bold).*

[3] **Final Semantic Space**

The *Reduced Study Space* sums up 28 groups of synonyms-antonyms (*see Appendix 4.1*), and while the *Reduced Reference Space* 51 groups (*see Appendix 4.2*). Then we apply a simple co-existence test, each adjective of the *Reduced Study Space* that also exists inside the *Reduced Reference Space* is considered as sufficiently representative of a shared architectural vocabulary and goes directly into the ***Final Space***.

The *Final Space* (*see Appendix 5*) is a list of adjectives with synonyms and antonyms. The bipolar list forms 20 groups representing different semantic axis, or *attributes*, as it will be called for the rest of the study.

[4] **Survey Semantic Space**

As previously said, each of the 20 attributes are represented by multiple bipolar adjectives. It is then necessary to proceed to a choice of a unique pair of bipolar adjectives for each attributes, in order to form our survey. In order to proceed to this choice, experts were called independently to chose a unique pair of bipolar adjectives to represent each attributes.

This *Final Space* list has been send to 8 experts in order to choose one pair of bipolar adjectives for each of the 20 attributes. The experts are either *Mechanical Engineers* specialized in the product design practice, or *Architectural Engineers* specialized in the study of the design process. Results of their votes can be consulted in appendix (*see Appendix 5*).

Additionally to the choice of adjectives pairs, they provided us with comments and feedback regarding to the attributes themselves. This step is used as a validation step before building the final survey. It is explained in longer details in appendix (*see Appendix 5*), but here are the main changes brought by experts' feedback.

Among their comments, it has been acknowledge that the adjectives within some of the attributes were representing slightly different intents. For the two concerned attributes (*see Appendix 5*), the decision of splitting the attributes in two independent sets was then taken. Similarly, two different attributes have been excluded because of concerns expressed by the experts about the potential difficult understanding of the adjectives and about adjectives judged as pejorative. Finally, another attribute have been excluded because it was considered to express the same intent than another attribute. This last attribute was then replaced by another one expressing more clearly the subjacent intent.

It leads us to a list of 20 attributes composed of bipolar pairs, the *Survey Semantic Space*, used in the study along with the *Semantic Differential Scale* (*Tab.8*). From now, we will call the attribute by its number and a list is accessible from the back cover of the present work, in order to link the number with the specific adjectives.

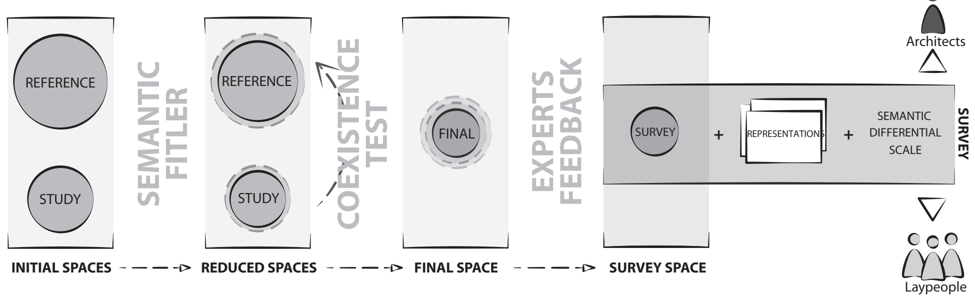


Fig.5 - *Steps followed in order to build the survey.*

	very	somewhat	neutral	somewhat	very	
'A' side	x	x	x	x	x	**'B' side**

'A' side		**'B' side**
contemporary	①	classical
complex	②	simple
hard	③	soft
robust	④	delicate
sharp	⑤	smooth
innovative	⑥	traditional
dynamic	⑦	static
relaxing	⑧	stimulating
quiet	⑨	noisy
varied	⑩	homogeneous
expansive	⑪	compact
discreet	⑫	extravagant
low	⑬	high
composite	⑭	monolithic
modest	⑮	audacious
small	⑯	large
vertical	⑰	horizontal
open	⑱	closed
heavy	⑲	light
common	⑳	unique

Tab.8 - *Survey Semantic Space of the 20 attributes used to assess architect's intents and lay-people's perception.*

4.4 **Survey procedure**

Now that we have the visual material and the framework to assess them, the survey can be built. Multiple pilot surveys were conducted to gather feedback to improve the survey. The structure of the survey has been revised, more precisely the moment to continue to the next page of the survey and the number of attributes and images to be shown per page.

In order to evaluate the 48 images gathered, we used Amazon's online service, *Mechanical Turk*. After a brief description about the tool itself, we describe the procedure followed by the two categories of participants, lay-people and architects (*Fig.6*).

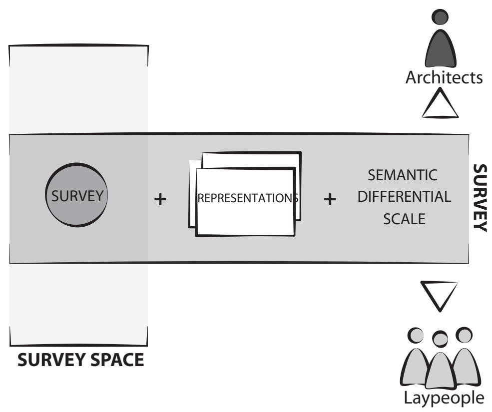


Fig.6 - *Components of the survey built to reach two categories of participants.*

Mechanical Turk

Mechanical Turk is a web-based crowdsourcing marketplace. Requesters post Human Intelligence Tasks (HITs) and workers complete them, receiving financial compensation for their time and attention.

This is a powerful tool for collecting data from large populations quickly and easily. In the interest of earning money with minimal efforts, we have to acknowledge the fact that some participants are not putting much efforts to accomplished the task, resulting in poor quality answers, useless for the study. Quality of responses has then to be verified in order to hopefully eliminate most of the dishonest responses.

To answer to that issue, Mechanical Turk allows requesters to specify certain restrictions on workers who would be interested in completing a HIT, such as their location or their approval rating. By setting a high requirement on the HIT approval rating for workers, it has be proven that it can improve quality of responses received (*Mason and Suri, 2012*).

Willing to gather quality answers, the following requirements were set. Mechanical Turk workers must present a profile with :

[-] HIT Approval Rate for all Requesters’ HITs greater than or equal to 95%,
[-] Number of HITs Approved greater than or equal to 100,
[-] Location in United States.

In our study, each worker would receive $1 for successful completion of the HIT, corresponding to roughly a $6/hour wage, within the normal range for typical HIT compensation. Moreover, for independence of results, each workers could accomplished the task only once (*see 4.6 Participants*).

Finally, an online training class has been followed before sending any survey. Ethical and legal guidelines are explained for conduction of research involving human subjects. The class is required by the Committee on the Use of Humans as Experimental Subjects (COUHES) for any research involving human subjects that is performed at *MIT*. Additionally to the class passing, a draft of the study explaining procedures and guidelines has to be submitted for approbation of the Committee, before involving any subject.

Procedure for lay-people

Once workers willing to participate to our study fulfill the requirements, the survey we built were presented to them. We will describe here the structure of the survey showed to the participants, an example is presented in appendix (*see Appendix 6.1*).

First, after a brief description of our research and our objectives, each participant were randomly shown three images. For each image, people were asked to assess the architectural intent by filling the 5-points scale for each of the 20 attributes perviously selected (*Tab.8*). During the survey procedure, each image was shown independently to fill the attributes list, in order to avoid as much as possible inter-representations comparisons. Moreover, the order of the attributes was randomised between each representations in order to avoid repetitive patterns in answering the survey.

Each of the three images shown to each participant comes from a different project and belongs to a different style of representation. The precautions taken about the images are really important for the data consistency. By avoiding to show two different representations from a same project, we aim to avoid the risk to rate a representation that might be completed with information previously seen on another representation. For the same reasons, we avoid the inter-projects comparisons by avoiding to show two different projects illustrated in representation from the same style.

Additionally to attributes list, participants were asked to rate the clarity of the image, using a 5-points scale going from very clear to very unclear.

Finally, we close the survey with some demographic questions, such as gender, age, professions, ... Those are presented in the end to avoid any self-suggestive or socially-accepted answering patterns.

It has to be noticed that images were shown anonymously in order to avoid any judgement linked to potential connotations of the architect's name. Although after the image has been rated by the participant, we decided to give credit to architects by mentioning who was the author of the project.

Procedure for architects

For the six architects who provided us with representations, the procedure was different. Although, we used the same scale and the same list of attributes, the images shown and the structure of the survey were different.

The procedure includes the assessment of the representations in two independent steps, firstly showing the representations as a whole and secondly each representation independently.

First, architects were shown together the three representations they provided us. They were asked to assess the overall clarity of the representations and the architectural intent of the project by using the attributes scale. In other words, they were asked to rate only their own personal project. This first step aims to capture the global intention conveyed by the project as a whole, independently to any explicit reference to the style of representation.

Next, they were shown independently each of their own images to assess the clarity of the representation and the architectural intent conveyed through the representation by using the same attributes scale. During this step, we aim to evaluate the self consistency of the architectural intents once they are more explicitly facing to their representations.

Finally, they were asked some demographic questions, such as gender, age, and experience. An example of the survey is presented in appendix (*see Appendix 6.2*).

4.5 **Data analysis methods**

Most usually, results gathered from a similar scale than used in the present study, are analyzed using two main statistical tests, the ANOVA and the Student tests (*e.g. Brown & Gifford, 2001; Imamoglu, 2000; Akalin et al., 2009*) .Although, to correctly apply this pair of tests the populations require to fulfill some assumptions, and among others the populations tested must be normally distributed (*Bluman, 2009, pp.448, 629*). However we are not able to affirm that the data follows a normal distribution for different reasons.

We are gathering the data on a 5-points scale as a ordinal variable. Below (*Fig.7*) stands one example of the frequency distribution obtained from the survey, given one representation participants were asked to rate each of the twenty attributes, being rated on a 5-points ordinal scale.

ATTRIBUTE EVALUATION

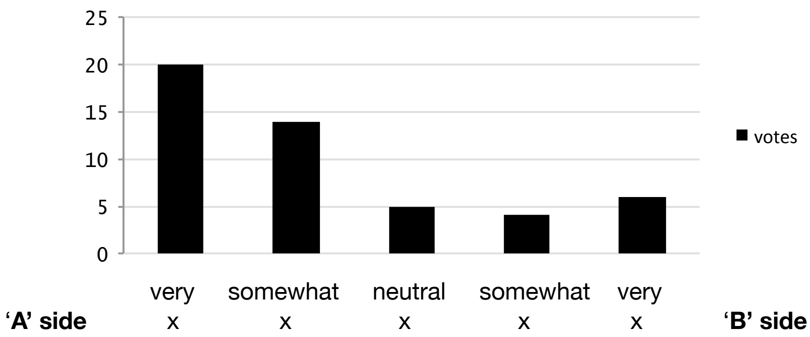


Fig.7 - *Example of the frequency distribution extracted from the survey data.*

It is obvious that the distribution is not symmetrically dispersed around the mean value, and not bell-shaped. Yet, symmetry and bell-shaped distribution are part of the assumptions for any normal distribution (*Bluman, 2009, p.303*). Since basic assumptions of normally distributed populations are not met, we need to use a different pair of statistical tests.

The ANOVA and Student tests are called parametric tests because there are making assumptions on the probability distribution. The Kruskal-Wallis and Mann-Whitney tests are considered the non-parametric alternatives to the one-way ANOVA and the Student tests, respectively (*Ref.2*). The big difference of the non-parametric alternatives is that they are not making any assumption on the distribution, and therefore may be a better fit to our set of data.

Few assumptions are required in order to properly apply the Kruskal-Wallis and the Mann-Whitney tests (*Ref.2*).

[-] the dependent variable must be in the order of the ordinal or continuous level,

[-] the independent variable must be constituted of independent groups,

[-] the observations must be independent within each group or between the groups themselves.

The data we are gathering actually fulfills these assumptions for the following reasons. Firstly, we use a 5-points scale to collect the data which is the definition of an ordinal variable.

Secondly, the different groups or, more precisely, the different representations can be considered independent as a drawing cannot simultaneously be a rendering or a CAD model, and vice versa.

Finally, we verified the last assumption is verified thanks to the way we designed the survey. Precautions were taken not to show two different sorts of representations from a same project to a same person. In other words, a single rater would never be presented with a drawing and a rendering (or a CAD model) representing the same project. By doing so we avoid the comparison of representations for a same project and therefore we provide the independence of the observations between groups. Additionally, nobody has been showed a same sort of representation from two different projects, for instance two drawings of different projects. We then avoid the comparison of similar representations of different projects, providing therefore the independence of the observations within groups (*see 4.4 Survey procedure*).

Our data consequently fulfills the conditions required by the pair of statistical tests. Keeping this in mind, we are describing in the following sections the two tests more precisely and how we apply them to our data.

Kruskal-Wallis test

The Kruskal-Wallis test is the non-parametric alternative to the one-way ANOVA test. In our case, it is used to determine whether there are statistically significant differences between the three representations from a same project, given the lay-people's perception of a particular attribute (*Ref.2*). More simply it will tell us whether we can say that for a single project an attribute is perceived differently between representations.

Note that the Kruskal-Wallis test only shows whether at least two representations are statistically significantly different from each other, without pointing which specific representations are different from each other (*Ref.2*). Another additional test is therefore necessary to compare pairs of representations. The post hoc test we are using is the Mann-Whitney test and it will be described in the next section.

In order to apply the Kruskal-Wallis test we rank all the data values from one representation, then we compute the ranks and finally we compute the Kruskal-Wallis H-value with the following formula (*Bluman, 2009, p.692*) :

$$H = \frac{12}{N\,(N+1)} \left(\frac{R_1^2}{n_1} + \frac{R_2^2}{n_2} + \frac{R_3^2}{n_3} \right) - 3\,(N+1)$$

Equ.1 - *Equation of Kruskal-Wallis H-value.*

where $N = n_1 + n_2 + n_3$

R_k = sum of ranks of sample k

n_k = size of sample k = number total of votes per representation

The Kruskal-Wallis test is working with the following hypotheses :

[H_0] There is no difference of perception of that specific attribute between the three different representations.

[H_1] There is a difference of perception of that specific attribute between the three different representations.

The larger the H-value is, the more likely the samples come from different populations. Moreover, if the H-value is large enough, the null hypothesis H_0 will be rejected. On the opposite, the smaller the H-value is, the less likely the samples come from different populations. Therefore, the hypothesis H_1 will not be rejected.

From this H-values, we can calculate the probability of rejecting the null hypothesis H_0 when that hypothesis was true, which is called the p-values. In other words, the larger the p-value is, the more we can mistakingly affirm that there are significant differences of perception between the three different representations. Meaning, the p-value is the probability to make a wrong decision.

We define a significance level, called alpha. Under this alpha level, p-values can reasonably be considered small enough not to mistakenly lead to the rejection of the null hypothesis H_0 while it was true. In human behavioral studies, it is common to use an alpha level of 0.05 as statistical significance, which will be similarly applied in our study.

Hence each sample sizes count more than five individuals, the distribution of the responses can be approximated by the chi-square distribution. This is a statistical artifact to facilitate the numerical computation of the p-values with the H-values correspondent, by allowing us to use chi-square values automatically computed by specialized softwares, such as *Matlab*.

The p-values are computed for each of the 20 attributes from all the 16 projects. A table showing all the numerical results is presented for reference in the appendix (*see Appendix 7.1*).

Mann-Whitney test

The Mann-Whitney test is the non-parametric alternative to the independent Student t-test. Here again it is used to determine whether there are statistically significant differences of perception between the three representations picturing a single project. It constitutes an extension of the Kruskal-Wallis test by comparing pairs of representations to determine which ones are different from the others (*Ref.3*).

In order to apply the Mann-Whitney test we follow the same process as previously and compute the Mann-Whitney U-values with the following formula (*Levine et al., 2008, p. 490*) :

$$U_1 = n_1 n_2 + \frac{n_1 (n_1+1)}{2} - R_1$$

$$U_2 = n_1 n_2 + \frac{n_2 (n_2+1)}{2} - R_2$$

Equ.2 - *Equation of Mann-Whitney U-value.*

where R_k = sum of ranks of sample k

n_k = size of sample k = number total of votes per representation

The Mann-Whitney test is working with the same hypotheses as previously stated :

[H_0] There is no difference of perception of that specific attribute between the two different representations.

[H_1] There is a difference of perception of that specific attribute between the two different representations.

The interpretations of the values obtain are similar to the precedent test. If the U value is large enough the null hypothesis will be rejected, which means that there are statistically significant differences between the representations. Note that here again we are using an alpha level of 0.05 for statistical significance.

The p-values are computed for each pairs of representations for the twenty attributes from all the sixteen projects. The numerical values are enlisted in appendix (*see Appendix from 7.2 to 7.4*).

4.6 **Participants**

Lay-people

We send 880 surveys through Amazon Mechanical Turk. After having completed the batch, we realized that all the answers did not have the same quality and some answers were clearly unusable. We then undertook a cleanup of the data.

In order to get rid of useless data, we defined some clear guidelines to clean the data. If a survey fulfilled one of the next criteria, it was considered unusable and therefore it was not be included in the next steps of our research:

[1] The survey has been completed far too quickly to having been taken seriously : after the first iterations of the survey we considered the boundary of 3 minutes under which was too fast - **90 surveys excluded**.

[2] All the answers from the survey are identical : in order to click as fast as possible the participant only click on the left or right side of the checkboxes - **17 surveys excluded**.

[3] Several surveys were completed by the same IP address and so probably by the same person, which goes against one of our precautions to gather independent answers - **87 surveys excluded**.

After the cleaning of the data, 686 surveys were remaining, representing close to 78% of the total number of surveys sent. In the remaining surveys the parity male-female is close to be respected with 57.8% of the surveys answered by men, and 41.7% by women. The median age of the participants is the range 31-40 years old and they are North American almost exclusively, which is a consequence of the way we designed the survey (*see 4.4 Survey procedure*). The average time needed to complete the survey was 7 minutes and 1 second.

Architects

As already said (*see 4.4 Survey procedure*), the architects answering the survey are the persons who provided us with representations for our study. Amongst the 16 projects included in this study, we had access to 6 persons performing in the architecture practice, 3 professionals and 3 students. They are between 21 and 60 years old and the gender split is 4 men for 2 women. Amongst them, 2 practice in Belgium, 2 in France and 2 in the US. They took the survey in an average time of 8 minutes and 49 seconds.

Again, it is important to notice that the architects we surveyed were asked to answer only on the representations of their own projects. In this way we can have access to their intentions without implying a comparison with others' work or any sense of competition.

5. RESULTS

The data gathered is analyzed regarding to the category of persons concerned, is lay-people or architects. In a first section (*see 5.1 Lay-people's perception*), we review the data collected from the lay-people, this part constituting the analysis of the perceptions of the representations. In a second section (*see 5.2 Architects' intents*), we focus on the architects' intents by developing and analyzing answers given by the architects who built the representations.

Previously to analyze the results, we give here a sense of the distribution of by giving the number of collected responses per projects' representations (*Tab.9*). The survey has been completed by at least 40 different participants for every single representation, and at least by 123 participants for each project.

	Hand-drawing	CAD model	Rendering	TOTAL
P1	43	43	44	**130**
P2	43	43	43	**129**
P3	45	44	48	**137**
P4	43	42	46	**131**
P5	43	44	42	**129**
P6	44	44	46	**134**
P7	43	41	44	**128**
P8	42	41	40	**123**
P9	44	45	44	**133**
P10	43	41	44	**128**
P11	44	40	41	**125**
P12	41	46	42	**129**
P13	42	43	42	**127**
P14	40	43	40	**123**
P15	45	42	41	**128**
P16	45	42	41	**128**
TOTAL	**690**	**684**	**688**	**2062**
RANGE	**40 - 45**	**40 - 46**	**40 - 48**	**123 - 137**

Tab.9 - *Number of responses per project and per representation.*

5.1 **Lay-people's perception**

In the following section we are trying to understand how lay-people expressed their perception through the survey. The findings are organized from general to specific observations. The general observations are shown by aggregating the results for all the attributes first, and for all the projects in a second time. The specific findings include more particular parameters, and they will be crossed with the observations previously made.

1 | **Attributes perception**

The goal we are trying to achieve is to understand whether the 20 studied attributes - tagged from *A1* to *A20* - are differently perceived given the three representations of a same project, or in other words whether the representation plays a role in the perception of a particular intent. For each attribute inside a single project, we compare the perception collected through surveys from a representation to another by computing Kruskal-Wallis H-values (*see 4.5 Data analysis methods*). Evaluation of the statistical significance help us consider whether the attribute is evaluated differently in at least one of the representations.

Once the p-values computed for all the attributes of all the projects (*see Appendix 7.1*), we can examine the distribution of the statistically significant results. This section explores the distribution of the significant results across the attributes.

The following chart (*Fig.8*) represents the distribution of the significant results for each attribute, which corresponds to the number of projects with a significant p-value for this attribute divided by the total sixteen projects. For instance, the column representing the attribute *A1* shows *44%,* which means that *44%* of the projects evaluated present a p-value showing significant difference of perception between the representations tested. Finally, the last column of the chart (*AVG*) shows the ratio of all the attributes perceived differently through the representations of all the projects.

The next formula synthesize how we build the charts *Fig.8*.

$$A_x = \frac{(\#\text{ projects w/ } A_x \text{ w/ KW} < 0.05)}{(\#\text{ projects total})} = \frac{(\#\text{ projects w/ } A_x \text{ w/ KW} < 0.05)}{16}$$

Equ.3 - *Concept formula used to build Fig.8.*

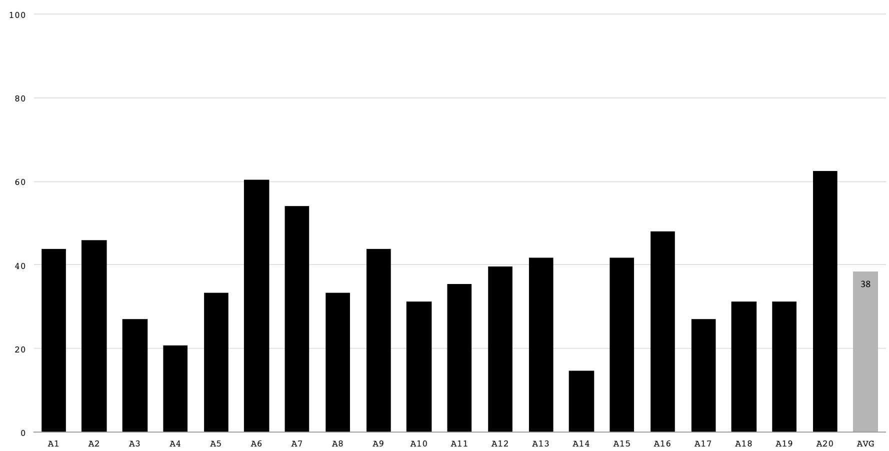


Fig.8 - *Percentage of projects differently perceived through the three representations, per attribute.*

It is easier to apprehend the different trends of this chart by explaining the extremes. A high percentage in this chart means that the attribute is perceived differently through the different representations in most of the studied projects, and so raises the question that all the representations do not convey the same intent. On the opposite, a small percentage means that there is only few of the studied projects for which we can say that people had a statistically different perception of the attribute in function of the representation, or in other words that there are few projects for which the representation plays a role in the perception of the attribute.

Before exploring results, note that a list of the 20 pairs of adjectives is at constant reach, printed on the flap of this thesis' cover. Additionally, later section (*see 5.3 Outlined results*) will thoroughly summarize findings about each attribute considered separately, referred here simply through short codification in order to increase readability.

We can observe that all the attributes are not evenly conveyed through the three representations. The results range from *15%* for *A14* to *63%* for *A20*. The attributes *A4* and *A14* are mostly conveyed in the same way through the three representations. We might suggest that the degree of *massiveness* of an architectural proposal seems to be conveyed similarly through the different representations. On the opposite, the way the attributes *A6*, *A7* and *A20* are conveyed depends more on the representation shown, and perhaps on the highly subjective assessment of *novelty*, *rhythm* or *uniqueness* in architecture.

In the last column we represent the ratio of all the significant results for all the attributes, in this case 38%. As a first gross approximation we cannot say that the sum represents neither a high or a low percentage. In the case of high percentage, it would have allowed us to say that there is an influence of the representation on the perception for most of the attributes and for most of the projects. While with a low percentage, it would have allowed us to say that there is very little influence of the representation on the perception of most of the attributes tested for all the projects. A *38%* result is not salient enough to reach any conclusion so far, therefore we need to refine our analysis.

Kruskal-Wallis test enables us to compare more than two representations and to have general trends. Nevertheless the test does not provide informations about which representation is different from the others or even if they are all different. The next step is therefore to break down the analysis by testing pairs of representations for significant perception differences, which will be done by using the Mann-Whitney test (*see 4.5 Data analysis methods*).

Here also we have computed the p-values for all the projects and all of their attributes (*see Appendix from 7.2 to 7.4*). We represent the repartition of the significant results using the same process than previously described in the three following charts, one per pair of representation compared - hand-drawing/CAD model, CAD model/rendering and finally hand-drawing/rendering. This way, we can better understand between which representations stand the perception differences.

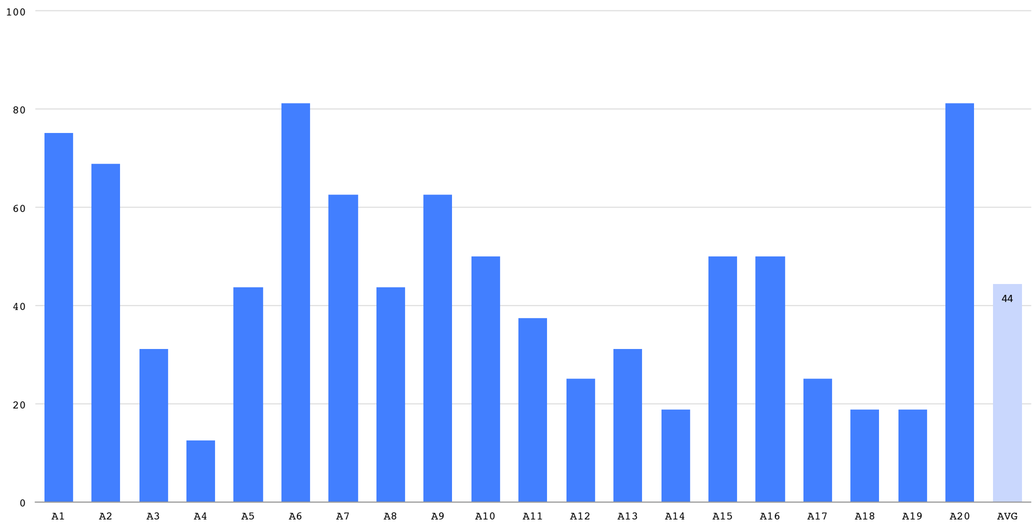


Fig.9 - *Percentage of projects differently perceived between hand drawing and CAD model, per attribute. (n=690)*

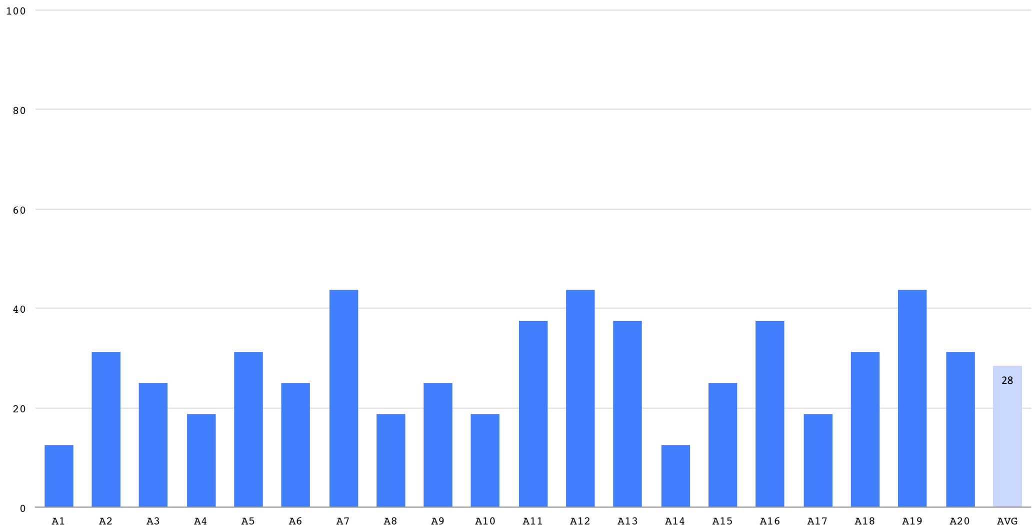


Fig.10 - *Percentage of projects differently perceived between CAD model and rendering, per attribute. (n=684)*

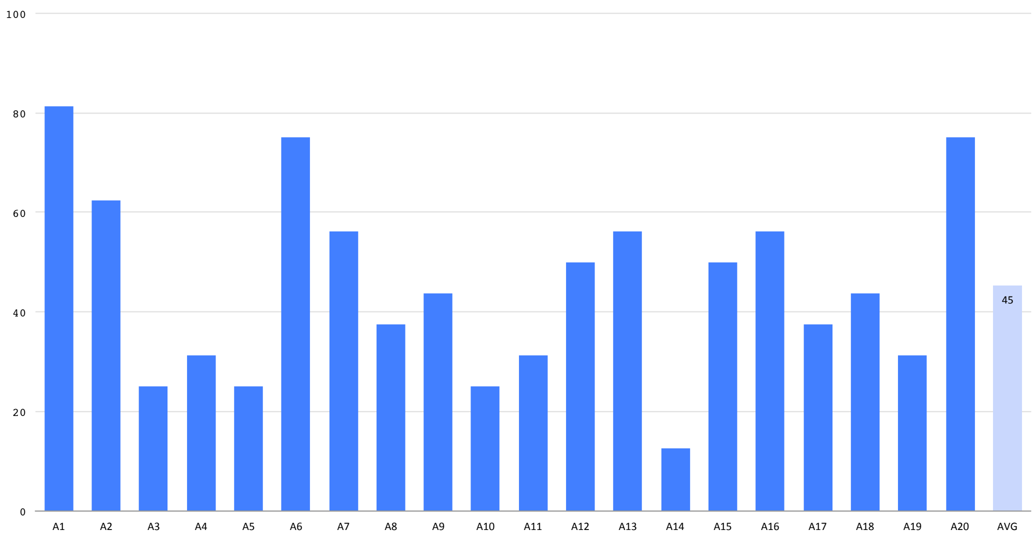


Fig.11 - *Percentage of projects differently perceived between hand drawing and rendering, per attribute. (n=688)*

In the last column of each chart we observe that the sum of all the attributes with a statistically significant p-value represents a much smaller ratio for the comparison between CAD model and rendering (*s=0.28*) than the other compared pairs that include hand drawings (*s=0.44 and s=0.45*). That means that there are less attributes from all the projects that are perceived differently between CAD model and rendering. Those two representations can therefore be considered as having smaller chances to convey different intents to the public.

As these graphs are a break down of the previous results, it is normal to observe again that the attributes are not evenly conveyed through the three representations. Two main observations can be made on the attributes regarding to how they were perceived (*Fig.12*).

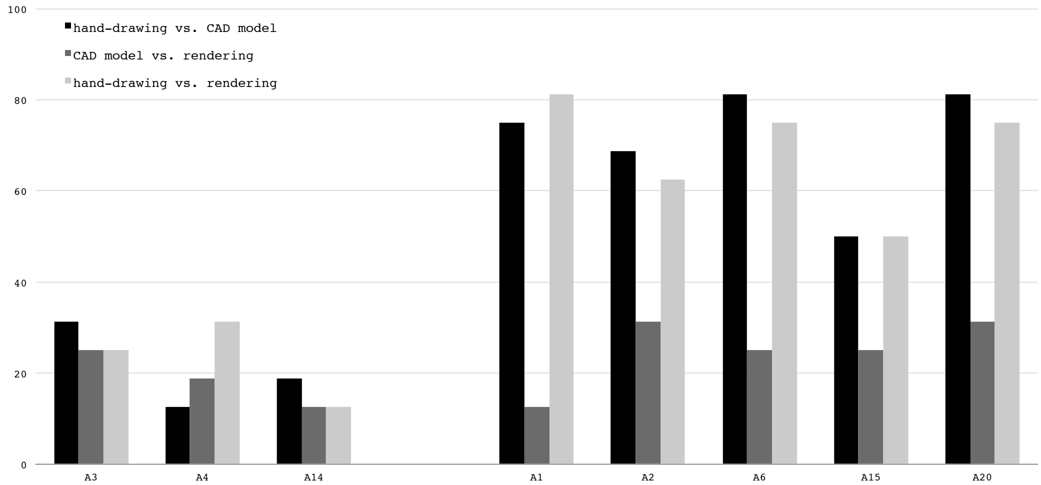


Fig.12 - *Two main groups of observations of peculiar attributes.*

In a first group stand all the attributes that are mostly conveyed in a similar way through the three representations, the attributes *A3*, *A4* and *A14.* This observation is pretty interesting. That means that we can use either a hand drawing, a CAD model or a rendering to similarly convey intents such as *softness*, *robustness*, or *compositeness*.

A second group includes the adjectives that are perceived mostly in the same way for a certain pair of representations and not for the others. This group includes the attributes *A1*, *A2*, *A6*, *A15* and *A20*. All of them are perceived mostly in the same way when we compare the pair CAD model/rendering but not at all with the two other pairs of representations. That means that those attributes are conveyed differently by the hand-drawing.

The last group includes all the remaining attributes and is more randomly represented in the charts, so it is difficult to draw any patterns from them.

Now that we have made observations on the results through the 20 attributes, we can do the same by grouping the results per projects.

2 | **Projects perception**

Previously we have broken down the data per attribute and we analyzed people's perceptions of these attributes, per pair of representation. In addition, we do here a perception analysis by crossing the projects studied. We want to show whether the sixteen studied projects - tagged from *P1* to *P16* - present differences in perception through the three representations, or whether there are projects with sets of representations that appear to be perceived in the same way.

The way we do it is pretty similar to the previous sections. We have already computed Kruskal-Wallis p-values comparing the perceptions of an attribute of a single project between the three different representations (*see Appendix 7.1*). The only difference is the way we are looking at the distribution. We want here to analyze the distribution of the significant results for each project, which corresponds to the number of attributes with a significant p-value for this project divided by the total twenty attributes.

$$P_x = \frac{(\#\text{ attributes of } P_x \text{ w/ KW} < 0.05)}{(\#\text{ attributes total})} = \frac{(\#\text{ attributes of } P_x \text{ w/ KW} < 0.05)}{20}$$

Equ.4 - *Concept formula used to build Fig.13.*

So for instance the *50%* represented for the first project *P1* means that in *50%* of the attributes evaluated, there was a p-value that enables us to say that there is a significant difference of perception of the attribute between the representations tested.

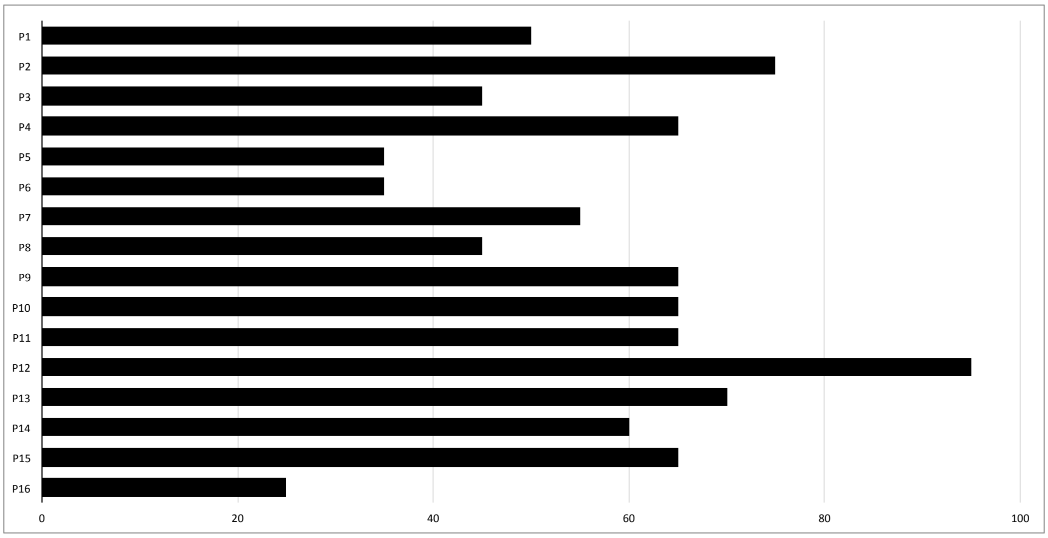


Fig.13 - *Percentage of attributes differently perceived between hand drawing and CAD model, per project.*

The meaning of the values obtained can be extrapolated from the extremes. A small percentage in the chart means the project includes only few differently perceived attributes through the three representations, meaning that the perception of the project is relatively independent of the representation.

The results range from *25%* for the project *P16*, for which most of the attributes are perceived in the same way independently from the representation, to *95%* for the project *P12*, for which almost all the attributes are perceived differently between at least two of the representations. Projects' representations are provided later in appendix for reference (*see Appendix 2*).

Once again we don't know between how many representations the perception difference occurs or between which representations. The next step is therefore to test pairs of representations for significant perception differences, using the Mann-Whitney test (*see 4.5 Data analysis methods*).

We then use the computed p-values per pair of representation (*see Appendix from 7.2 to 7.4*). Changing the way we are looking at the distribution, we represent the repartition of the significant results per project with the formula previously explained (*Equ.4*). It's then possible to understand where, between representations, stands the particularly important perception differences.

We observe here that each project is not equally conveyed through the different representations. We can make three main observations (*Fig.14*).

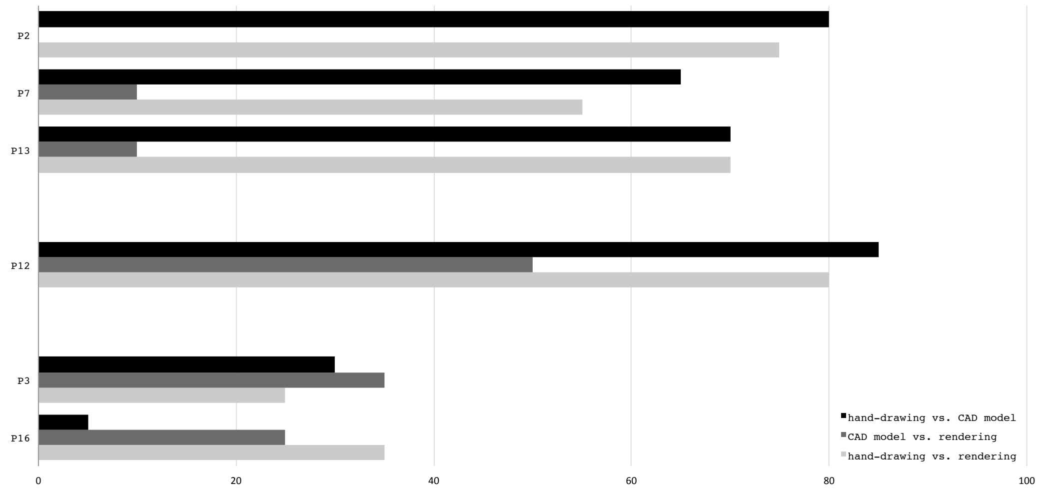


Fig.14 - *Three main groups of observations of particular projects.*

First, we can point out the same observation as for the attributes insights : several projects are conveyed mostly in the same way by the CAD model and the rendering but very differently by the hand-drawing. This come down to high percentages of statistically significant differences in the first and third column of each series, while low or null percentages can be observed in the second chart, and we can notice that the projects *P2*, *P7* and *P13* specifically follow this configuration.

For others projects we can see that there is less influence of the representation on the perception, resulting in lower percentages in all three charts. That is the case for two of the studied projects, projects *P3* and *P16*.

On the contrary, the perception of the project *P12* is really dependent of the representation showed to raters, which is represented by high percentages in all the three charts.

These observations are interesting but it is complicated to compare a project to another. Indeed, each project has is own intent. It is therefore difficult to compare them on the same basis.

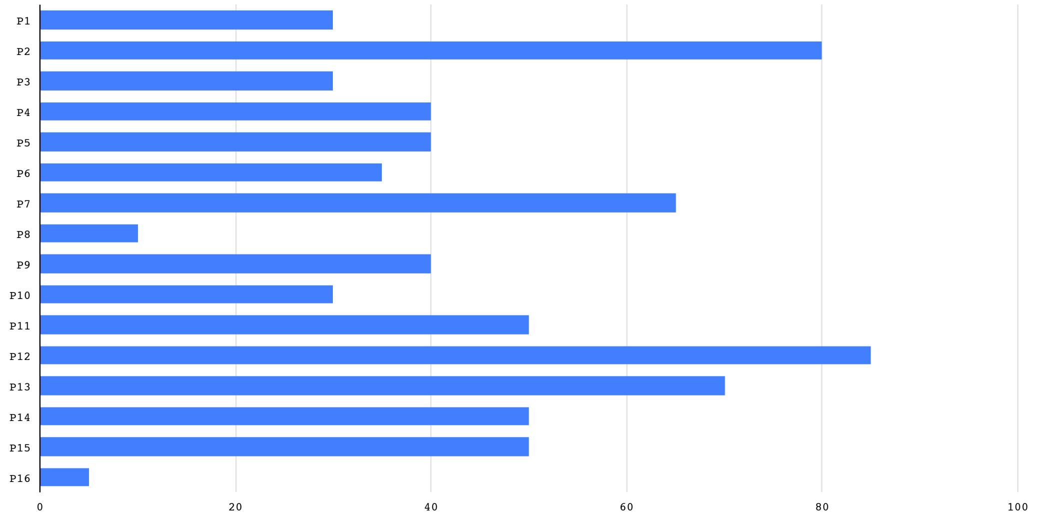


Fig.15 - *Percentage of attributes differently perceived between hand drawing and CAD model, per project. (n=690)*

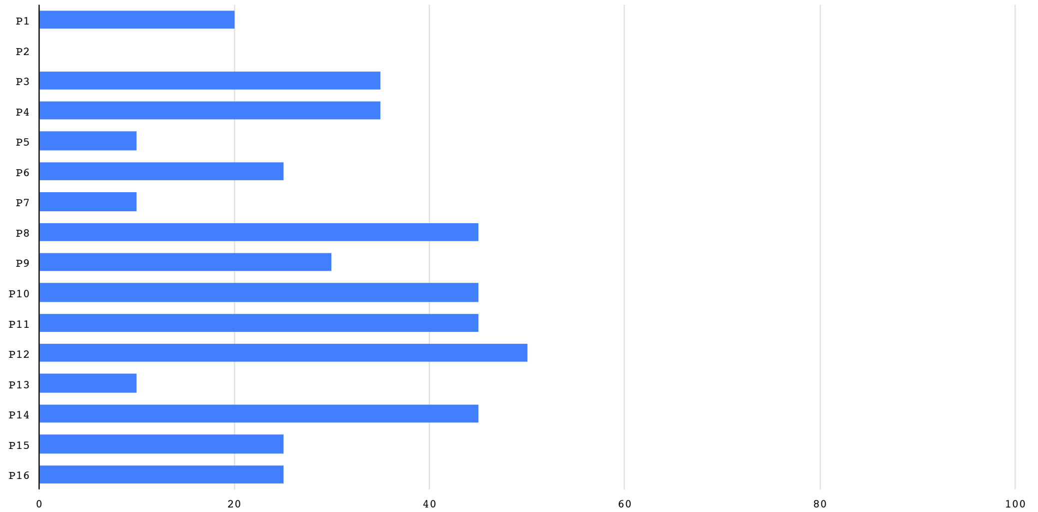


Fig.16 - *Percentage of attributes differently perceived between CAD model and rendering, per project. (n=684)*

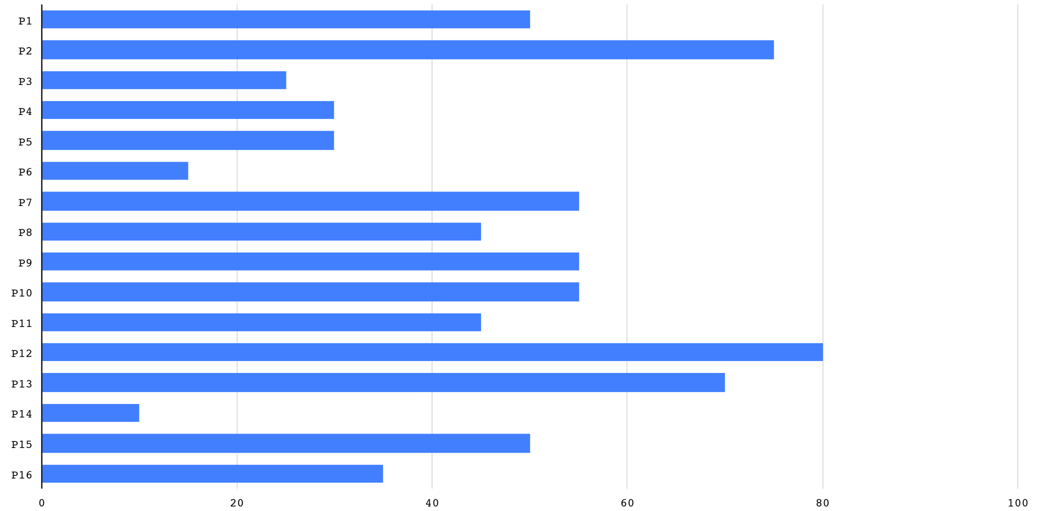


Fig.17 - *Percentage of attributes differently perceived between hand drawing and rendering, per project. (n=688)*

3 | Representations clarity

Additionally to the rating of the attributes previously described, we asked participants to rate the clarity of each representation. They had to describe the clarity of the representation using a 5-points scale spanning from totally unclear to totally clear.

The next figure represents the results of this question. We sorted out the votes expressed by the lay-people through the survey. We divided the results per representation and merged all the projects. The results go from very clear on the top to very unclear on the bottom, passing by a neutral state in the middle part of each bar (*Fig.18*).

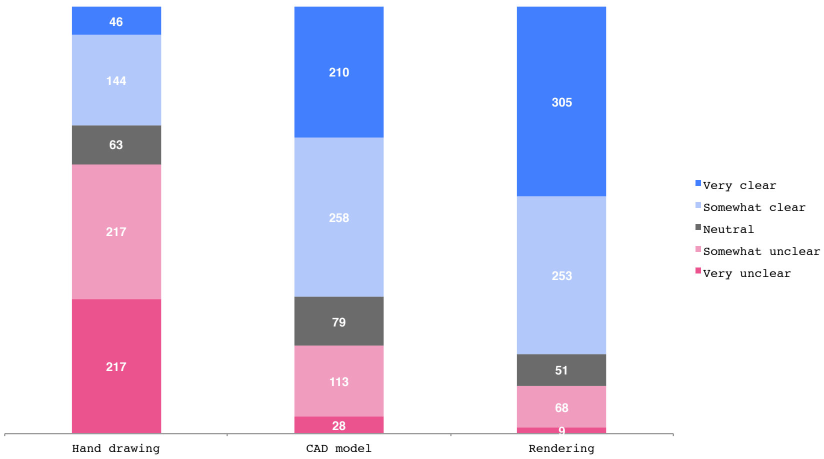


Fig.18 - *Clarity of the images for both the primary and secondary projects, votes expressed by the lay-people. (n=687)*

The results show a clear progression of the clarity perception from the lay-people perspective, going from mostly unclear for hand-drawings to mostly clear for both CAD models and renderings. This observation can be nuanced as we observe that the highest jump is present between hand drawing and CAD model representations, while being much smaller between CAD models and rendered representations.

Moreover, it is interesting to notice that the number of neutral votes is not really affected by the type of the representation rated.

The previous results are shown in proportions. We decided to show the results in this way because it doesn't require any ponderation or weighting of the different possible answers. The weighting of the answers is a little bit tricky because it involves a certain subjectivity. Indeed when someone is voting, we don't know whether this person considers the possibilities evenly far from each other. Is «*somewhat clear*» halfway between «*very clear*» and «*neutral*»? We think that it changes from one person to another and it is therefore really complicated to talk about the answers in averages, which would have required a ponderation of the answers.

We can plot the same data but only for the six primary projects - for which we had access to the architect (*Fig.20*). Obviously we can still observe the same shift of clarity from a representation to another. Although here we can add another layer of information : for these projects we had access to the architects who created the representations, which means we can ask them to rate the clarity of their own images, in the same way as the lay-people.
While architects and lay-people perceived an overall similar clarity of CAD models and rendered representations, it is not the case for hand drawings. Architects and lay-people indeed perceived really

differently the clarity of the hand drawings they were shown : the architects rated the images as being quite clear while the lay-people rated them as being quite unclear. It seems that the architects overestimate the clarity of their fuzzy hand-drawn representations.

This give us an idea of how clear representations are perceived by the public. It becomes even more interesting when we try to correlate these results with characteristics of participants' answers. In the next section we overlap representations clarity with participants' agreements on representations.

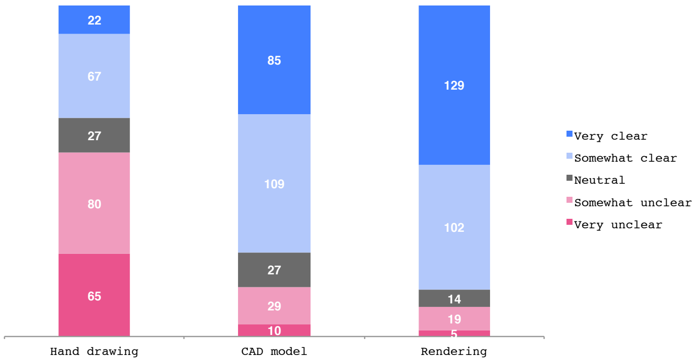


Fig.19 - *Clarity of the images for the primary projects, votes expressed by the lay-people. (n=261)*

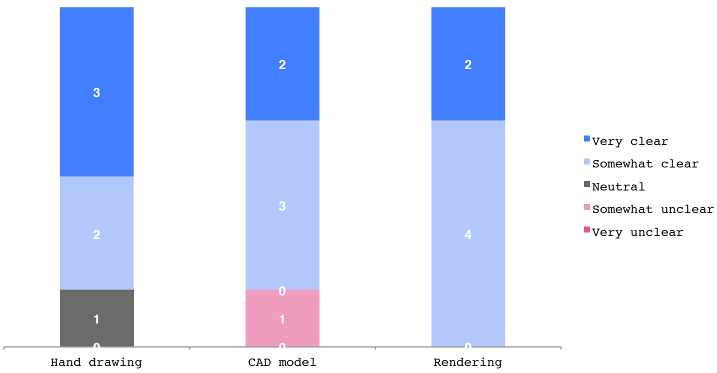


Fig.20 - *Clarity of the images for the primary projects, votes expressed by the architects. (n=6)*

4 | **Participants agreement**

The goal we pursue here is to show whether a certain representation tends to make people agree more coherently on a perception of an attribute. The most typical way to do it would be to study the standard deviation of the answers for each attribute. The standard deviation would represent the spread around the mean of people's answers for each attribute. As already said, to be able to compute a mean we need to weight every possibilities of the survey, and because we are facing ordinal data we cannot be sure that the distance between all the possibilities is a constant one (*see 4.5 Data analysis methods*). Therefore we are not going to use the standard deviation as a variable.

In order to still be able to test agreement between raters, we are going to define a new variable, the Q ratio, an original test we defined specifically for this question, representing the degree of disagreement. The way we compute it is pretty simple and we are going to show how we proceed illustrated by graphs on the next page.

First we take the participants' votes for the attributes of a representation (*Fig.21*). Next we cluster the two shades of rates for each side of the attributes. Here we assumed that people rating on one side of the attribute are mostly agreeing with each other, either for the «*somewhat*» or for the «*very*» alternatives (*Fig. 22*). We then obtain three groups of votes: the A side (in *blue*), the neutral (in *grey*) and the B side (in *pink*). Once we have those groups we can compute the Q values for each attribute of a project representation (*Fig.23*).

The Q value is equal to the ratio of the number of votes on one side of an attribute over the number of votes on the other side.

$$Q = \#\text{ A votes} / \#\text{ B votes} \qquad \text{if } \#\text{ A votes} < \#\text{ B votes}$$
$$Q = \#\text{ B votes} / \#\text{ A votes} \qquad \text{if } \#\text{ A votes} > \#\text{ B votes}$$

Equ.5 - *Concept formula defining the Q ratio, the degree of disagreement.*

The Q ratio goes from 1 to 0. The two extremes are respectively a complete tie between the A and the B side of the attribute (*Q=1*), or on the contrary a tendency of votes to show only on one side of the attribute (*Q=0*). A high Q value means that the votes are quite evenly divided between the two sides of the attribute, and so that indicates a certain disagreement in the votes. On the opposite a low Q value means that the votes tend more clearly to one side of the attribute, showing then a certain agreement in the votes.

A table of all the Q values computed can be consulted in the appendix if necessary (*see Appendix from 7.5, 7.6 and 7.7*). Results are discussed in the following sections, breaking the results first per attribute and second per project.

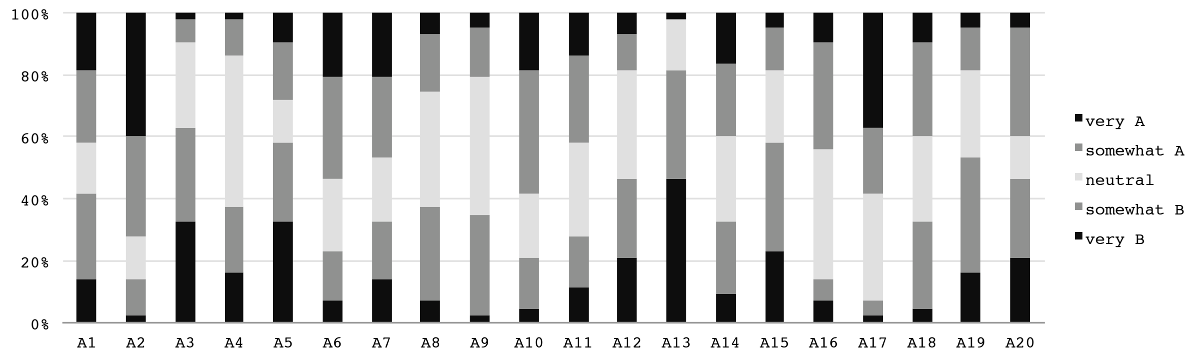


Fig.21 - *Example of the votes repartitions per attribute for the hand-drawing of the project P1. (n=43)*

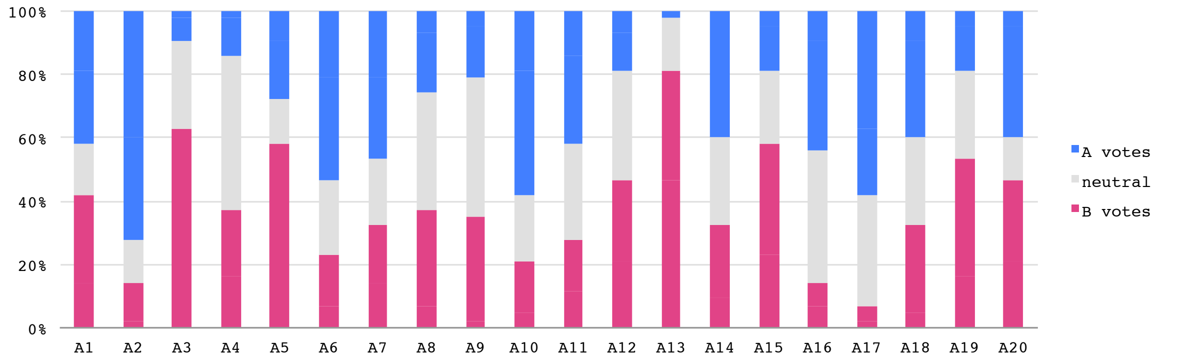


Fig.22 - *Votes repartitions between the A side and the B side of the attributes for the hand-drawing of the project P1. (n=43)*

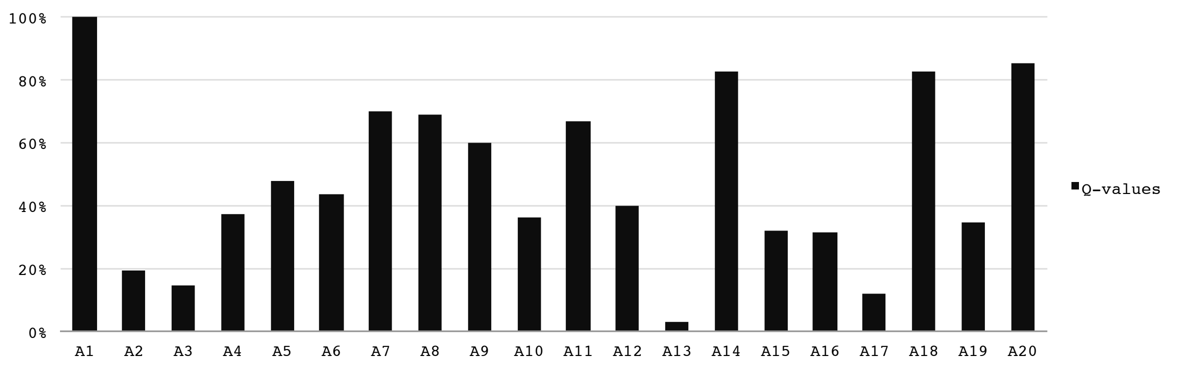


Fig.23 - *Values of the Q ratio for each attributes of the hand-drawing of the project P1. (n=43)*

Agreement per attribute

To analyze general results we then group the results of the Q values by doing averages. First we average the Q values per attribute (*Fig.24*). In this graph each line represents a different attribute with averaged Q values from a representation to another.

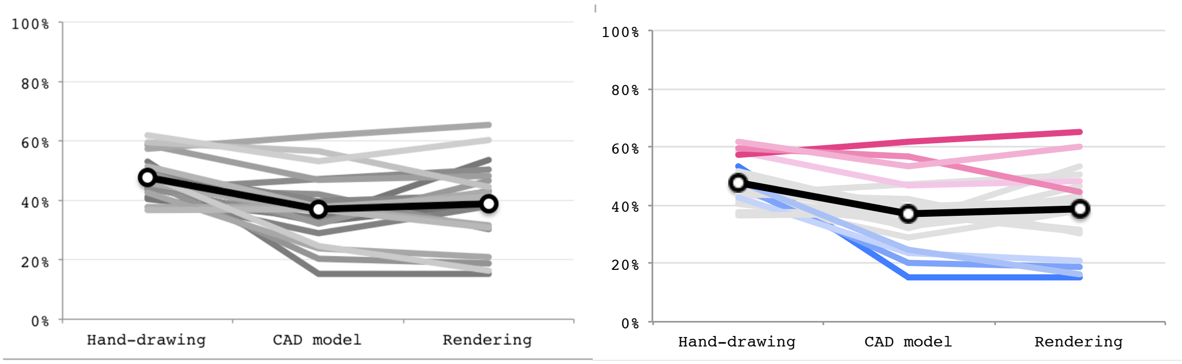


Fig.24 - *Averaged Q values per attribute compared to the representation.*

The average of all the attributes, represented with a black bold line, shows us the overall quite flat trend of all the attributes (*Q1=0,49; Q2=0,38; Q3=0,39*). Therefore we cannot say that there is a unique clear correlation between the representation and the agreement on all the attributes taken as a whole. Nevertheless we can point out some other trends.

It is easy to notice that for the hand-drawings the results are much more condensed around the average than for the CAD models and the renderings. That indicates that people agree as much for all the attributes, when looking at the hand-drawings. Things are different for the CAD models and the renderings. The spread out of the results around the average indicates that the results depend much more on the attribute.

On the one hand we can notice that for some attributes there is no real agreement for the hand-drawings and it changes to a quite strong agreement for the CAD models and the renderings. This is the case for the attributes *A1*, *A6*, *A16* and *A20* (*in blue, Fig.24*). That means that for those attributes a clearer representation has the consequence of bringing a stronger agreement. It is interesting to point out that previously these same attributes were particularly noticed to be perceived in the same way for the CAD models and the renderings and very differently for the hand-drawings.

On the other hand we can observe that the attributes *A11*, *A14*, *A18* and *A19* present high percentages (*in pink, Fig.24*). So for these attributes people strongly disagree, which might mean either that the projects are not really made to convey these intents or either that people might not really understand the attribute and then the answers might be more random. Moreover we see that for each of these attributes the variations from a representation to another are much smaller than previously. That means that the perception of these attributes is pretty much independent of the representations shown.

So we understand that the first observation about the mean can be nuanced: there are attributes for which the perception is dependent of the representation, and for some other attributes it is not.

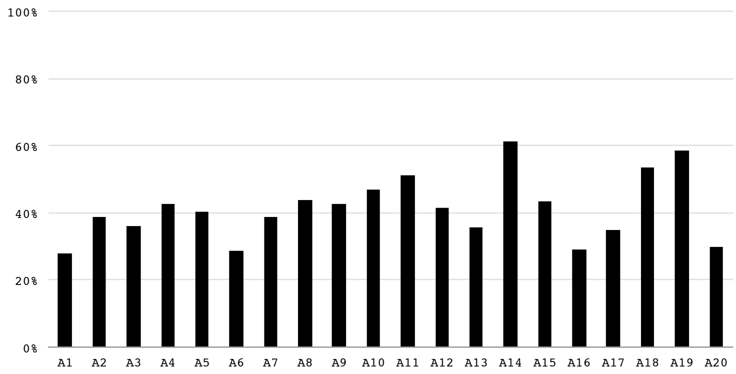


Fig.25 - *Averaged Q values for each attributes of the three representations altogether.*

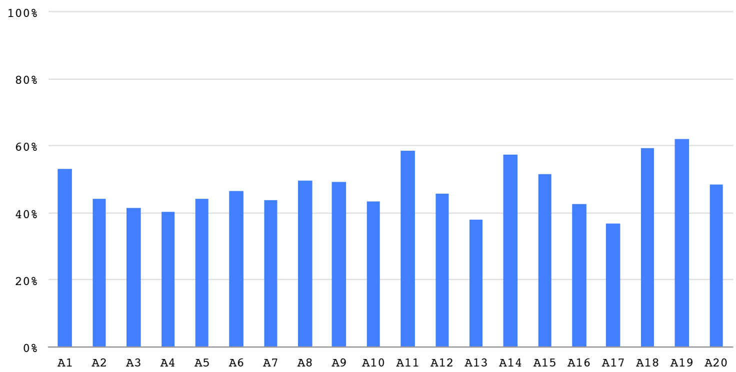


Fig.26 - *Averaged Q values for each attributes of the hand-drawings. (n=690)*

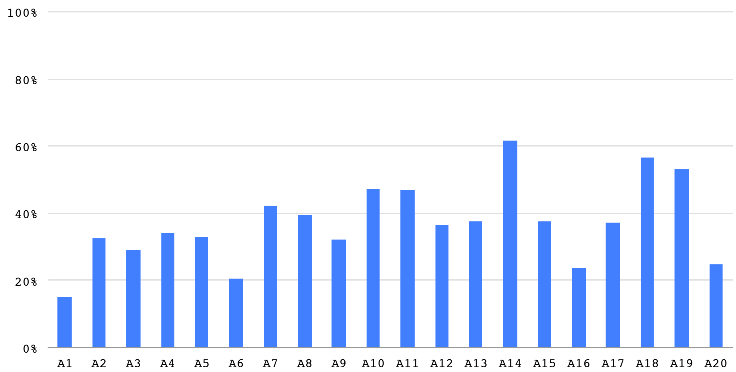


Fig.27 - *Averaged Q values for each attributes of the CAD models. (n=684)*

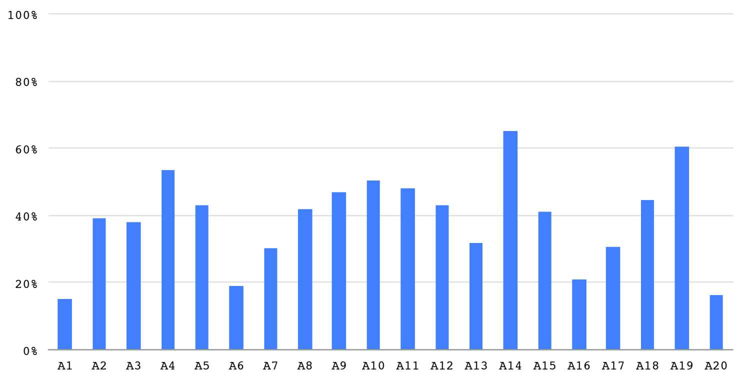


Fig.28 - *Averaged Q values for each attributes of the renderings. (n=688)*

Agreement per project

The second way of averaging the Q values is to proceed per project (*Fig.29*). Here each line in the graph represents a different project with averaged Q values from a representation to another.

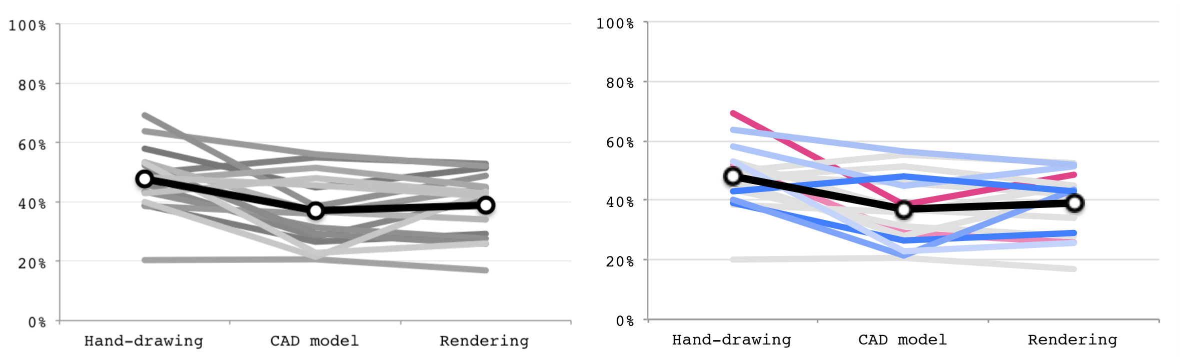


Fig.29 - *Averaged Q values per project compared to the representation.*

The average of all the projects is obviously the same than previously because based on the same data. So let's directly try to focus on specific observations.

The extreme results are represented in *pink* on the graph (*Fig.29*). On the top, the project *P10* presents the least agreement about the attributes rated for the three representations, while on the bottom the project *P8* shows a quite high agreement for all the attributes of the three representations. It is important to notice that for these two projects the agreement of perception is relatively independent of the representation shown.

Moreover for six of the sixteen projects a particular pattern appears (*in blue, Fig.29*). For the projects *P2*, *P4*, *P7*, *P13*, *P14* and *P15* the agreement is sensibly higher for the CAD models than for the hand-drawings and the renderings. That indicates that there is a correlation between the clarity of the representation and the agreement on the attributes, but there might be another factor explaining the lower agreement of the renderings over the CAD models.

We can conclude by saying that the correlation between the agreement on an attribute and the clarity of a representation does not appear clearly for most of the cases. It requires an attribute per attribute analysis. Furthermore there is no clear link between the agreement and the number of differently perceived representations, which was analyzed in previous sections (*see 5.1.1 Attributes perception and 5.1.2 Projects perception*). Note again that all the results will be outlined later in its own section (*see 5.3 Outlined results*)

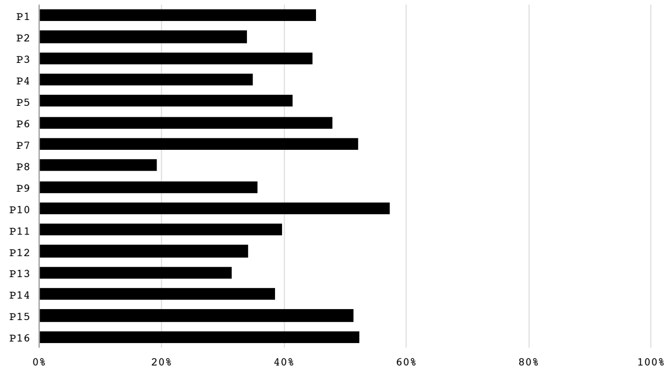


Fig.30 - *Averaged Q values for each attributes of the three representations altogether.*

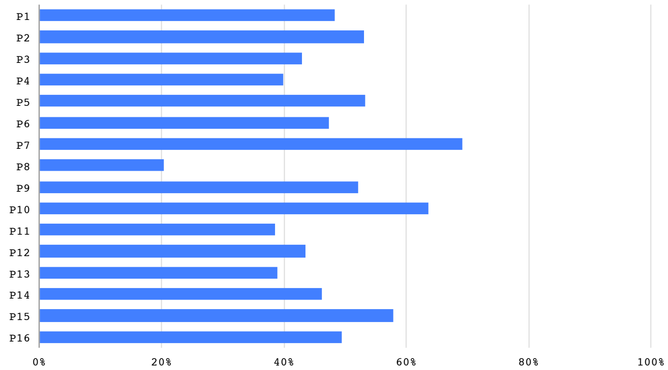


Fig.31 - *Averaged Q values for each attributes of the hand-drawings. (n=690)*

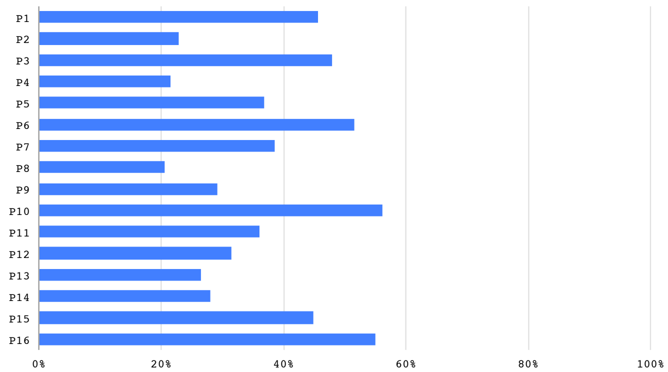


Fig.32 - *Averaged Q values for each attributes of the CAD models. (n=684)*

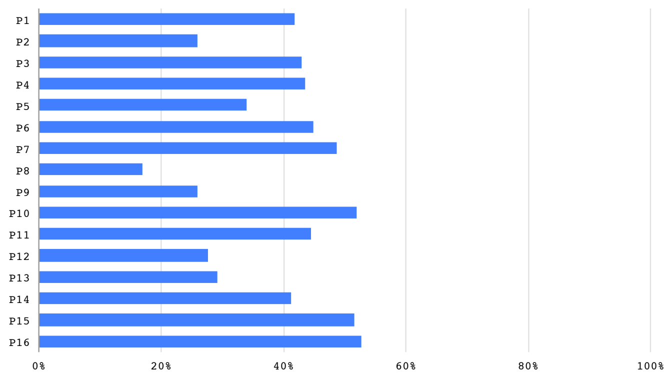


Fig.33 - *Averaged Q values for each attributes of the renderings. (n=688)*

5.2 **Architects' intents**

So far we have only focused on how lay-people perceived the representations. The next sections will be focusing on what the architects intended in their projects. As already explained we had access to the architects for six of the sixteen projects chosen (*see 4.2 Selection of projects*). So it is important to remind that the following results will include only these six projects, as we cannot ask them to complete our survey. The six architects were asked to rate the representations they built themselves, using the same attributes list as the lay-people.

First the architects were shown the three representations together and they were asked what was the architectural intents they wanted expressed, overall through the project. Next they were shown representations one by one and they were asked what they were trying to convey in each of those representations (*see 4.4 Survey procedure*). Below is the analysis of these two sets of data.

1 | **Correlation intent-perception**

Now than we have lay-people's data and architects' data it becomes interesting to see whether participants' perception and architect's intents match or not. In order to be able to compare multiple participants' answers to the unique answer of the architect, a particular methodology was built. We are going to describe the methodology and it will be illustrated with graphs on the following page based on the participants' votes of the hand-drawing of the project *P1*.

We first range participants' votes for each attribute (*Fig.34*). The statistical mode of each attribute is identified, representing the main perception of the attribute (*in blue, Fig.35*). Next we report the intent expressed by the architect (*in pink, Fig.36*). Finally, we consider that the architect successfully conveyed the intent if the main perception, represented in blue, and the architect's intent, represented in pink, match. Otherwise we consider that the attribute is not perceived by the public as initially intended. There are several important things to be noticed about the architects' intents data.

First, the only data used as the architects' intents is corresponding to the case where the architects were shown the three representations together. This choice was made because it represents the overall intentions that were initially intended in the project and not what the architect think of each representation separately.

Next, we clustered the two shades of architect's intents (*Fig.36*). We considered that an intent failed to be conveyed only if people mostly perceived the opposite side of the attribute. If someone perceived a representation as being «*somewhat A*» while the intent was «*very A*», we considered that the intent was successfully conveyed.

Finally, architects were asked to rate some attributes as neutral when they didn't intended anything for those attributes. These cases are not included in the following analyses because there is no intent to compare the perception with. The neutral votes can be observed as an absence of highlighted attribute shade on the example chart (*Fig.36*).

In the appendix, a table including all the numerical results can be found (*see Appendix from 8.1 to 8.3*). We are going to explore the results by breaking them down firstly by attributes and secondly by projects.

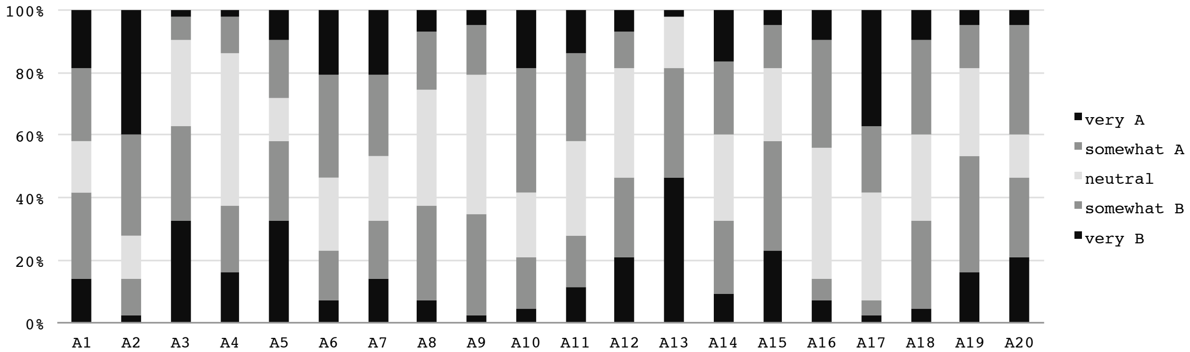


Fig.34 - *Example of the votes repartitions per attribute for the hand-drawing of the project P1. (n=43)*

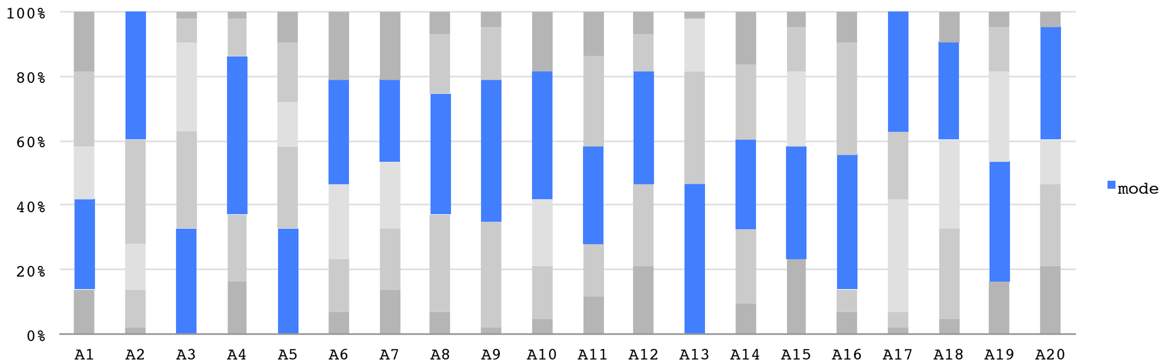


Fig.35 - *Example of the votes mode per attribute for the hand-drawing of the project P1. (n=43)*

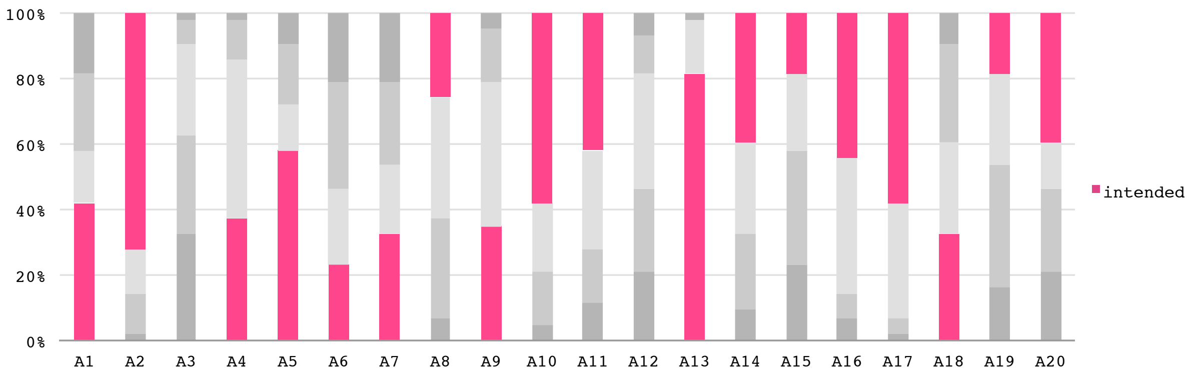


Fig.36 - *Example of the architect's intent per attribute for the hand-drawing of the project P1. (n=43)*

Analysis per attribute

Following the process previously detailed, we can then focus on the distribution of successfully conveyed intents. We first plot the overall results including all the representations (*Fig.37*).

This analysis includes the six primary projects with three representations each, so each attribute is rated eighteen times. Amongst them some attributes are not intended by the architect. The first task is therefore to plot per attribute the number of representations for which the architect wanted to convey the attribute. This is illustrated in the following chart by the height of each column (*Fig.37*).

Some of the intended attributes are not perceived by the public as they were meant by the architects. The second task is then to report the number of successfully conveyed intents over the intended attributes, represented in *black* on the same chart (*in black, Fig.37*).

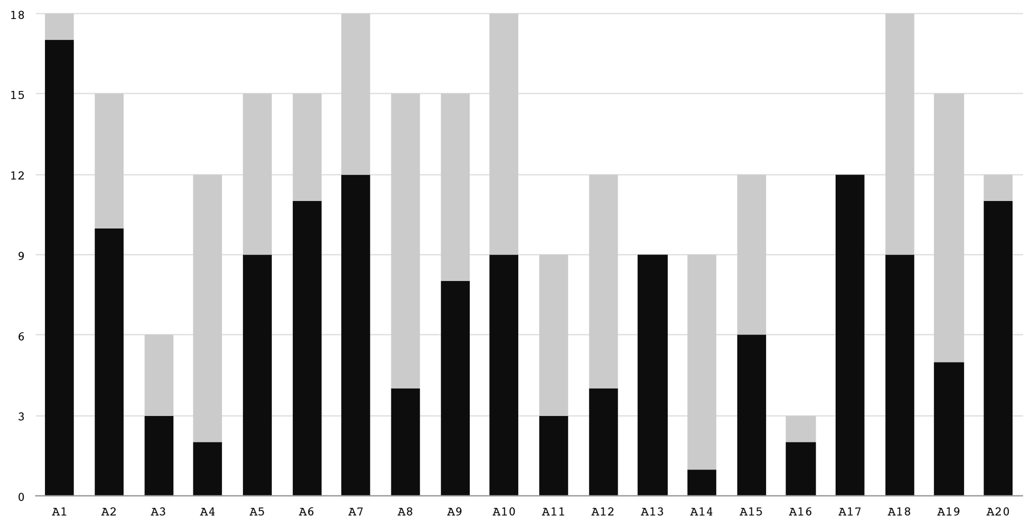


Fig.37 - *Ratio of representations perceived as intended (dark) over not perceived as intended (light), per attribute.*

We can observe that all the attributes are not evenly conveyed. There are very varied results: some attributes are really often intended and some others are almost not (*height of each column*). some attributes are mostly perceived as intended and some others are mostly not (*black/grey* ratio). Let's try to have a look at the results.

A first group of attributes includes the attributes *A3* and *A16*. It can be observed that these attributes are not intended in most of the cases by the architects. That might indicate that these attributes are too specific to be applied to all the projects. Note that it is not because those attributes are not rated by the architects that the general public is particularly undecided (*see 5.1.4 Participants agreement*). From previous insights we can notice that these attributes were some of the attributes for which people agreed the most. So an architect not willing to convey an intent doesn't mean that people won't agree on a specific perception.

The attributes *A1*, *A13*, *A17* and *A20* form a second group of results. Each time an architect intended them in his project, these attributes were mostly successfully conveyed by the representations.

Finally other interesting observations are joined in a third group, which includes the attributes *A4* and *A14*. These attributes were most of the time unsuccessfully conveyed. The explanation could be that architects and lay-people don't have the same definition of the attributes, or it could also be that these particular intents are difficult to be conveyed through the studied representations.

Going more specifically, we can show the data representation per representation using the similar type of chart. We obtain then three graphs, one for each of the representations (*Fig.38, 39 and 40*).

Results from a representation to another are pretty much similar but for a few attributes. For the attributes *A2*, *A8*, *A9*, *A10* and *A15* we can observe a certain benefit of using a CAD model or a rendering to transmit successfully an intent. Nevertheless it stays quite marginal and there is no dramatic differences between the representations.

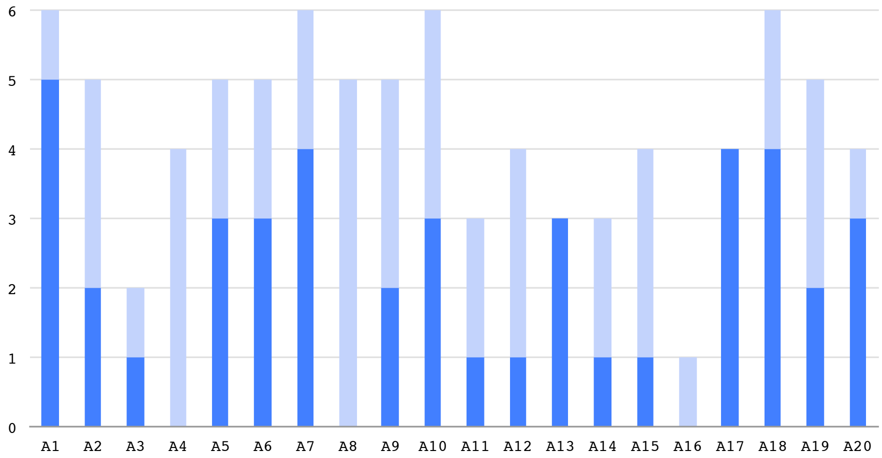


Fig.38 - *Ratio of projects for which an attribute is perceived as intended (dark) over it is not perceived as intended (light), for hand-drawings.*

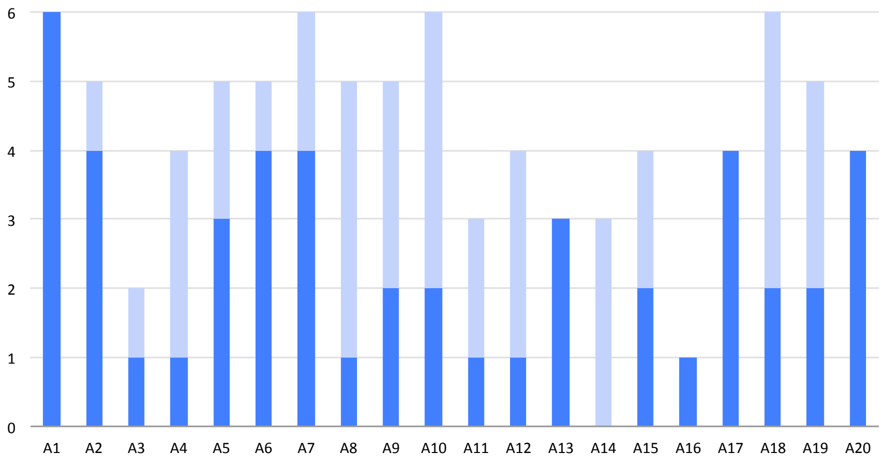


Fig.39 - *Ratio of projects for which an attribute is perceived as intended (dark) over it is not perceived as intended (light), for CAD models.*

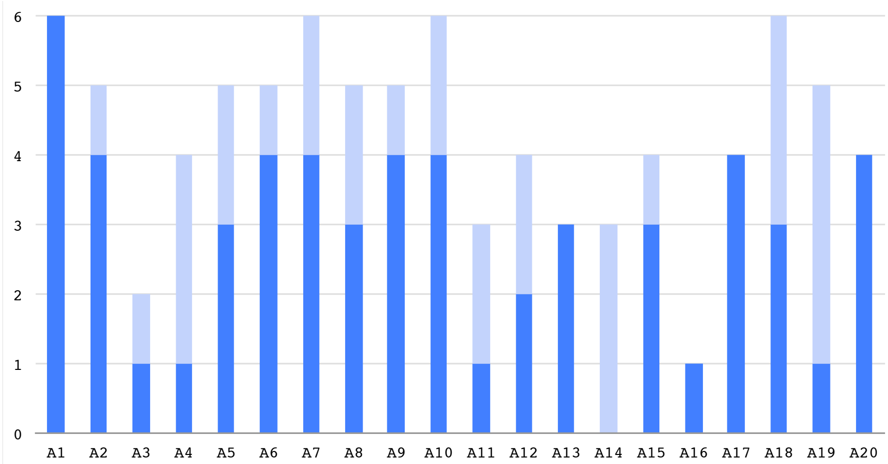


Fig.40 - *Ratio of projects for which an attribute is perceived as intended (dark) over it is not perceived as intended (light), for renderings.*

Analysis per project

The same type of analysis can then be done but this time by breaking down the results by projects. Here we plot the overall results as a first approach (*Fig.41*).

Each project was evaluated with twenty attributes through three representations, so each project is rated sixty times. As it is based on the same data, here also amongst the sixty attributes per project some were not intended by the architect. We then plot, per project, the number of attributes for which the architect had an intent. This is illustrated in the following chart by the total length of each row (*Fig.41*). Then we report the number of successfully conveyed attributes on the same graph (*in black, Fig.41*).

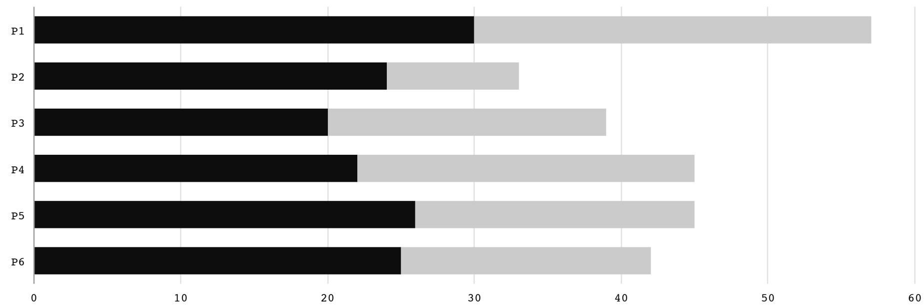


Fig.41 - *Ratio of attributes perceived as intended (dark) over not perceived as intended (light), per project.*

The first observation is that the number of successfully conveyed attributes per project appear to be fairly close from each other, with a maximum for the project *P1* (*i=30*) and a minimum for the project *P3* (*i=20*). The number of attributes with an intent from the architect span from the project *P1* (*n=57*) to the project *P2* (*n=33*).

It is interesting to notice that the number of intended attributes is not correlated to the number of successfully conveyed attributes. That might indicate a misjudgment from the architect in terms of exaggeratedly rating attributes that he didn't really conveyed in his/her project.

We can then take a look at the same results distributed representation by representation (*Fig.42, 43 and 44*).

Slightly higher success can be observed with the renderings than with the hand-drawings. Although more generally most of the results don't vary that much, except for the CAD model of the projects *P2* and *P6*.

This last observation is emphasized if we plot the ratio number of successfully conveyed attributes versus number of intended attributes (*Fig.45*).

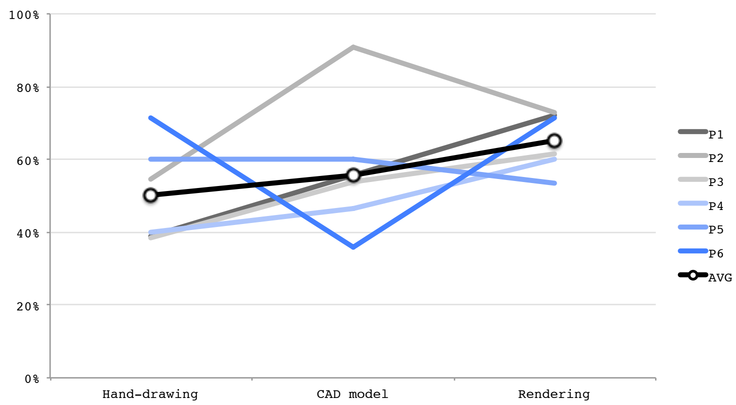
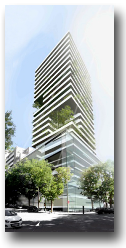
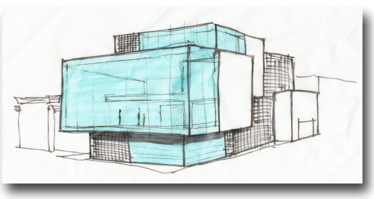
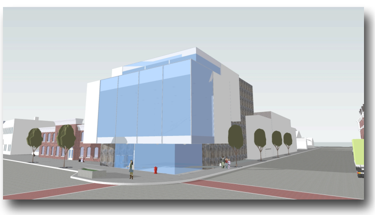


Fig.45 - *Ratio of the number of successfully conveyed attributes over the number of intended attributes.*

Here also we can see the average trend showing that renderings convey ($S_3 = 0.65$) more successfully the intended attributes than CAD models ($S_2 = 0.56$) and CAD models than hand-drawings ($S_1 = 0.50$), which is one of the main argument from the architects to use renderings over other kinds of representations. But this average is biased. Actually we can see that only three of the six projects are following scrupulously this trend.

Indeed the CAD models from the projects *P2* and *P6* have very significant differences with the other data point. On the one hand, the CAD model from the project *P6* has a very low success in conveying the intent in comparison to the other two representations of the same project. On the other hand, the intent of the project *P2* has been really effectively conveyed and especially the CAD model.

	HAND-DRAWING	COMPUTER MODEL	RENDERING
P2			
P6			

Tab.10 - *Representations sets of the peculiar projects.*

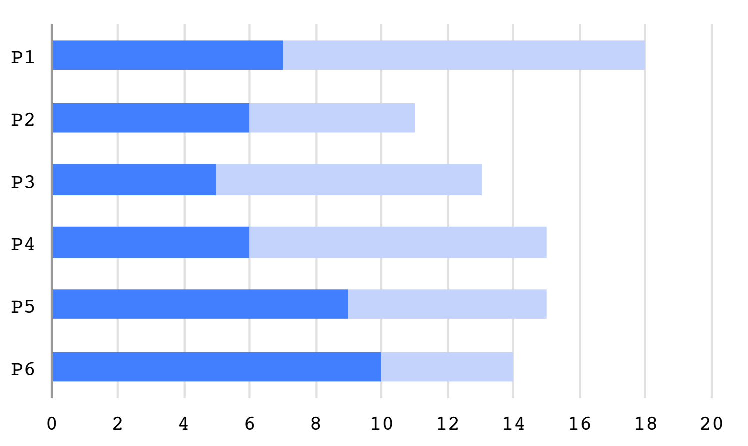


Fig.42 - *Ratio of attributes perceived as intended (dark) over not perceived as intended (light) per project, for hand-drawings.*

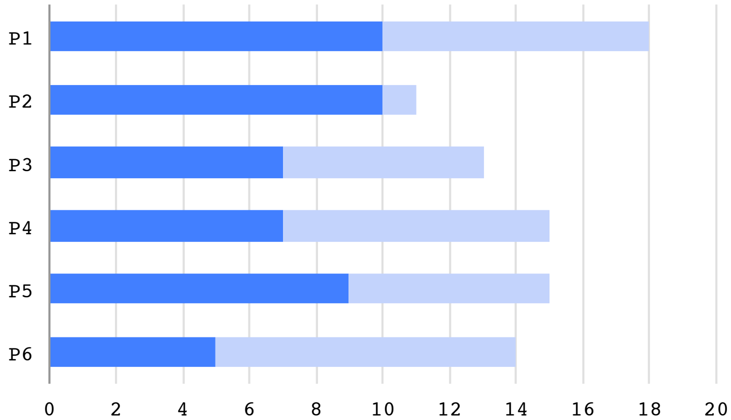


Fig.43 - *Ratio of attributes perceived as intended (dark) over not perceived as intended (light) per project, for CAD models.*

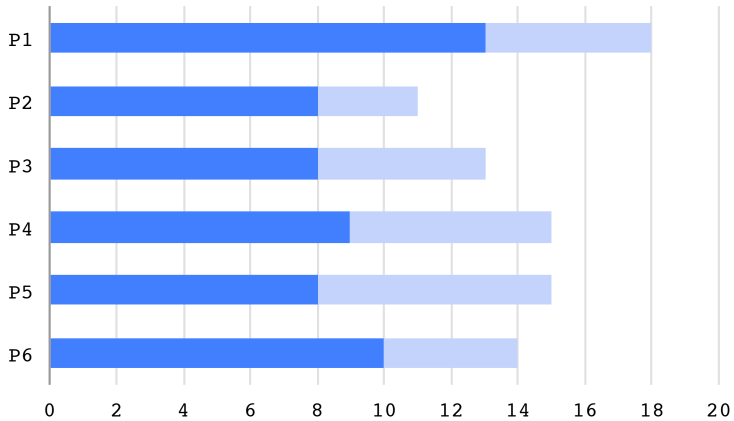


Fig.44 - *Ratio of attributes perceived as intended (dark) over not perceived as intended (light) per project, for renderings.*

2 | **Intent inconsistency**

When we asked architects to express their intents we proceeded in two steps as already explained. First the architects were shown the three representations together and they were asked what was the architectural intents overall, in their project. Note that we used these data to analyze the correlation intent-perception. Next they were shown representations one by one and they were asked what they were trying to convey in each representation.

Once we gathered the data from this second data set, we realized that there were inconsistencies in the intent they were expressing from a representation to another. Architects were rating a representation on one side of an attribute while on another representation they were rating the same attribute one the other side. This means that architects themselves conceded that certain attributes were not consistently represented through the three representations.

In the data two kind of inconsistencies were differentiated: light and strong inconsistencies. Here enclosed are the different cases we considered as being lightly or strongly inconsistent (*Tab.11*).

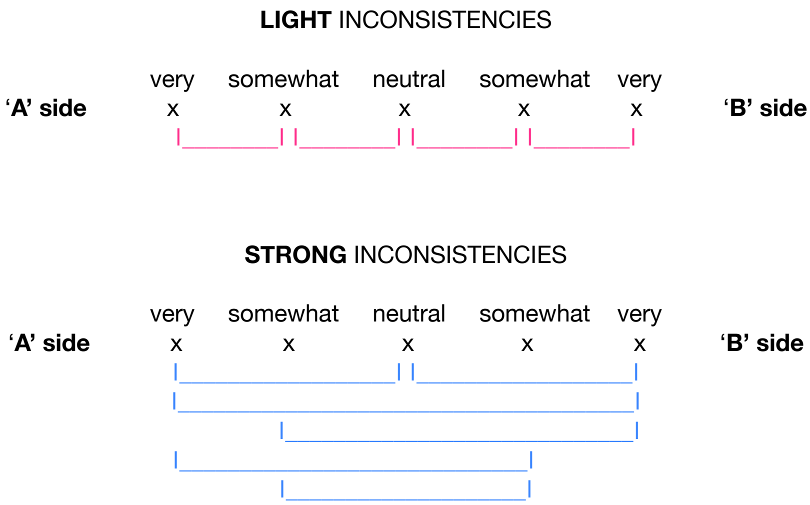


Fig.46 - *Light or strong inconsistent cases when comparing intent on two different representations.*

Light inconsistencies	**Strong** inconsistencies
Very A / Somewhat A	Very A / Neutral
Somewhat A / Neutral	Very A / Somewhat B
Neutral / Somewhat B	Very A / Very B
Somewhat B / Very B	Somewhat A / Somewhat B
	Somewhat A / Very B
	Neutral / Very B

Tab.11 - *Light or strong inconsistent cases when comparing intent on two different representation from a same project.*

The inconsistent attributes can then be reported project by project. All the representations are taken as a whole for a first approach (*Tab.12*). From these inconsistent attributes, we also notice the number of them for which the ratio test previously computed were showing statistically significant differences (*see Appendix 7.1*). The purpose is to understand whether the attributes rated inconsistently by the architects from a representation to another are also perceived differently by the lay-people from a representation to another.

From these numbers, we can see that there is no significant proportion of the inconsistent attributes that were also perceived differently through the three representations by the lay-people. There is no appearance of a clear correlation between these two variables.

Project	**Inconsistent attributes** (○ = lightly | ● = strongly)	**# Inconsist.** (by archi.)	**# Inconsist.** **w/** KW < 0.05 (by archi.)
P1	❺❼⓭	3	2
P2	①②⑤⑥⑦⑩⓭⓮⓰⓱⓲⓴	12	3
P3	①④⑤⑦⑧⑨⑩⓫⓰⓱⓲⑳	12	7
P4	②④⑤⑥⑧❿⓬⑭⑰⑲	10	6
P5	①③④❻⑦❽⑨⑩⑪⑫⑯⑰⑱⑳	14	6
P6	❷❸❹❺❼❽❾❿⑪⓭⑭⓱⑱⓳	14	6

Tab.12 - *Inconsistent attributes revealed by the architect through the three representations, and the number of them with a Kruskal-Wallis statistically significant p-value.*

Additionally we can show the relation between the number of inconsistent attributes statistically significantly differently perceived (*dark blue*) and the total number of statistically significant differences (*black*) (*Fig.47*).

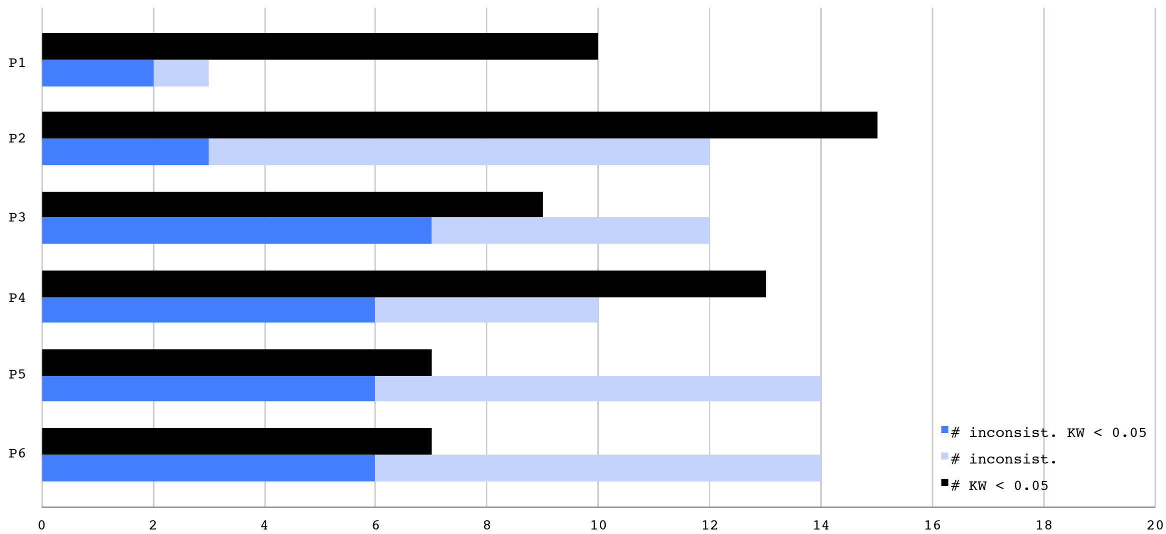


Fig.47 - *Comparison of the number of differently perceived attributes through the three representations and the number of inconsistencies revealed by the architect.*

From this chart and the previous observations, we don't see a clear correlation between the number of inconsistencies and the number of attributes perceived differently in the representations by the lay-people. Note that the previous charts take both sorts of inconsistencies altogether. Although if we focus on the most important inconsistencies, and so the strong inconsistencies, the analyzes would lead us to the same conclusions.

Moreover we can notice that for the projects *P3*, *P5* and *P6*, most of the attributes that were showing statistically significant differences between the representation previously obtained, *represented in black*, are actually inconsistent attributes, *represented in dark blue*. So for these projects we can say that most of attributes perceived differently by the lay-people are attributes inconsistently rated by the architects, but the opposite is not true at all.

These results can be broken down representation by representation. We followed then the same process of noticing the inconsistent attributes but this time by showing between which representations the inconsistency is occurring (*Tab.13*).

In this table, it is interesting to notice that comparison between hand-drawing/CAD models presents the smallest number of inconsistencies in five of the six projects. That means that most of the architects had the same intents between the hand-drawing and CAD model of their projects.

Here also, there is not a clear correlation between the number of inconsistent attributes and the number of attributes that were also perceived differently through pairs of representations by the lay-people. So the conclusions are the same as before. There is not a particular pair of representations showing any correlation.

In addition, we can show here again the relation between the number of inconsistent attributes statistically significantly differently perceived (*dark blue*) and the total number of statistically significant differences perceived by the lay-people (*black*) by pair of representations (*Fig.48, 49 and 50*).

As we have already said the comparison hand-drawing/CAD model presents the smallest number of inconsistencies for most of the projects. Although when we look at number of attributes statistically significantly differently perceived, the smallest numbers are for the pair CAD model/rendering. So for the architects hand-drawing and CAD model convey the closest intents while it is CAD model and rendering that are being perceived the closest by lay-people. That shows us that they react differently in front of the same representations.

Interestingly, some attributes switch from lightly to strongly inconsistent, and vice-versa, from on pair of representations to another. The concerned attributes are the attributes *A11* and *A18* for the project *P3*, and the attributes *A2*, *A3*, *A10* and *A17* for the project *P6*.

Project	Rep.	Inconsistent attributes (○ = lightly | ● = strongly)	# Inconsist.	# Inconsist. **w/** MW < 0.05
P1	1 | 2 *		0	0
	2 | 3 **	❺❼	2	0
	1 | 3 ***	❺❼⓭	3	1
P2	1 | 2	⓭⓮⓰⓴	4	3
	2 | 3	①②⑥⑦⑩⓮⑰	7	0
	1 | 3	①⑦⑩⓭⓮⓰⓴	7	6
P3	1 | 2	①④⑤⑩⓫⓰⓱⓲⑳	9	3
	2 | 3	⑦⑧⑨⑪⑱⑳	6	3
	1 | 3	①④⑤⑦⑧⑨⑩⓫⓰⓱⓲	11	4
P4	1 | 2	⑩⑫⑰⑲	4	1
	2 | 3	⑥⑧⑩⑫	4	2
	1 | 3	⑥⑧⑰⑲	4	3
P5	1 | 2	③④⑥⑦⑨⑩⓬⓰⑰⑱⑳	11	6
	2 | 3	①⑥⑧⑩	4	0
	1 | 3	①③④⑦⑧⑨⓬⓰⑰⑱⑳	11	4
P6	1 | 2	②❸❹❺❼❿⑪⓱⑱⓳	10	3
	2 | 3	❷❸❹❼❽⑨⑩⑬⑭⑰	10	1
	1 | 3	❷③❺❼❽⑨⑩⑪⑬⑭⑰⓳	12	2

Tab.13 - *Inconsistent attributes revealed by the architect per pair of representations, and the number of them with a Mann-Whitney p-value statistically significant.*

(*) 1 | 2 = *comparison hand drawing and CAD model*
(**) 2 | 3 = *comparison CAD model and rendering*
(***) 1 | 3 = *comparison hand drawing and rendering*

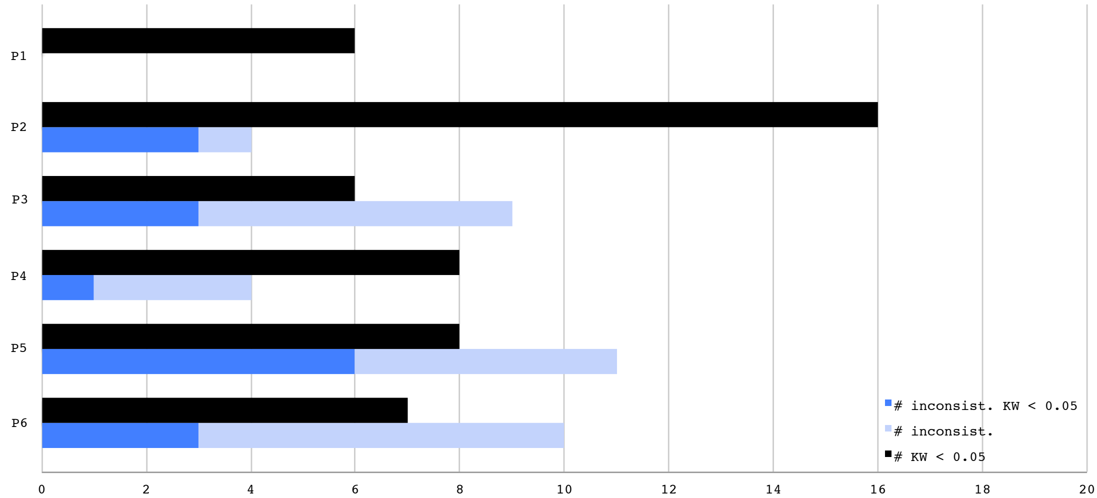


Fig.48 - *Comparison of the number of differently perceived attributes between hand drawing and CAD model and the number of inconsistencies revealed by the architect.*

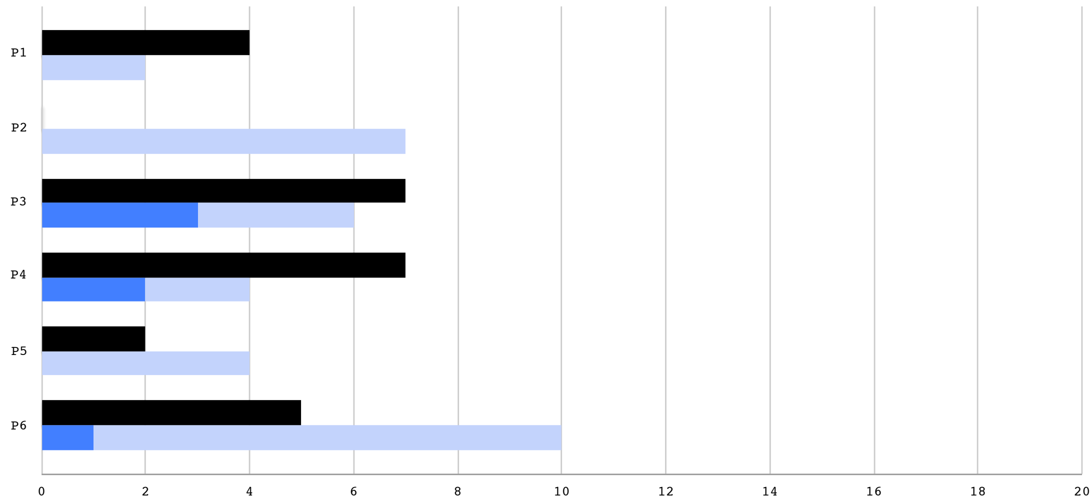


Fig.49 - *Comparison of the number of differently perceived attributes between CAD model and rendering and the number of inconsistencies revealed by the architect.*

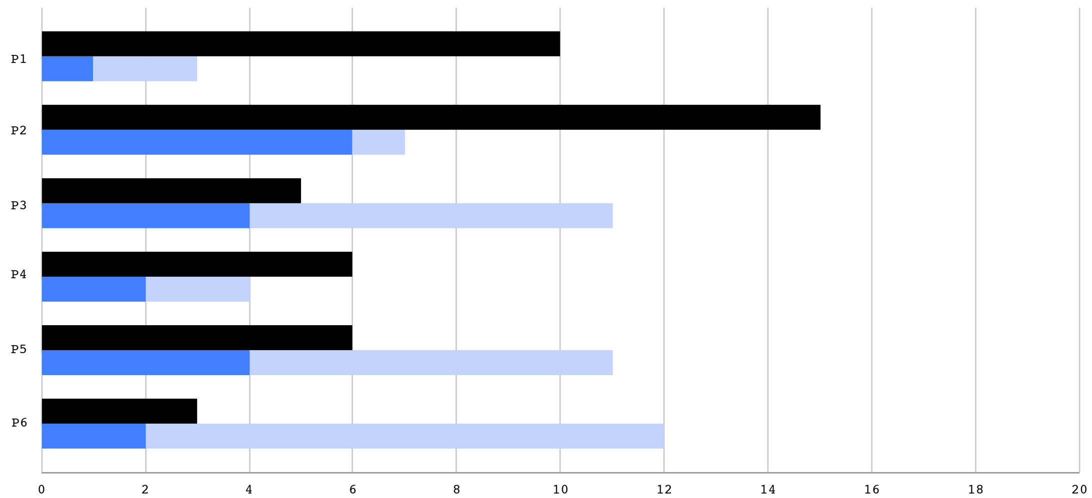


Fig.50 - *Comparison of the number of differently perceived attributes between hand drawing and rendering and the number of inconsistencies revealed by the architect.*

Once we have noticed the inconsistent attributes between pairs of representations, we can observe that some of them are recurrent in several projects. We then constructed a table in order to see it more clearly (*Tab.14*). Note that for readability issues we chose only to show the attributes with more than two occurrences.

The attribute *A10* (*varied-homogeneous*) appears to be recurrently inconsistent for the all three pairs of representations. That means that for most of the projects this attribute has been rated by the architect differently for all the three representations. Nevertheless this is not because the architect is rating the representations as having different intents that people perceived the representations as differently as him. Indeed, if we cross this observation with previous results (*see 5.1.1 Attributes perception*), the attribute *A10* does not appear to present particularly high proportion of differently perceived projects representations. In other word, the fact that the architect rate the representations differently does not imply that lay-people will do so.

Moreover, from this table we can see some of the attributes presenting high numbers of inconsistencies within the architects' rating. Being inconsistent in at least four projects over the six, in two pairs of representations, the attributes *A7* (*dynamic-static*), *A8* (*relaxing-stimulating*) and *A17* (*vertical-horizontal*) shows that the architects are conscious that these attributes are not conveyed evenly through all the representations. Although, this observation cannot be linked neither with the number of differently perceived projects, lay-people's agreement, or the degree of success of these attributes to be conveyed.

Finally, we can notice that, additionally to the information presented in the table, the attribute *A15* (*modest-audacious*) is the only one not presenting any inconsistency in the architects' rating, i.e. architects are thoroughly consistent through representations when it comes to the «*modest-audacious*» side of their project.

Number of inconsistencies per attributes (+2 occurrences)		
1 | 2	2 | 3	1 | 3
		3x ①
3x ④		
		3x ⑤
	3x ⑥	
	4x ⑦	5x ⑦
	4x ⑧	4x ⑧
		3x ⑨
4x ⑩	4x ⑩	3x ⑩
		3x ⑬
3x ⑯		3x ⑯
4x ⑰		4x ⑰
3x ⑱		
3x ⑳		

Tab.14 - *Frequency of inconsistence of attributes between pairs of representations.*

(*) 1 | 2 = *comparison hand drawing and CAD model*
(**) 2 | 3 = *comparison CAD model and rendering*
(***) 1 | 3 = *comparison hand drawing and rendering*

5.3 **Outlined results**

The data showed that characteristics could be differently perceived depending on the visual stimuli presented. The previous observations and analysis showed different trends among the attributes. For clarity and succinctness, we collected the results in a unique table presented below (*Tab.15*).

We included five different categories of observations. First, we report observation related to lay-people's perception data, starting with how the three representations altogether are **differently perceived by lay-people.** Followed then by **lay-people's agreement** still regarding to the three representations as a whole. Next, we outline observations related to architects' intents. The attributes **intended frequency by the architects** relates whether some attributes were intended most of the time or not at all by the architects. Additionally, the number of **successfully conveyed intents** through the three representations is reported. Finally, the last column shows the frequency of **architects' inconsistencies**, whether attributes were particularly often inconsistently rated by the architects through the three representations as a whole.

			Differently perceived by lay-people	**Lay-people's agreement**	**Intended frequency by architects**	**Successfully conveyed intents**	**Architects' inconsistenc.**
A1	contempora	classical	-	▲	▲	▲	-
A2	complex	simple	-	-	-	-	-
A3	hard	soft	▽	-	▽	-	-
A4	robust	delicate	▽	-	-	▽	-
A5	sharp	smooth	-	-	-	-	-
A6	innovative	traditional	▲	▲	-	-	-
A7	dynamic	static	▲	-	▲	-	▲
A8	relaxing	stimulating	-	-	-	-	▲
A9	quiet	noisy	-	-	-	-	-
A10	varied	homogeneo	-	-	▲	-	▲
A11	expansive	compact	-	▽	-	-	-
A12	discreet	extravagant	-	-	-	-	-
A13	low	high	-	-	-	▲	-
A14	composite	monolithic	▽	▽	-	▽	-
A15	modest	audacious	-	-	-	-	▽
A16	small	large	-	▲	▽	-	-
A17	vertical	horizontal	-	-	-	▲	▲
A18	open	closed	-	▽	▲	-	-
A19	heavy	light	-	▽	-	-	-
A20	common	unique	▲	▲	-	▲	-

Tab.15 - *Particular observations summarized per attribute.*

▲ = *High or highly ...*
▽ = *Low or lowly ...*

While this table will be commented later in the following section (*see 6.1 Discussion outcomes*), a few interesting observations can be made.

[1] We can notice that the attributes *A4* (*robust-delicate*) and *A14* (*composite-monolithic*) are mostly perceived in the same way by the lay-people through the three representations, but not as intended by the architect. That means that the representations convey evenly this intention but mostly not as initially aimed by the architect. Note that the attribute *A14* is presenting a low level of agreement among lay-people's votes, which indicates that the perception is the same through the three representations while being highly undecided.

[2] Next, we observe that the attribute *A7* (*dynamic-static*), being often intended by the architects, is highly differently perceived by the lay-people while it is highly inconsistently rated by the architects. Then, despite the frequent use of this attribute by the architects, they assessed this attribute as it would convey differently in the representations. This shows that despite they intend extensively the degree of *movement* of a design proposal, they have the perception that it would be conveyed differently through the representations, which is verified by the high degree of differences of lay-people's perception.

[3] It is also interesting to observe that the attribute *A17* (*vertical-horizontal*) is highly inconsistently rated by the architects from a representation to another, and in the same time the same attribute is highly successfully conveyed to the lay-people through the representations. This paradox shows that, despite architects' acknowledgment that the representations are conveying different intents, they succeed to convey through the representations the degree of *verticalness* of an architectural proposal.

[4] And finally, there is another paradox. For the attribute *A20* (*common-unique*), we observe that the representations are mostly perceived as different by the lay-people, but in the same time, they seem to convey mostly faithfully the architect's intent regarding to the degree of *uniqueness* of the proposal. It might be explained by the design of our metrics. On one hand, the success of conveyance of the attribute is explained by the fact that the bigger number of lay-people's votes is most of the time matching with the architect's intent. On the other hand, very diversified distributions of the other remaining votes are explaining the differences of perception of the representations.

Then, it is interesting to summarize the observations we gathered while comparing a style of representation to another. Below, we outline our main findings regarding the criteria of comparison, previously developed, between the different representations (*Tab.16*).

From this table, we can observe that the pairs including hand-drawing (*first column, Tab.16*) are showing similar features. It means that the traditional hand-drawn representation is differentiated from its computer generated homologues, i.e. CAD model and rendering. From the lay-people's perspective, computer produced images are perceived to convey similar intents. Moreover, computer representations are seen as more clear than hand-drawing, and they seem to provoke a similar level of agreement. It means that the clarity of a representation is not the only factor involved in viewers' agreement about an architectural intent. Additionally, we notice that the pairs of computer representations convey more successfully to lay-people the initial intent of the architect.

Although, we notice some nuances within the pair of computer representations. Comparing CAD model and rendering (*second column, Tab.16*), it seems that they convey mostly the same intents to the lay-people with similar level of agreement. Nevertheless, CAD model is slightly more successfully conveying the architect's intentions.

'A' is ... compared to **'B'**

	B **Hand-drawing**	B **CAD model**	B **Rendering**
A **Hand-drawing**	-	-	-
A **CAD model**	- mostly perceived differently - more clear - mostly as disagreed on as - more successfully conveying an intent	-	-
A **Rendering**	- mostly perceived differently - more clear - mostly as disagreed on as - more successfully conveying an intent	- rarely perceived differently - as clear - as disagreed on as - more successfully conveying an intent	-

Tab.16 - *Comparison of representation characteristics assed in the study by lay-people.*

6. DISCUSSION

6.1 Discussion of outcomes

Perception of representations

The most general findings of the present study suggest that CAD models and computer renderings are mostly conveying the same intents to the non-experts participants, while hand-drawing differs from this pair of representations.

This is especially supported by the attributes *A1* (*contemporary-classical*), *A2* (*complex-simple*), *A6* (*innovative-traditional*), *A15* (*modest-audacious*) and *A20* (*common-unique*), that are somehow related to abstract and subjective perception of *architectural styles* and «*fashions*», which seem to be interpreted similarly through the two computer representations.

Several potential explanations might be advanced to explain the difference when it comes to conventional drawing. Hand-drawings used in our sets of representations are very abstract. Without any additional information brought by written or oral argument, it is then difficult for the lay-people to capture a clear intent. Moreover, this is reinforced by the fact that the general public is not used to deal with this particular mean of communication, while architects are trained to express and to depict intents using this media.

In order to convey an intent during the decision making process, it appears that it is not worth to invest time and money in the production of high quality computer generated images. This goes in the same direction as Pietsch's (*2000*) suggestions to develop quickly rendered computer models, with low realism and accepted levels of abstraction and accuracy, as defined by Radford et al. (*1997*), during the decision making process in order to receive stakeholders' feedback in the most effective way.

Nevertheless, we have to nuance these observations. Three attributes are perceived evenly through the three representations, *A3* (*hard-soft*), *A4* (*robust-delicate*) and *A14* (*composite-monolithic*). Looking at the meaning of the attributes, we might suggest that the sensorial appraisal of *materiality* seems to be conveyed evenly through the three studied representations.

Perceived clarity

The results show that the conventional drawing is seen as mostly unclear by the lay-people, while the two other computer generated images are seen as mostly clear. Interestingly we noticed that low and high quality rendered visualizations present clarity levels pretty much similar. That shows us that both of these representations are seen clearly as long as they are generated through a computer. A first explanation of that homogeneity between the different computer representations might stand in the definition of clarity, as understood by the non-expert participants. The initial purpose was to rate the ability and the ease to read the architectural intent, however it seems that it has shifted towards a clean «*look*» of the representation, which is quite different.

This observation goes along with other research. Compared to traditional drawings, it has been showed that computer generated images are perceived more accurate and more realistic (*Bates-Brkljac, 2007*), and therefore more credible, following the definition of credibility by Radford et al. (*1997*).

Moreover, our data shows that there is a difference between the clarity assessments of hand-drawings between architects and lay-people. Architects tend to assess the conventional drawing much more clear than the non-experts. Other research has already noticed that architects' perception differs from the lay-people's, and especially about the traditional representations, such as hand-drawing. Compared to the general public, architects would tend to assess hand-drawings more accurate and as more realistic (*Bates-Brkljac, 2007*).

This observation, as the others, could be explained by the familiarity with the representation. Hand-drawing has been used extensively in the architecture history as the principal ideation tool. Architects are therefore used to see and to use hand-drawing to explore ideas. It is then comprehensible that after a certain training they find hand-drawing as being relatively clear to them, while it won't be automatically the case for the lay people. As Bates-Brkljac (*2007*) stated, «they (architects) can fill the blank.»

Perception agreement

Based on the increase of clarity of computer visualizations, we were expecting to observe an increase of agreement among participants' responses. The preconceived idea was that a very unclear representation would lead to more random responses, and then to more disagreement among participants' answers. But it is interesting to notice that, based on our data, the homogeneity of the responses seems to be independent from the perception of the clarity of the representation.

Although, four of the twenty attributes (*A1(contemporary-classical)*, *A6 (innovative-traditional)*, *A16 (small-large)* and *A20(common-unique)*) present a clear increase of agreement is brought by the two computer generated representations compared to the conventional hand-drawings. That can be translated by saying that the degree of *novelty* and *size* of an architectural proposal are more homogeneously understood through the computer representations. Nevertheless this is very much related to the attribute rated, and it seems difficult to draw a clear correlation between clarity and agreement.

While this result is the first of its kind in architecture, similar topic has been explored in the product design practice. It has been found that as the mode of representation becomes more sophisticated, the differences in how people perceived the product decrease (*Artacho-Ramirez et al., 2008*). So for the design practice, the more the representation becomes realistic, the more there is a shared agreement about its perception. This conclusion goes along our observations made on four over the twenty attributes, however for most of the cases our findings are in opposition with this research.

We additionally observed that some attributes were presenting high disagreement in lay-people's votes for the three representations, i.e. the attributes *A11* (*expansive-compact*), *A14* (*composite-monolithic*), *A18* (*open-closed*) and *A19* (*heavy-light*). It seems then that the intents related to the sense of *materiality* and *massiveness* of a proposal are difficultly perceived on the screen support, or paper support. For these particular intents, it might be necessary to use other media, such as physical models or dynamic visualization.

Successfully conveyed intents

The main argument used by certain practicing architects to use high quality computer generated images, over low quality ones, is the ability to convey more faithfully their intent to the client, while being more appealing. Part of our results are supporting this viewpoint. Our findings suggests that, in the average, renderings would convey more successfully the intended attributes than CAD models and CAD models than hand-drawings. Crossing with previous results, that means that while CAD models and renderings mostly convey the same intent, renderings are slightly more successfully conveying architect's intents.

Nevertheless, we have to nuance these conclusions as the results are based only on six projects, which is not a large data set. Therefore, it is delicate to draw direct conclusions from this observation. Moreover the average is pretty biasing our observations. Actually we can see that only three of the six projects are following scrupulously this trend (*see 5.2.1 Correlation intent-perception*). Two other projects show very different trends : a very low degree of success to convey the architectural intent for the CAD model of the project *P6,* and, on the opposite, a very high degree of success for the CAD model of the project *P2*.

Although, all the attributes are not showing the same trend neither. We made observations that can be divided in three main categories.

First, we noticed that only few architects have intended the attributes *A3* (*hard-soft*) and *A16* (*small-large*). That might indicates that these particular adjectives are too specific to be considered in all the 6 studied projects. It might also mean that these attributes are not considered as important during the design process and constitute more a consequence of the design than an end in itself. Moreover, it has to be acknowledge that nowadays architecture practice is mainly focusing on virtual appraisal of design proposal. Consequently, it is depriving architecture from other sensorial approaches. Additional means of communication, such as physical models for example, might facilitate the conveyance of *sensorial* intents as the attribute *A3* (*hard-soft*).

Crossing with previous results, the fact that architects haven't intended these attributes doesn't mean that people don't have a specific perception of them. Actually, these attributes actually figure among the most agreed attributes. So an architect not willing to convey a specific intent can't be sure that people won't agree on a specific perception. It reminds us that architectural design is complex and while architects have some specific intents, other less considered features will nevertheless be perceived and assessed by the viewers.

Second, the degree of success of each attribute is not homogeneous. While some attributes were mostly successfully conveyed by the representations (*A1*, *A13*, *A17* and *A20*), others were most of the time unsuccessfully conveyed (*A4* and *A14*).

The mostly successfully conveyed attributes can be divided in two categories. First, the attributes *A13* (*low-high*) and *A17* (*vertical-horizontal*) seem to be obvious to assess, therefore it is not surprising to observe that these intents are mostly successfully conveyed. Second, for the attributes *A1* (*contemporary-classical*) and *A20* (*common-unique*), it is interesting to notice that most of the architects assessed their own proposal as being *contemporary* and *unique*, and they are joined on that by the lay-people. With a critic point of view of contemporary architecture practice, it seems that every architect is trying to design something *different* and *unique* in order to be seen by the largest public.

If we break down the observations per representation, we noticed that some attributes were slightly more successfully conveyed by the computer representations than the hand-drawing. The concerned attributes are divided in two categories. The first category of attributes includes the attributes *A8* (*relax-stimulating*) and *A9* (*quiet-noisy*). This might be explained by the presence of absence of decorum (i.e. trees, sidewalks, sky, ...) of the computer representations that enable to convey sensorial appraisal of an atmosphere. The second category of attributes includes the attributes *A2* (*complex-simple*) and *A15* (*modest-audacious*) which might be explained by the «*showish*» side of brought by certain photorenderings.

Other attributes were most of the time unsuccessfully conveyed, which includes *A4* (*robust-delicate*) and *A14* (*composite-monolithic*). As previously said, they represent a certain sense of *materiality* or *massiveness* of a proposal. While they are conveyed evenly through the representations, they are not conveyed as initially intended. It means that all the three representations are conveying well the intent but the explanation could be that architects and lay-people don't have the same definition of the attributes, or it could also be that these particular intents are difficult to convey through the studied representations.

Third, no correlation has been found between the number of intended attributes and the number of successfully conveyed attributes. As previously said, people's perception of a specific attribute is independent of the willing of the architect to convey a specific intent. The might be caused by a misjudgment from the architect that leads him to rate attributes that he didn't really want to convey in his project, the way the survey was defined might as be a cause of it.

Intent inconsistencies

From the assessment of the project representations as a whole by the architect(s), who created them, to individual assessments of each representation, several attributes were inconsistently rated. During a conversation post-study, one of the six architects has been recognized that each specific representation of the set is created to convey a particular intent. According to this architect, it is then normal to find that some attributes are not consistently assessed through the three different representations because they were not designed for that. The understanding of a project, without any speech-based argumentation, is completed by going through all the different representations of a project and not all of them individually, consistently with (*Estevez, 2001*) observations about representations fragmentation.

Moreover, another reason was the post-assessment of the proposal. During the design process, architects might have a clear intent they want to convey through the proposal presentation. Once the representations done, architects might recognize that some representations are not conveying their intentions as faithfully as they were imagining.

When we compare hand-drawings and CAD models, they present the smallest numbers of architects' inconsistencies for most of the projects. Additionally, the smallest numbers of statistically significantly differently perceived attributes stand for the comparison of CAD models and renderings. That means that for the architects hand-drawings and CAD models convey the closest intents, while it is CAD models and renderings that are being perceived as the closest by lay-people. This might be explained again by education around the use of conventional architectural drawing.

When we nuance the results, for half of the six projects (*P3*, *P5* and *P6*) most of the attributes differently perceived by the lay-people are attributes inconsistently rated by the architects. Although, it would be wrong to state that most of attributes inconsistently rated by the architects are perceived differently by the lay-people.

Moreover, some attributes presented high numbers of inconsistencies, including the attributes *A7* (*dynamic-static*) and *A8* (*relax-stimulating*), indicating once again the limitations of the 2D representations to convey these intents, and *A17* (*vertical-horizontal*), which might be paradoxical in comparison to the success of conveyance of this intent to the lay-people.

That being said, there is no appearance of a clear correlation between the number of successfully conveyed attributes and the number of inconsistencies within a project, neither between the number of attributes perceived differently in the representations by the lay-people and the number of inconsistencies.

6.2 **Additional considerations**

Aside from our results and findings, other considerations have to be included in the discussion about the different architectural representations.

Bates-Brkljac (*2007*) stated that perception of images was different regarding to the population concerned. More specifically, according to her, professionals want to see information in the representations, while councillors are seeking for a «sell design». That leads us to a really important point. While the ratio of the efforts needed over the effects produced clearly leans in favor of roughly computer generated images, it is important to remind that this statement would remain true only if the communication excludes the commercial point of view, that goes along with the architectural competitions. In other words, if the architect is looking for a new client through a competition, the need to please the client and to be appealing might justify the additional hours of computing work. In this context, high quality computer renderings have a clear advantage over the low quality computer generated images.

Moreover, the way the project-being-designed appears to the client is also a factor to take into account. Photorealism seems complete and non-negotiable to the client. (*Richens & Schofield, 1995*) It has been recognized that «*architects often prefer to show their clients sketches of their designs, rather than photorealistic images....showing the client a sketch and thereby transputing to him or her the message "this is the first draft" is more powerful and convincing than showing the client a photorealistic image and adding an appropriate verbal comment.*» (*Strothotte, 1994, p.C466*).

In other research in academic environment, architecture instructor appeared not trusting and disliking the use of computer generated images over the traditional representations because that would lead to loss of author identity and to problems of authenticity. (*Basa and Senyaph, 2005*) Moreover, during the education process the exclusive use of the computer aided representations is feared to lead to the loss of hand drawing skills over the time. (*Shu, 2000; Angulo et al., 2001*)

Finally, there is an additional factor that we haven't yet explored and that is not negligible, that is the production time of representation. Architects involved in our research were asked to rate the time commitment needed to produce the different representations (*Tab.17*).

	Averaged production time		
Hand-drawing	~ 10 min	=	~ 10 min
CAD model	~ 6 h	=	~ 300 min
Rendering	~ 16 h	=	~ 800 min

Tab.17 - *Averaged time to produce one image of each of the representation types.*

The use of CAD models, or low quality computer generated images, enables to save almost two third of the production time. These estimations by the architects include the production of the CAD model itself. Although, once the CAD model is created, it doesn't take more time to create multiple representations with different angle of view or different iterations. For the computer renderings used in our study, the production time as indicated here is necessary for the production of each single image.

7. CONCLUSIONS

7.1 **Contributions**

We can now conclude by summarizing our main contributions from our exploration of the perception of an architectural intent through different representations.

We noticed that lay-people and architects assess differently the representations. First, while architects seem to find hand-drawings and CAD models conveying mostly the same intents, it is CAD models and renderings that are being perceived the closest by lay-people. Second, hand-drawings are considered as much clearer by the architects than the non-experts. This might be explained again by education around the use of conventional architectural drawing, and raises the question of the relevance of each representation at each stage of the decision making process.

The degree of success of a representation to convey an intent is higher for the renderings then for the CAD models, but given the small number of projects tested, it stays comparable.

From our research it seems that low-end representations constitute the most efficient mean of architectural visual communication, being the best balance between success of conveyance of the architectural intent and time commitment.

Furthermore, we can make summarize some of our findings about attributes perception.

Most of the architects assessed their own proposal as being *contemporary* and *unique*. Moreover, we noticed that only few architects have intended *sensorial* attributes as softness.

The sensorial appraisal of *materiality* seems to be conveyed evenly through the three studied representations. While, intents related to the sense of *materiality* and *massiveness* of a proposal are difficultly perceived on the screen support, or paper support. For these particular intents, it might be necessary to use other media, such as physical models or dynamic visualization. Moreover, Intents somehow related to abstract and subjective perception of *architectural styles* seemed to be interpreted similarly through the two computer representations.

Sensorial appraisal of an *atmosphere* are conveyed slightly more successfully by the computer representations than the hand-drawn representations, which might be explained by the presence or absence of decorum.

7.2 **Limitations**

A first limitation is the number of architects that participated to the second part of our study. Despite the numerous demands over various media, only 6 projects with a direct access to the architect have been collected. With such a small sample, there might be a need to find complementary data in order to draw more significant conclusions about the architects' votes.

Moreover, despite our precautions about the consistency within a type of representation, there are still differences between the images used in the study. The approach we have adopted was to take the representations already done by the architects from a previous proposal, mostly because of time constrain. From a project to another there are then unescapable variations, such as the representation of the sky, the ground, etc. Therefore, it might be needed to extend the study with more representations, varied in their content but consistent in their form.

Finally, another potential limitation is that we designed our survey to be answered by participants living in the United States only. Therefore, results might be biased by external cultural factors.

7.3 **Future work**

Based on the present study, the findings claimed here would benefit from complementary work dealing with the same thematic, to bring more confident and more generalizable answers to the questions initially raised. Future work would need to provide more consistent representations, for instance by asking architects to use very specific features within the representation.

In order to determine rigorously the precise feature to vary from a representation to another, a detailed study of the use of representation within the current practice would be necessary. Then only, a set of very consistent representations can be produced. Different architects might be asked to accomplish the task in order to include their different personal styles, within the limit of the features previously determined. Moreover the assignments accomplished by the architects should concern architectural project varied in their scale, their program, and their typology.

As already mentioned, the present study includes exclusively American participants, which might constrain our conclusions. Depiction of realism of representation styles, for example, has been linked to social context and cultural background as crucial factors of understanding realism of pictures (*Goodman, 1976; Arnheim, 1969*). Common styles of depiction in architectural representations have also been linked to groups of people within a same cultural context (*Giddings & Horne, 2002*). Therefore it would interesting to confront our findings with future research using a similar framework. Comparable findings might indicate that as the architecture practice is becoming more and more internationalized, the perception of architectural visual products is becoming more homogeneous. The independence of the cultural context might be resulting from a general habituation due to the increasing exposure of the lay-people to such media in the day-to-day life, for instance through advertisement for real-estate developments in the street or in the media.

Finally we have noticed that architects are still extensively using conventional hand-drawings to communicate ideas to their peers in order to have quick feedback on their proposals. Therefore a potential extension of the study would explore the communication of an intent through different media but rather within the peer review process.

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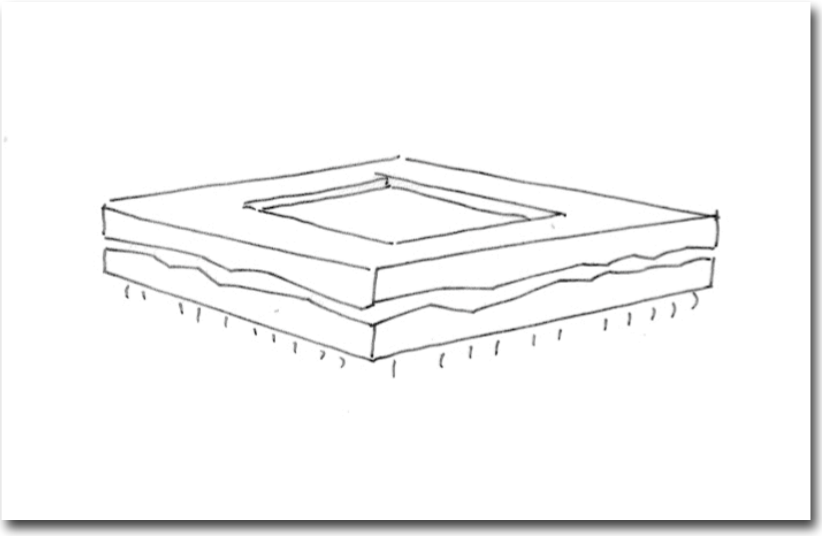
APPENDIX

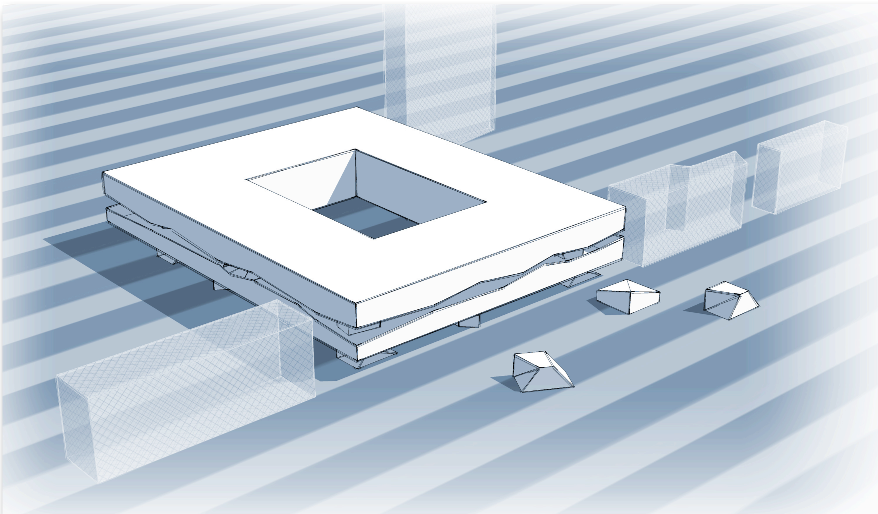
1. **Recruiting poster**

2. **Projects representations**

2.1 **Primary projects representations**

P1





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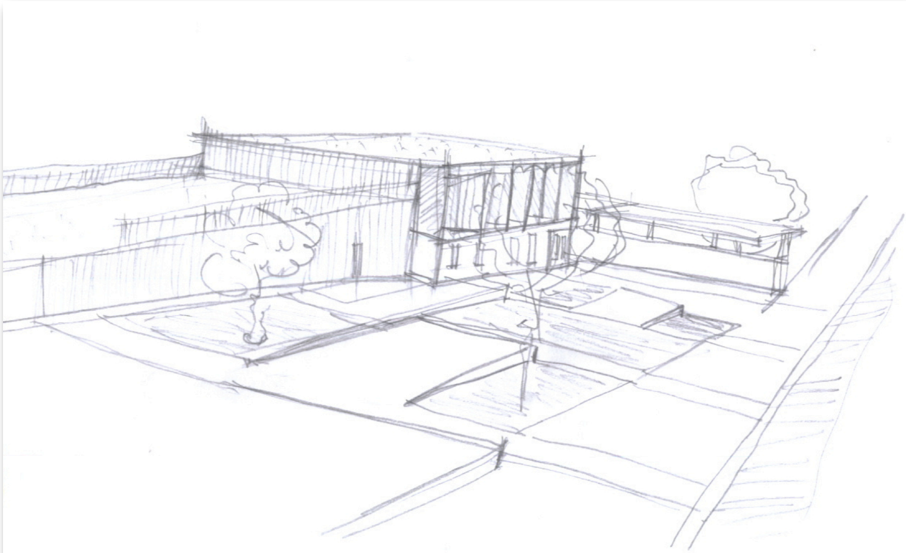

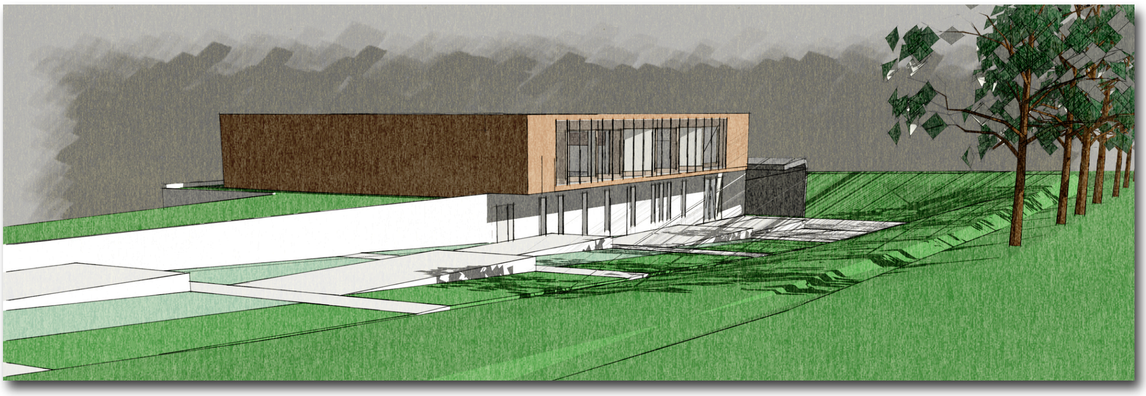

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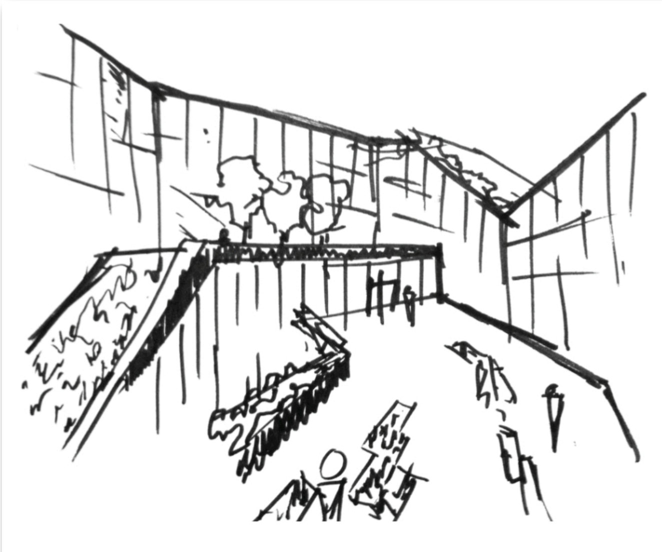

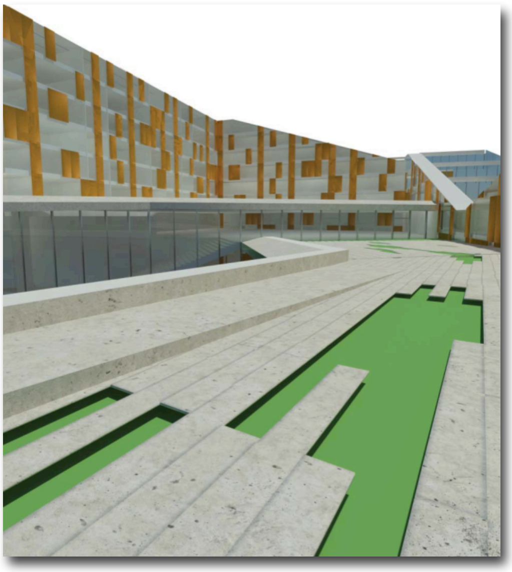

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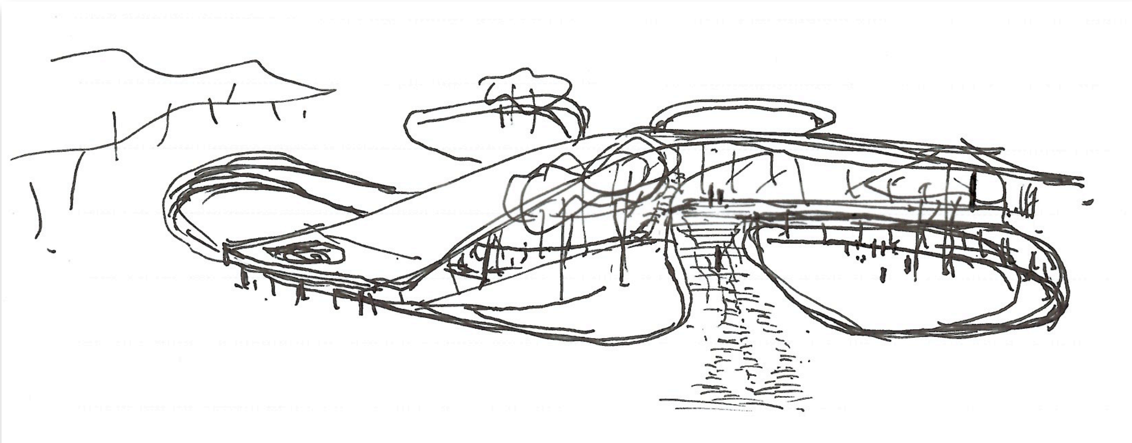

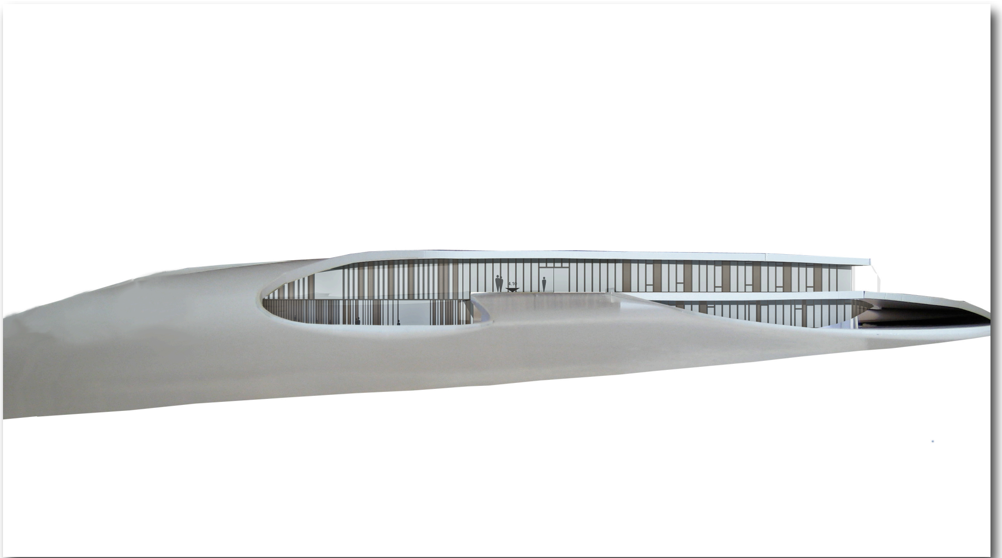

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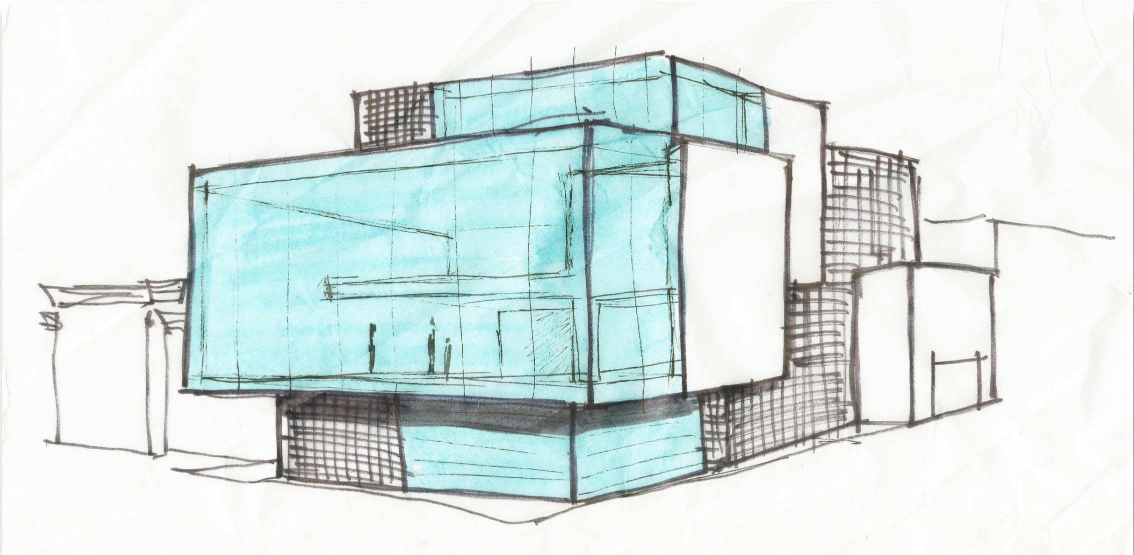


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2.2 **Secondary projects representations**

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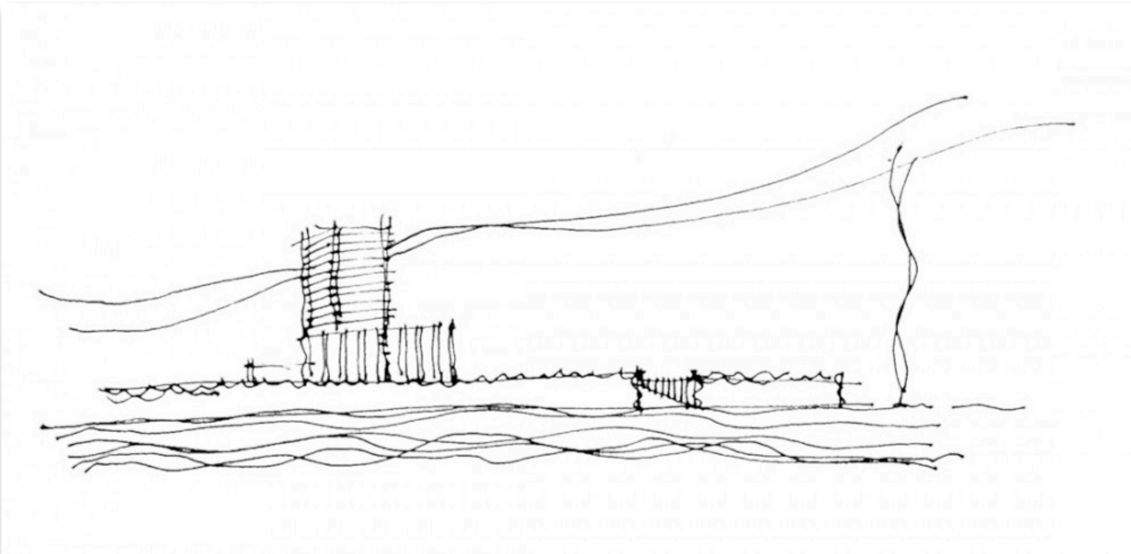

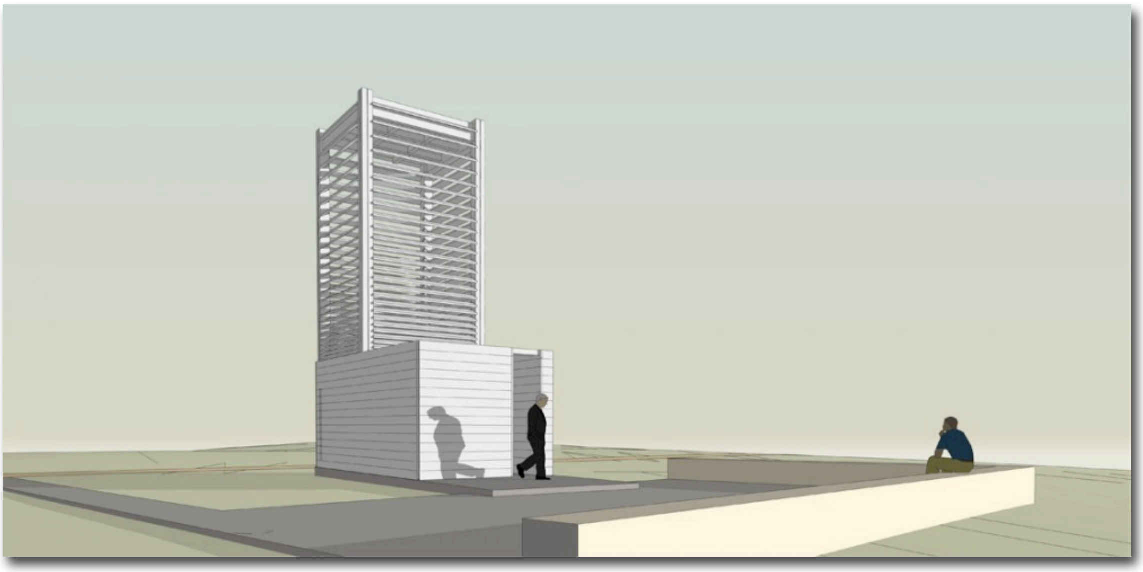

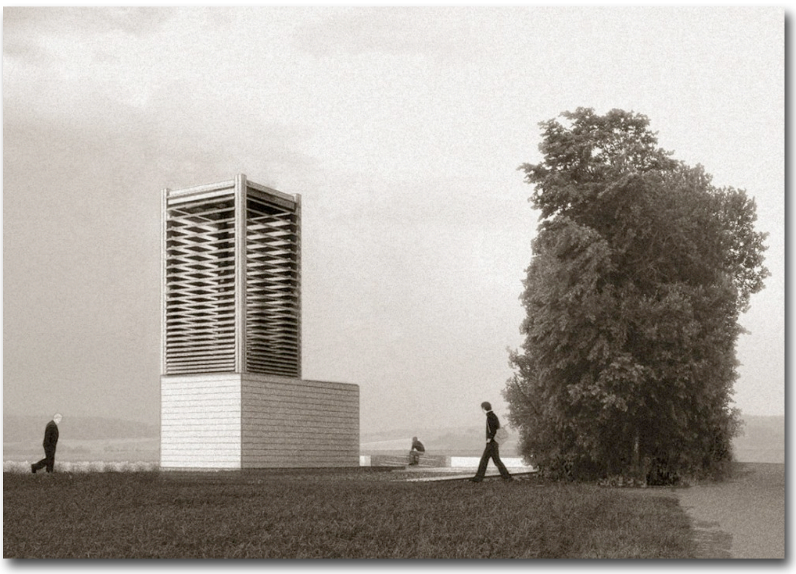

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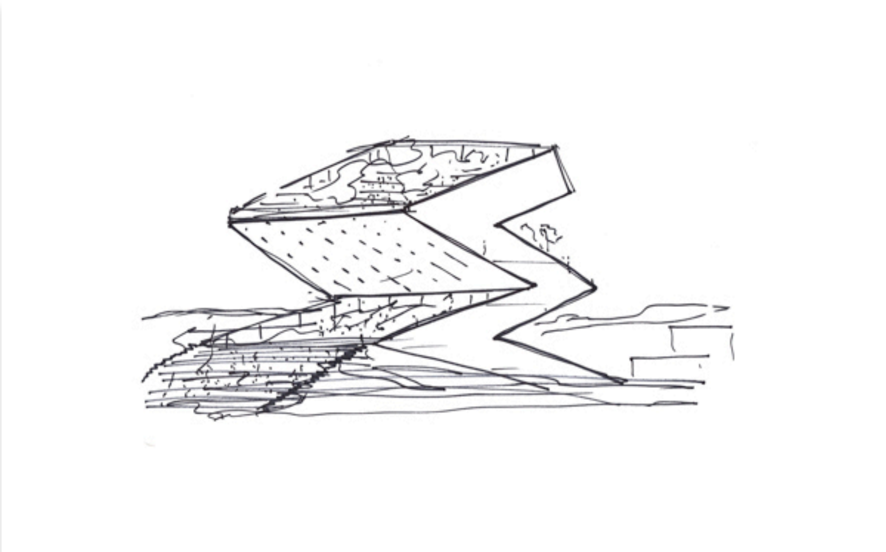

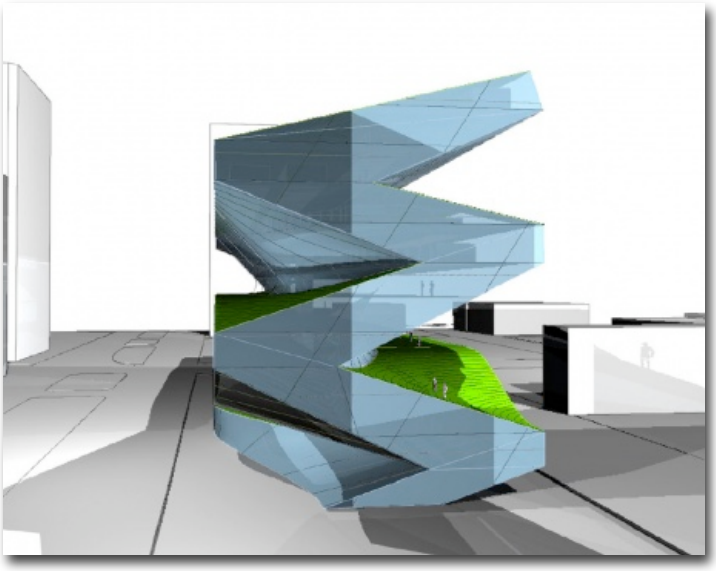

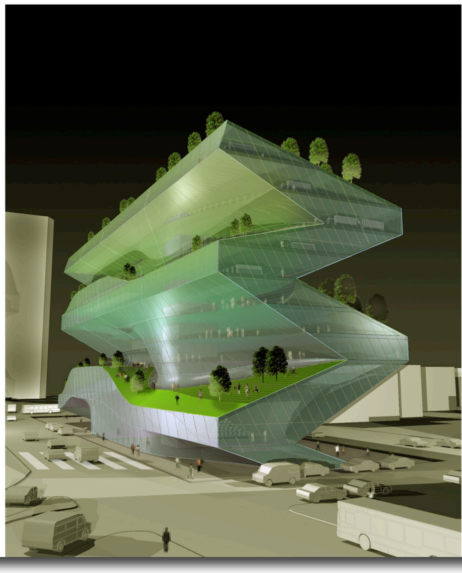

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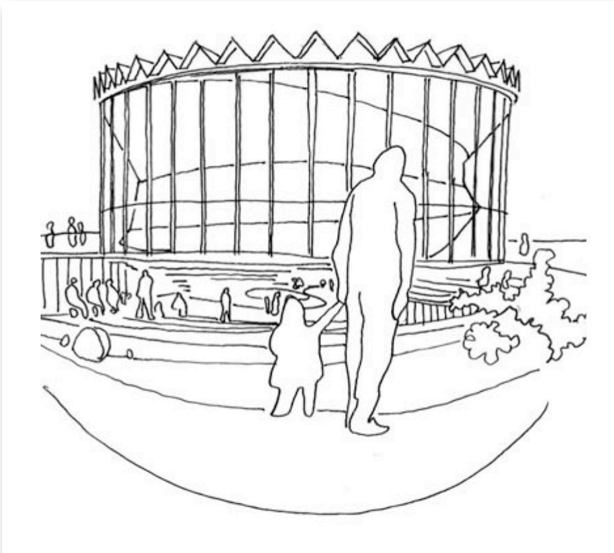

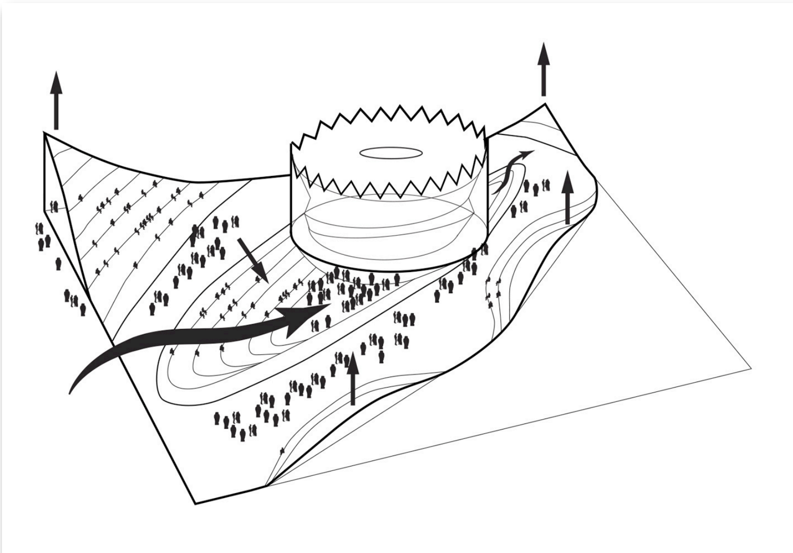

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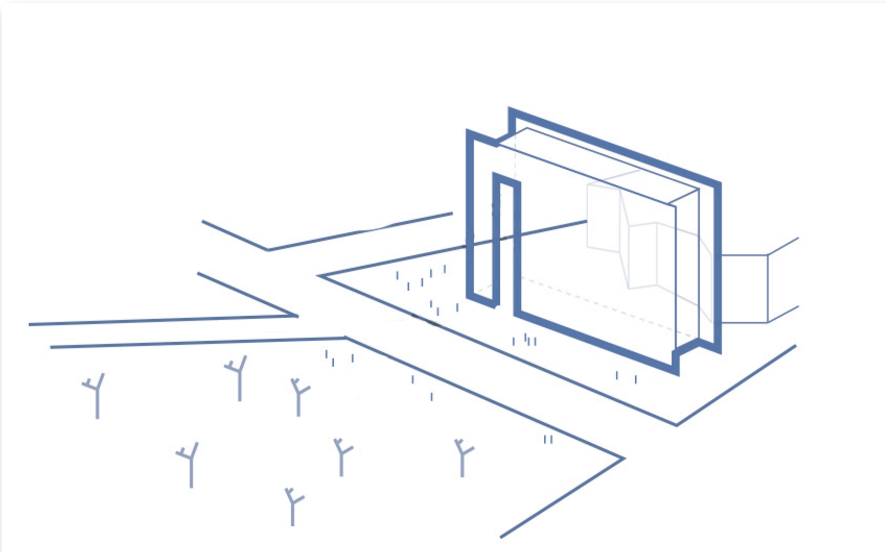

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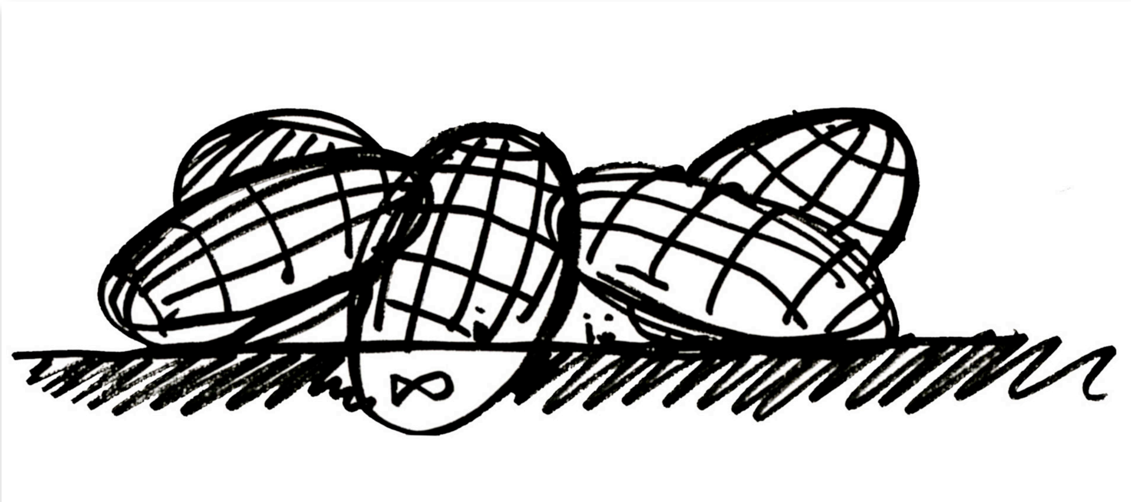

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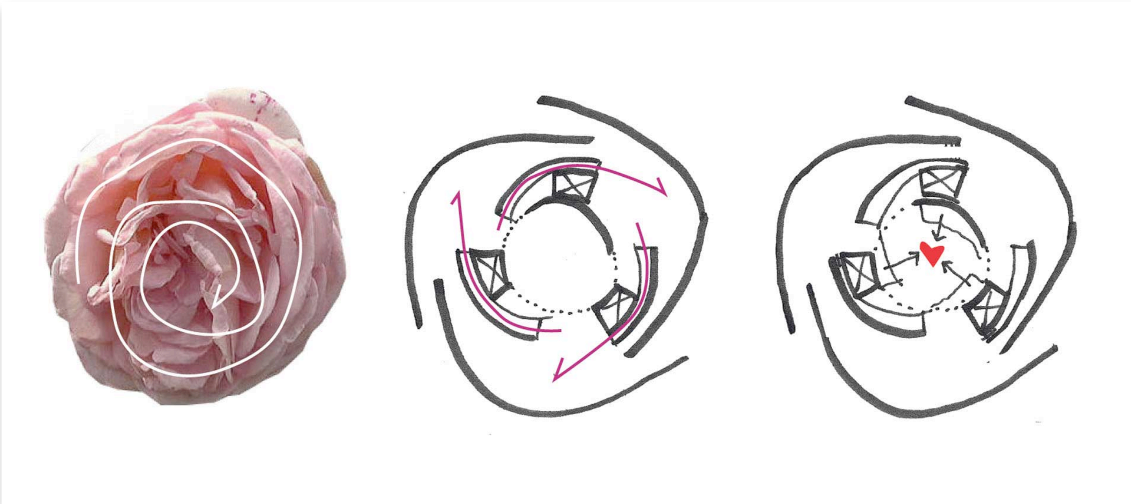

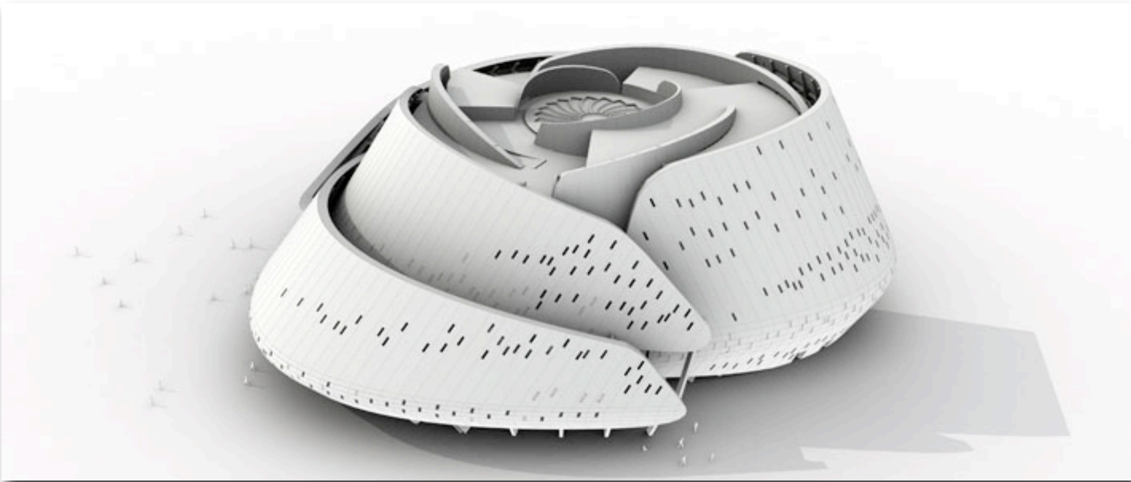

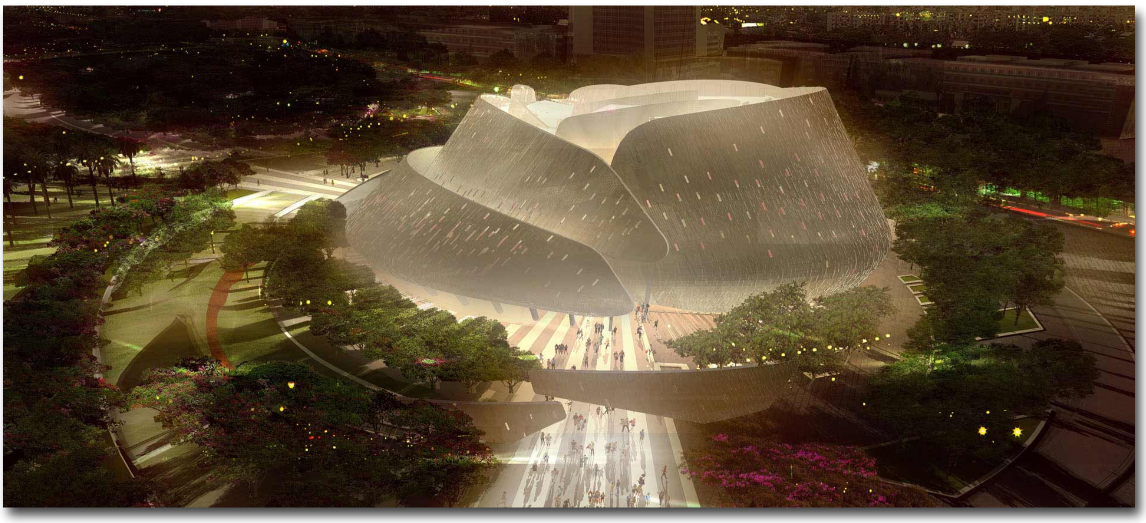

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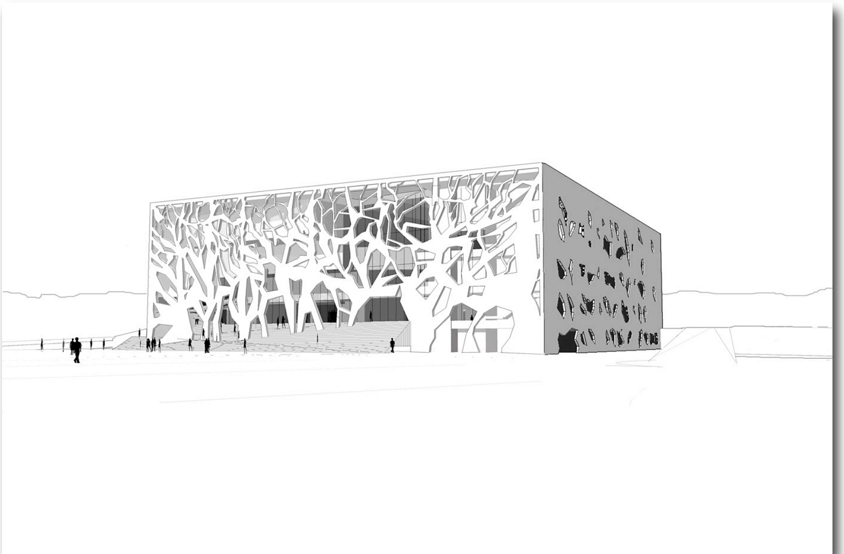

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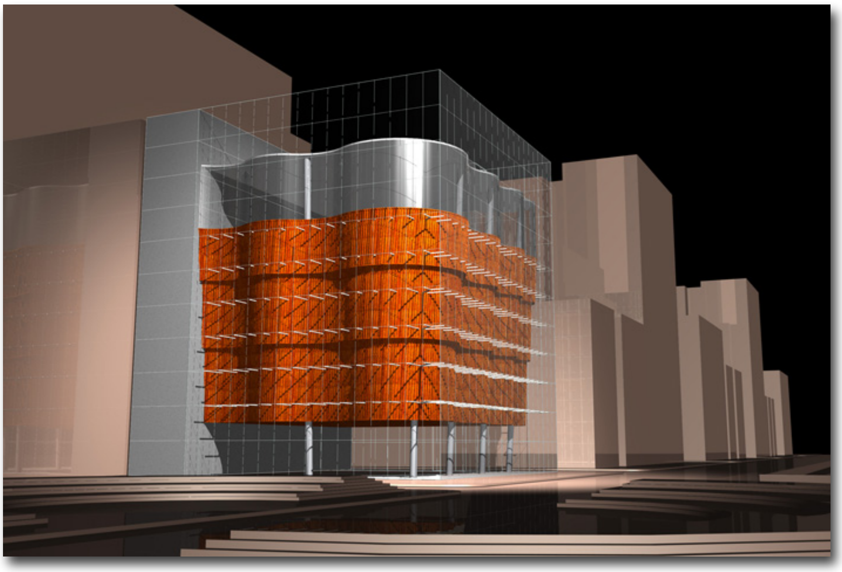

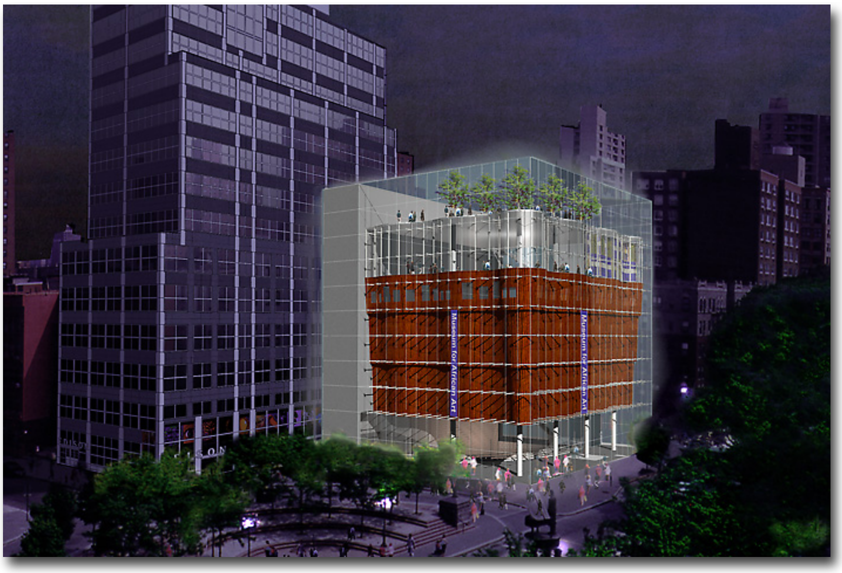

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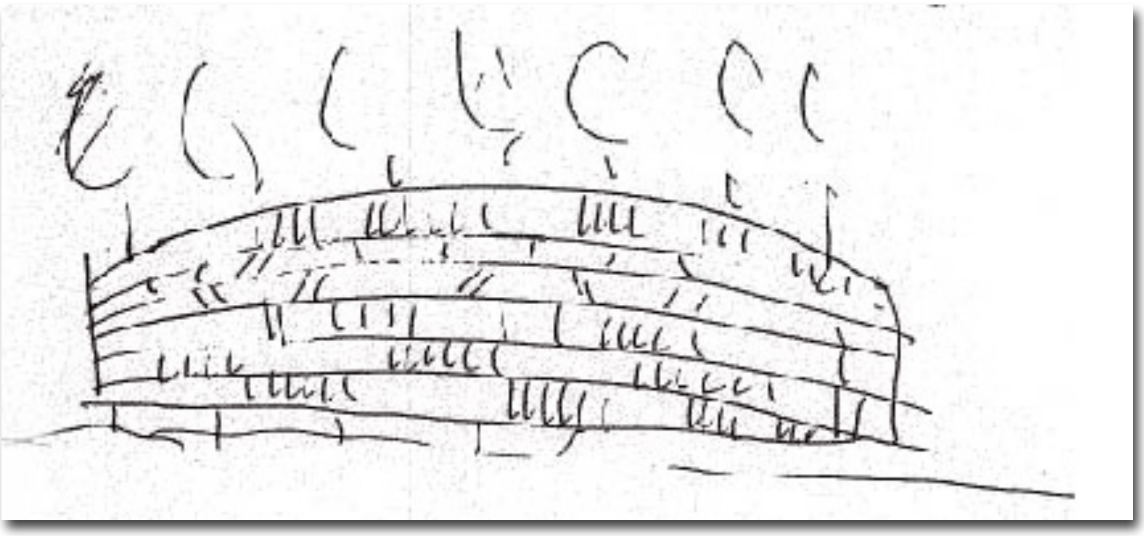
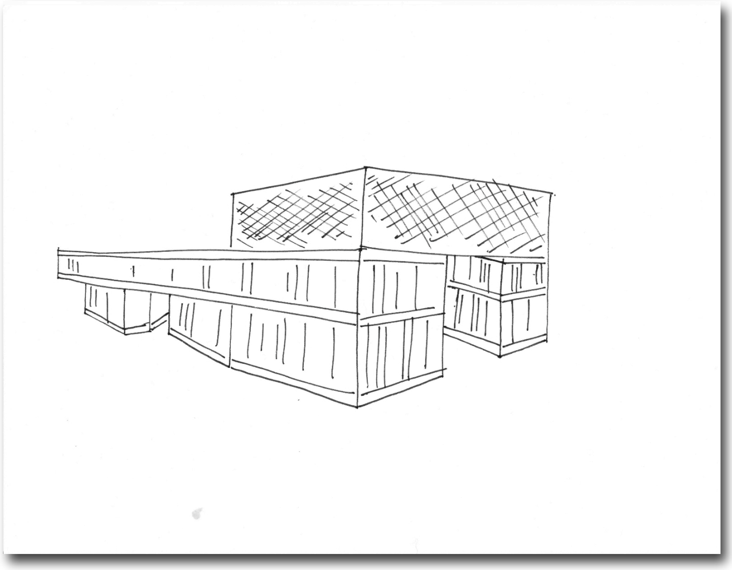
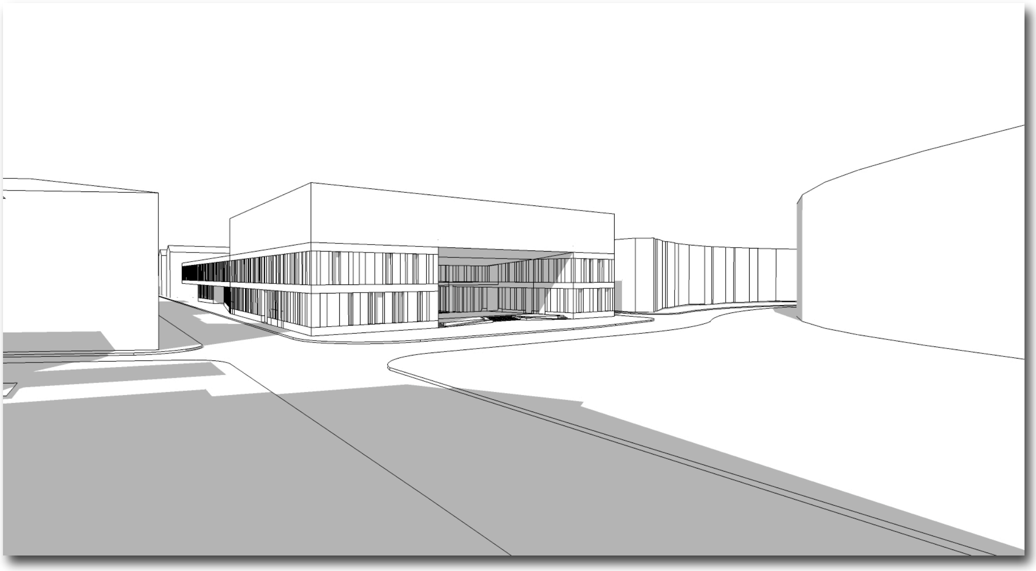


P16





3. Projects descriptions

3.1 **Primary projects descriptions**

P1 | Arena 91 - Architectes Ingénieurs Associés

Urban monument
Functional dynamic
Opening on the city
Powerful image of a **monolith**

Translated from French

«*Monument urbain*
Dynamique fonctionnelle
Ouverture à la ville
L'image puissante d'un monolithe»

http://www.a-i-a.fr

P2 | Residential Tower - Nicolas Fontaine

The privileged position of the tower on the edge of the city, at the corner of Paseo de Rosales and Paseo de Moret, is the only neighbourhood that connects the center with a continuous green space. The position of this residential tissu is therefore highly valuable.

The architectural principle of this project is to propose a tower composed of **diaphanous** spaces and a set of double glazen layers revealing the heart of the tower and thus marking the **verticality** of the building. Note that this composition can also mark the entry and allow entry of more consistent light. The basic idea is to create a project in a particular environment, plan a space of continuity with the park.

Translated from French

«*La position privilégiée de la tour sur ce bord de la ville, à l'angle des Paseo de Rosales et Paseo de Moret, est le seul secteur qui relie le centre en un espace vert continu. La position de ce tissu résidentiel est ainsi doté d'une haute valeur économique.*

Le principe architectural de ce projet est de proposer une tour composée d'espaces diaphanes et d'un jeu de double paroi en verre laissant apparaître le coeur de la tour et marquant de ce fait la verticalité de celle-ci. Remarquons que cette composition permet également de marquer l'entrée et de permettre une entrée de lumière plus conséquente. L'idée fondamentale est de réaliser un projet dans le cadre d'un environnement particulier, planifier un espace de continuité avec le parc.»

http://nfontainearchitecture.blogspot.com

P3 | Village Hall - Eurl Alga

The project is a village hall on a highly inclined ground, which explains the long approach ramp. The guiding idea was to conceive an **integrated** building and very few **salient** in comparison to the ground. In brief : an **elegant** wooden **box** delicately posed in a cantilever way on a wall.

Translated from French

«*C'est une salle des fêtes dans un terrain a forte pente, d'où la grande rampe d'accès. L'idée directrice a été de faire un bâtiment intégré et très peu saillant par rapport au terrain. En résumé : une élégante boîte en bois délicatement posée en porte-à-faux sur un mur.*»

P4 | Library and Residential building in Seoul - Nathan Mattson

As the people of Seoul grow collectively older, the values and bonds of the city and its residents will be tested by a generational divide. Aspiring towards intergenerational integration, our project is based on a desire to not only bring people together in an environment of mutual comfort, but to promote a beneficial collaboration of young and old through culture, history, and art, not only available in a library, but also in the **collective** experience of the occupants.

Our project is not only a **combination** of programs, with the library and residential, but a point of transfusing generations. Young, old, learning, and living all blend together in the central courtyards of the building creating a unique community within the project.

http://nathanmattson.com

P5 | Center for Childrens Psychiatry - Osar

The building's concept is a architectural **landscaped** transit-building. The approach to the building has to be easy, **nice** and **comforting** for the children (and family). The top floor is the entrance where the more public functions are. The more you go down in the building, the more private it becomes. The living areas and therapie rooms are on the floor below, from where there is a direct contact with the outside space and an extra view on the trees that are functioning as a backdrop.

http://www.osar.be

P6 | Community Art Center - Oleksandra Topolnyska

The idea of the Community Art Center is to connect and mix different spaces together and to create a **comfortable** and **sociable** place for everyone. By **mixing** different spaces together the structure presents an opportunity for spaces to be more **open** and **spacious**. The café gallery and the library gallery all enhance more opportunities to view art work, while individual have a snack or use the area for relaxation. The exterior of the building is also linked to the concept of **mixed use** of spaces. This model is achieved by infusion of void **rectangular blocks** of particular spaces, which allow the structure to get multi space functionality. The extension of the main gallery, towards the Kellogg Park, gives a feeling of the Art Center itself reaching out to the community and **inviting** everyone to come and participate.

http://sashatopolnytska.com

3.2 **Secondary projects descriptions**

P7 | Field chapel - Student of the Illinois Institute of Technology

The task of the design was to create a place of spirituality. Professor Flury defined the project for the twelve students who come from Alabama, Alaska, California, Florida, Idaho, Illinois, Tennessee and China, as “an interdenominational chapel, a space for people who are in a search for God – a place for **quiet** reflection, but also one that welcomes hikers and cyclists who appreciate a rest stop that has a sense of **beauty**.”

The structure is visible from afar but can only reached by foot or by bicycle via a steep country lane. The students developed outdoor facilities and space as a logical consequence of interaction: when arriving at the site, a narrow footpath leads between an existing hedge and the blank tower facade to a small gravel forecourt, which is bounded on 2 sides with **massive** benches made of local limestone. This forecourt represents the secular realm. A brick platform rises from this forecourt, upon which visitors enter a closed patio and ultimately the sanctuary. This platform traverses the profane to the divine.

Surrounded by four closed walls, views are limited to the sky and the tower, which encloses the chapel sanctuary. “The courtyard and chapel are situated in a sea of faith,” according to the students. “The Secular and the Sacred touch each other, they are connected with one another.”

http://www.archdaily.com/37921/field-chapel-in-boedigheim-students-of-the-college-of-architecture-at-the-illinois-institute-of-technology-ecker-architekten/

P8 | Newer Orleans - UNstudio

This project aims to understand the building as a tool in re-establishing a balanced ecology between culture and commerce. It is a type of ‘playground’; a **safe** haven where participants can congregate without **fear** of reprisal and a setting that people transiently share. In this design, the ancient ziggurat motif is transformed into a design model that combines various public and private programs in a stepped series of radically different environments: **sun-seeking** versus **shadow-rich**, **open** versus **enclosed**, **serrated** profile versus **smooth** elevation. The mediatheque, which stores and preserves information of all types, forms part of a network of new community centers dedicated to learning and culture. The mediatheque is also a hub: a place for meeting and exchange, with differently themed **landscaped** plateaus that garland the building.

http://www.unstudio.com/projects/newer-orleans

P9 | Warsaw Rotunda - MUS architects

We believe that the Warsaw Rotunda is a valuable part of the city landscape. It is a building with a **strong** form, object with a hidden **beauty**. While designing New Rotunda we tried to notice and extract synthetic traits of character and beauty of the **original** design of the building, while keeping **fresh contemporary** look, functionality, structure and aesthetic.

We can build the "**new**" in the correlation and reasonable dialogue with the "**old**". City and historical architectural mater is created by layering and multithreading. Similarly, the Rotunda 2.0 should preserve historical layer of his best traits of character : location, scale, shape, strong form and unique roofing. This set of features in a **modern** form and modern material is an exit point through which we design.

The next step is to think about the group of new features and modern architectural forms derived directly from today’s aesthetic sensitivity and the "pulse" of the city. Reinterpretation of the form and function of the Rotunda must proceed so that the new heart of the building was modern implant, which establishes a **symbiotic** relationship interesting new connections with the old organism, together creating a valuable place in Warsaw both functional and aesthetic.

RTND 2.0 is a modern design and a **hybrid**. It preserves the function associated with the place of inception - PKO Bank, but at the same time create high-quality public space supplemented by a number of features that are generators of urban life. **Amphitheatrical** square shaped supplemented with **low** vegetation and **high** and **small** architectural forms the "Green Enclave in the City" . The result is a complex concentration of urban life. Under the Rotunda you can make an appointment and meet , but also relax, use a reading room, information center, cafes and pubs. The internal design of the rotunda was changed. The new steel structure internal "cocoon" is a **combination** of function, form and structure.

The loads from the roof and floor are transferred through the openwork structure (network of steel tubes) in the steel ring and trusses, new ground floor, then through the wall reinforced concrete poles on one side and on the other - on the foundation.
"New Face" of the Rotunda is a coherent and well thought hybrid between "Old" and "New". It is modern, **conceptual** and **functional** - a place of symbiosis , multithreading and the culture of dialogue on many levels. Place symbolic, **metaphorical** and **unique**. Place of living. Imagine this place and meet at the Rotunda!

http://www.bustler.net/index.php/article/warsaw_rotunda_entry_by_mus_architects/

P10 | nternational Gastronomic Center - C. Carranza, S. Martin, P. Suarez, W. Casola

Architecture is always conceived as a specific problem, by this we come to the examination of the facts like first approach in search for an agreed solution to the subject-problem and the site-situation, and thus, accept and enable the facts to manifest themselves in a consistent architecture.

The good location and communication of the capital are the main contributing facts. Its square, condensation of urban life brings meaning to the buildings, and there links the most significant. It is a place of encounter and exchange serving both day and night. A natural vent space within the urban frenzy.
Moreover, the layout and the streets determine the architecture, which was modified and adapted over time, where the dividing buildings predominate with their commercial spaces and restaurants in ground floor.
In its immediate environment the most important buildings are Place Eugene Flagey, the "Ancien Institut National de Radiffusion" and the school of architecture "La Cambre D'Horta" which are separated by a very finely crafted wall that passes almost unnoticed. The site in particular, is presented as the visual mouth of Lesbroussart street, which has the highest number of restaurants.

And here like the own facts of the particular urban situation in which is attached to the program requirements of the IGC dictates the solution. The center of cultural exchange through gastronomy should be an intensive life experience as much from the professional plane of the close friends like of the space plane, as much in both the inside and outside feels part of a continuous exchange of experiences. The International Gastronomic Center is then:
A building **dividing**, or rather a thought as a party wall, building with a liveable urban thickness. A building **opened** to the public space and part of it. A building that encompasses the environment during the day and differently during the night. An urban screen, visual opening and point of recognition in the city. A building that responds both to the program requirements as to the opinions of the place.

And it can not be anything else, you must have the ability to recognize the situation and recognize for what it is, a new piece in the urban board, with the sufficient capacity to be different and to show its contemporary character by becoming present in the present, but also with the necessary delicacy to be part of the history of Brussels as the new worldwide capital of gastronomy.

Translated from Spanish

«La arquitectura se plantea siempre como un problema específico, por esto procedemos al examen de los hechos como primera aproximación en busqueda de una solucion acorde al tema-problema y al sitio-situación, y así, al aceptarlos, hacer posible que los propios hechos se manifiesten en una arquitectura acorde.

La capital bien situada y comunicada es la principal aportadora de hechos. Sus plazas, condensadoras de la vida urbana aportan sentido a los edificios, y allí radica el hecho más significativo. Es un lugar de encuentro e intercambio que actúa tanto de dia como de noche. Un espacio de desahogo natural dentro del frenesí urbano.

Por otra parte el trazado y sus calles determinan la arquitectura, que se fue modificando y adaptando al paso del tiempo, donde predominan los edificios entre medianeras y con sus espacios comerciales y restaurantes en planta baja.
Es asi que en su entorno próximo los edificios más relevantes de la Place Eugéne Flagey, el "Ancient Institut National de Radiffusion" y escuela de arquitectura "La Cambre D´horta" se encuentran a su vez separados por una medianera muy sutilmente trabajada que pasa casi desapercibida. El sitio particularmente, se presenta como la desembocadura visual de la calle Rue Lesbroussart, que presenta la mayor cantidad de restaurantes.

E aquí como los propios hechos de la particular situación urbana en la que se encuentra junto a los requerimientos programáticos del IGC dictan la solución. El centro de intercambio cultural a través de la gastronomia deberia ser una intensiva experiencia vivencial tanto desde el plano profesional de los allegados como del plano espacial, tanto en el interior como en el exterior uno se siente parte de un continuo intercambio de experiencias. El Internacional Gastronomic Center es entonces:
Un edificio entre medianeras, o más bien, un edificio pensado como una gran medianera, un espesor urbano habitable. Un edificio abierto al espacio público y parte de él. Un edificio que se nutre del entorno durante el día y se diferencia durante la noche. Una pantalla urbana, desembocadura visual y punto de reconocimiento dentro de la ciudad. Un edificio que responde tanto a los requerimientos programáticos como a los dictámenes del lugar.

Y es que no puede ser otra cosa, debe tener la capacidad de reconocer su situación y de reconocerse como lo que es, una nueva pieza dentro del tablero urbano, con la sufiente capacidad para diferenciarse y mostrar su caracter contemporáneo haciendose presente en el presente, pero también con la necesaria delicadeza de ser parte, y ayudar a conformar o mejor dicho a formar parte de la historia de Bruselas como la nueva capital de la gastronomía a nivel mundial.»

http://www.arquideas.net/es/igc1382

P11 | Batumi Aquarium - Henning Larsen

Batumi Aquarium is inspired by the characteristic pebbles of the Batumi beach – the residue of dynamic seas continually shaping the shorefront throughout millennia. The building will be situated in the port of Batumi and will stand out as an **iconic** rock formation – **visible** from both land and sea.

The formation constitutes four self-supporting exhibition areas where each of the four stones represents a unique marine biotype – the Mediterranean, the Black Sea/Red Sea, the Aegean Sea and the Indian Ocean. The four dispersed aquarium exhibitions are connected by a central, multipurpose space including café, auditorium and retail functions with views of the black sea and Batumi beach as **scenic** backdrop. Visitors gather in the central space to convene, play, eat, shop and relax before continuing their adventures through the exhibitions.
Batumi Aquarium will become a **modern**, **cultural** aquarium offering visitors an educational, entertaining and visually **stimulating** journey through the different seas. Unfolding around the aquarium, a landscape of different sea archipelagos provides attractive opportunities for innovative outdoor research and learning, public space and meeting places along the beach.
The building's **significant** expression inspired by nature will not only make Batumi Aquarium a **spectacular** new **landmark** in Georgia but also a state-of-the-art contribution to exploring life underneath the sea surface.

http://www.henninglarsen.com/projects/1000-1099/1061-batumi-aquarium.aspx

P12 | Massar Children's Discovery Centre - Henning Larsen

The Massar Children's Discovery Centre will be the heart of a Syrian educational programme - Massar. The centre will through science-based, hands-on experiences offer activities to empower young Syrians to contribute actively in building their future.

The discovery centre has a unique location in the heart of Damascus. The building comprises exhibition, library, education and administration space. The centre will be an **integrated** main attraction within a new 170,000m² public realm on the site.
The form is **inspired** by the unique Damask rose. The proposal suggests a shell structure allowing a **playful** and **dazzling** scenography of light into the interior spaces - like light filtering between rose petals. Exhibition and administrative areas are laid out between the rose petals creating interior labyrinth journeys inspired by walks in the old city of Damascus formed by walls with the sky as the window.
The centre of the rose forms a large communal orientation space. This is where people meet, share knowledge and develop new ideas together – a cross pollination of knowledge. From here series of journeys rise upwards in form of a web of ramps and steps interweaving the public plateau with the upstairs shell structure.
The **central vertical** movement under the open sky challenges the traditional horizontal movement in the Arab city.

http://www.henninglarsen.com/projects/0800-0899/0820-massar-childrens-discovery-centre.aspx

P13 | ANIMA Cultural Center - Bernard Tschumi

The town of Grottammare and the nearby communities, together with a local foundation, have decided to create a **special** facility with a 1,500-seat **multi-purpose** auditorium (the Main Room), **combined** with a 250- to 400-seat meeting room, together with educational, exhibition, and recreation spaces. With its location close to the sea and its direct connection to the highway, A.N.I.M.A. can be a major regional activator. Rather than resorting to **convoluted** volumes to arrive at some now predictable **extravagance**, Bernard Tschumi Architects designed the ANIMA building around two clear ideas or concepts.

First, we wanted the interior of the building to read as a small town of sorts, and to generate **unexpected** events through its plazas and cortili. Second, we aimed at a **simple** exterior, with four vertical perimeter walls or facciate, hence investigating the concept of "facades" instead of envelopes in this project.

On the inside, we made the plan like an ideal **square** (72x72 meters) with the Main Room in the middle. By rotating the Main Room slightly, we generated a sequence of four trapezoidal courts, or cortili, places of social encounters and gatherings. On the outside, we anchored the four facciate of the ideal square firmly into the ground and proceeded to carve openings into each, according to orientation and use. By being **abstract** and **figurative** at the same time, we avoided **conventional** façade composition, giving a **strong** and **creative** presence to the ANIMA building. The image of both the front facade and the fifth facade (the roof) is a work-in-progress and will evolve with further technical studies.

Together, our two concepts of cortile interior and facciata exterior result in a building both **simple** and with a **striking** presence. It pays homage to major contributions from the Italian cultural identity, in particular for the front facade to Pericle Fazzini, a major artist from Grottammare.

http://www.tschumi.com/projects/68/

P14 | Museum for African Art - Bernard Tschumi

Following an invited competition, the Museum for African Art selected Bernard Tschumi Architects to design its new building located along Museum Mile in New York City, at the Northeast corner of Central Park on Fifth Avenue and 110th Street. Zoning constraints required a street-wall facade that is **aligned** with existing residential buildings along Fifth Avenue.

The project for the Museum for African Art combines **traditional** wood with the most **contemporary** glass structure with the intention of providing an **emblem** of access and participation to its visitors. It represents a new kind of museum, one that juxtaposes MAA's historic aim of exhibition with increased focuses on audience and accessibility. The building was intended to be designed as a **resource** and a **stimulus**. It includes flexible, dramatically lit galleries, further enhanced by the integration of media and technology-equipped spaces for education and research, and multipurpose social spaces. The interior areas aim to suggest the multiplicity of

African cultures while avoiding literal references to specific techniques and styles. The museum was conceived as a vehicle for exploration of, and by, multiple communities.

Circulation through the museum elaborated a ritual, or route, of multiple sequences. The soaring glass walls that mark the museum's perimeter facilitate incredible views over Central Park. As one moves through the space, the park becomes central to the museum experience since escalators, elevators, and stairs are located at the periphery of the building. Locating all fixed elements of circulation and service on the periphery of the floor plate allows maximum flexibility in the interior spaces of the building. In this manner, MAA would become the only museum on Fifth Avenue to reveal the park landscape so explicitly.

http://www.tschumi.com/projects/23/

P15 | Alésia Museum and Archaeological Park - Bernard Tschumi

The scheme consists of two separate but related structures. One building is a museum located at the position of the Gauls during the siege at the top of the hill above the town. A second building is an interpretive center located at the Roman position in the fields below. The museum is built of stones, similar in look to the town buildings but with contemporary technology, and is buried partially into the hill so that from above it appears as an extension of the landscape. The interpretative center is built of wood, much as the Roman fortifications would have been at the time of the siege. The roof of the building is a garden planted with trees and grass, camouflaging the presence of the building when seen from the town above. A keen awareness of the surrounding landscape as it pertains to the historic battle is integral to the visitors' experience.

The project creates two buildings with a **simple**, **cylindrical** shape. The envelops adapt through materials to their surroundings, while the form of the buildings is de-emphasized. By pairing the structures, committing to **integrating** the buildings with the landscape, and using a **simple round** building typology, the buildings manage to defer to the battle site while fostering a sense of respect and awe through a muted formal presence. The strategies of giving maximum presence to historical events and respecting the sensitive insertion of buildings into their natural environment respond to the ambition of the project while reflecting the imperative of modesty demanded by archaeologists. To be both **visible** and **invisible** is the paradox and challenge of the project.

http://www.tschumi.com/projects/8/

P16 | Roman Empire Museum - Maxime Cunin

Placed a Roman Empire museum in opposite of the Nîmes Roman Arenas is not an easy task. The project has to propose a **powerful** image to accurately represent the **symbolic** of the Roman Empire, while respecting the imposing Arenas that take part in the urban historical heritage.

The project is composed of a base and a top, each one with its own material. The base uses proportions similar to the verticals and horizontals from the Arenas' facade and uses the same stone as well. The translation is not literal but rather a **modern** composition, using vertical shifts to create a **dynamic** facade and therefore induces pedestrian flows and shows entries to the archeological garden. In total **contrast** the top is a simple and light perforated corten box, delicately posed on its **massive** base. We can therefore observe a powerful and **harmonious opposition** of materials, colors and proportions.

In the archeological garden the walker's glance is naturally led toward the meeting point between horizontal and vertical of the building, where the reconstitution of a Roman pediment takes its place, emphasized by a zenith light filtered by a perforated corten skin. Under the power of this patrimonial object the skin is yielding and then it gives an importance to the emphasized object. The architectural heritage is inside the heart of the museum in the same time than facing to the Arenas with an interesting dialogue.

Translated from French

«Asseoir un musée de la romanité en vis-à-vis des Arènes romaines de Nîmes n'est pas tâche aisée. Le projet doit à la fois proposer une image puissante pour représenter justement la symbolique de l'empire romain, tout en respectant les imposantes Arènes faisant partie du patrimoine historique urbain.

Le projet est composée d'une base et d'un couronnement, avec leur propre matérialité. La base utilise des proportions similaires aux verticales et horizontales présentent sur la façade des Arènes et utilise également la même pierre. La traduction n'est pas littérale mais une composition moderne, utilisant des décalages verticaux pour créer une dynamique de façade et ainsi, inciter certain flux piétons ou indiquer les entrées vers le jardin archéologique. En total contraste, le chapiteau est une simple et légère boite en acier corten perforé, délicatement posée sur sa base massive. On trouve ainsi une puissante opposition dans les matériaux, les couleurs et les proportions, tout en trouvant une certaine harmonie.

Dans le jardin archéologique, le regard du promeneur est conduit naturellement vers le point de rencontre horizontal et vertical du bâtiment où la reconstitution d'un fronton romain prend place, mise en valeur sous une lumière zénithale tamisée par une peau d'acier perforée. Sous la puissance de cet objet patrimonial, cette peau se plie et donne une grandeur à l'objet ainsi mis en scène. Le patrimoine est au coeur du musée, mais aussi de la place en face des Arènes offrant un dialogue intéressant.»

3.3 **Reference projects adjectives**

STUDENTS' PROJECTS

Amsterdam Academy of Architecture, 2009 - ***Yearbook: 2007-2008*** **- Rotterdam, 010 Publishers** *(61 projects)*

dramatic	intimate	vertical	homogeneous
linear	powerful	rugged	exciting
quiet	rough	small	structured
mysterious	high	serene	hybrid
sculptural	neutral	harmonised	monolithic
polished	flat		

Amsterdam Academy of Architecture, 2010 - ***Graduation projects: 2009-2010*** **- Amsterdam, Architectura & Natura** *(25 projects)*

smooth	public	warm	connecting
landmark	private	static	rebellious
stacked	tense	complex	light
local	uniform	transparent	contrasting
protecting	colourful	coherent	open
revealing	traditional	contrasted	heavy
independent	experimental		

Correa F., 2009 - ***GSD Platform 2*** **- Cambridge, Actar and Harvard University Graduate School of Design** *(34 projects)*

connected	dispersed	pleasant	contemporary
efficient	engaging	familiar	modular
tensional	conceptual	rational	flexible
ecological	permeable	dynamic	temporal
ornamental	technological	organic	stable
rustic	historical	industrial	simple
rural	social	volatile	breathing
isolated	cultural	expressive	discreet
integrated	intense	unconventional	opaque

Van der Veen H., 2011 - *Archiprix International MIT Cambridge USA: the world's best graduation projects. Architecture - Urban design - Landscape architecture* - Rotterdam, 010 Publishers *(61 projects)*

intriguing	austere	graceful	futuristic
poetic	sharp	sensual	enigmatic
original	appealing	silent	fragile
innovative	harmonious	suspended	romantic
layered	sporadic	monotone	fragmented
massive	chic	extravagant	pure
relaxing			

Van der Veen H., 2007 - *Archiprix International Tongji University: the world's best graduation projects. Architecture - Urban design - Landscape architecture* - Rotterdam, 010 Publishers *(62 projects)*

vernacular	ended	conflictive	emotional
fresh	fixed	symbiotic	disappearing
crowded	spontaneous	blurred	changeable
authentic	regular	protective	narrow
temporary	succulent	noisy	prestigious
closed			

Kemper A., 2010 - *Retrospecta 2009-2010* - New Haven, Yale School of Architecture *(107 projects)*

abstract	ceremonial	tight	refined
rigid	classical	illuminating	rythmic
dissolved	monumental	eroded	functional
tactile	axial	economic	iconic
complicated	expanding	compact	clustered
interesting	confined	expansive	old
ambiguous	deployed	adaptive	architectonic
securable	varied	robust	peaceful
confused	floating	modulated	

Tatcher K., 2008 - *Retrospecta 2007-2008* - New Haven, Yale School of Architecture *(71 projects)*

aligned	generic	rigorous	surveyable
rotated	conventional	limitless	interrupted
animated	typical	timeless	positive
undulating	unconstrained	dark	furtive
suplenting	disconnected	nuanced	particular
unified	porous	dematerialized	choreographed
cantilevered	fantastic	controlled	primitive
elegant	seductive	great	introverted
spacious	shifted	incredible	

PROFESSIONALS' PROJECTS

The Architectural Review, 2010 - *The Architectural Review 2010/1 (1355)* - London, Emap *(7 projects)*

audacious	intriguing	sentimental	powerful
insensitive	raw	angled	sober
composite	delicate	complex	modest
discreet	fresh	weighted	plain
discontinuous	ornate	poised	austere
compact	smooth	autonomous	minimalist
dense	dramatic	linear	monotonous
elevated	static	free-standing	unitised
blocky shape	subtle	rigorous	faceted
vertical	basic	tense	graceful
stockade-like	sensitive	coloured	curved
fuzzy	extravagant	tranquil	angular
modern	mysterious	surreal	appealing
intense	abstract	convivial	sensuous
soft	sinuous	neutral	traditional
hard	old	hermetic	rustic
simple	artificial	enigmatic	

The Architectural Review, 2010 - *The Architectural Review 2010/2 (1356)* - London, Emap *(7 projects)*

vaulted	strong	small	sophisticated
rectangular	vernacular	colourful	dynamic
horizontal	brutalist	curious	sculptural
circular	radical	layered	modular
emerging	narrow	typical	hectic
authentic	numinous	translucent	

The Architectural Review, 2010 - *The Architectural Review 2010/3 (1357)* - London, Emap *(5 projects)*

eccentric	flexible	sharp	dark
axial	industrial	local	theatrical
conventional	intimate	ancient	orthogonal
elegant	classic	decent	ostensible
massive	infornal	dignified	unsophisticated
delight			

The Architectural Review, 2010 - *The Architectural Review 2010/4 (1358)* - London, Emap *(8 projects)*

serene	precarious	severe	open
undulating	piled	perched	rough
combinating	fine	floating	isolated
serious	fragile	ephemeral	

Domus, 2013 - *Domus/January 2013 (965)* - Milano, Editariole Domus *(5 projects)*

provocative	shimmery	suspended	organic
simplistic	enfiladed	contrasting	messy
distinguished	longitudinal	lightweight	happy

Domus, 2013 - *Domus/February 2013 (966)* - Milano, Editariole Domus *(6 projects)*

unfinished	old-fashioned	surprising	serenity
disconnecting	coherent	direct	respectful
disappearing	high	unambiguous	

4. Reduced Semantic Spaces

4.1 **Reduced Study Space**

abstract conceptual	**1**	figurative symbolic
open opening	**2**	enclosed
modern	**3**	old
new contemporary	**4**	
vertical verticality	**5**	
high	**6**	low
smooth	**7**	salient
simple	**8**	convoluted
strong	**9**	
spacious	**10**	
dynamic	**11**	
contrast opposition	**12**	
quiet	**13**	stimulating stimulus powerful
elegant	**14**	
extravagance	**15**	
original creative	**16**	traditional
conventional	**17**	unexpected
combination combined mixing hybrid	**18**	monolith
massive	**19**	
safe	20	fear
small	**21**	
iconic landmark significant emblem	**22**	
landscaped	23	
comforting	24	
playful	25	
central	26	
metaphorical	27	
serrated	28	

*Groups of synonyms-antonyms forming the Reduced **Study** Space.*

LEGEND

IN COMMON REDUCED STUDY & REFERENCE SPACES

4.2 **Reduced Reference Space**

modern contemporary	**1**	old-fashioned old classic classical ancient
massive heavy weighted	**2**	light floating
complex complicated sophisticated	**3**	simplistic unsophisticated basic simple
open porous permeable	**4**	closed hermetic
robust hard strong	**5**	fragile delicate soft
temporary volatile ephemeral temporal	6	timeless
angular angled sharp faceted	**7**	smooth
adaptive changeable flexible	8	fixed rigid
original innovative	**9**	traditional typical
dynamic animated	**10**	static
rough rugged raw unfinished	11	polished refined fine subtle
linear longitudinal	12	sinuous undulating
relaxing peaceful serene quiet silent tranquil	**13**	exciting noisy crowded hectic tensional powerful intense tense
convivial warm happy social	14	dramatic serious austere severe
pure minimalist sober	15	ornate ornamental
rigorous controlled rational	16	
varied nuanced layered contrasted	**17**	homogeneous monotonous
expanding expansive spacious deployed	**18**	confined compact dense
sensitive emotional sensual sensuous sentimental	19	insensitive brutalist
discreet furtive	**20**	eccentric extravagant
authentic	21	artificial
enigmatic mysterious curious intriguing	22	
transparent translucent	23	opaque plain
conventional	24	unconventional surprising rebellious
limitless unconstrained	25	ended
confused messy	26	structured
flat	**27**	high
composite hybrid combinating	**28**	monolithic
discontinuous fragmented interrupted	29	
vertical	**30**	horizontal

ambiguous	31	
ostensible		unambiguous
sculptural	32	
monumental		
disappearing	33	emerging
dissolved		
blurred		
narrow	34	
tight		
abstract	**35**	
conceptual		
expressive	36	neutral
elegant	**37**	rural
chic		rustic
prestigious		
organic	38	rectangular
circular		
curved		orthogonal
small	**39**	
generic	40	particular
historical	41	futuristic
rotated	42	axial
intimate	43	
introverted		
protective	44	
protecting		
stable	45	poised
		precarious
rythmic	46	
regular		
cantilevered	47	
suspended	48	
elevated	49	
perched	50	
modest	**51**	audacious
		landmark
		iconic

*Groups of synonyms-antonyms forming the Reduced **Reference** Space.*

LEGEND

IN COMMON REDUCED STUDY & REFERENCE SPACES

5. **Final Semantic Space**

VOTES	'A' side	#	'B' side	VOTES	
1	modern	1	old-fashioned	1	
6	contemporary		old	2	
1	new		classic		
			classical	5	
			ancient		
8	complex	2	simplistic		
	complicated		unsophisticated		
	sophisticated		basic		
	convoluted		simple	8	
3	robust	3	fragile		SUBSETTING
1	hard		delicate	6	
4	strong		soft	2	
2	angular	4	smooth	8	
1	angled				
5	sharp				
	faceted				
	salient				
2	original	5	traditional	7	
5	innovative		typical		
	creative				
8	dynamic	6	static	8	
	animated				
2	relaxing	7	exciting	1	SUBSETTING
3	peaceful		noisy	2	
1	serene		crowded		
	quiet		hectic	1	
1	silent		tensional	1	
1	tranquil		tense		
			powerful		
			stimulating	3	
			stimulus		
3	varied	8	homogeneous	5	
	nuanced		monotonous	3	
	layered				
	opposition				
5	contrasted				
	expanding	9	confined	2	
3	expansive		compact	6	
5	spacious		dense		
	deployed				
7	discreet	10	eccentric	1	
1	furtive		extravagant	7	
1	flat	11	high	8	
7	low				

2	composite	12	monolithic	8	
4	hybrid		monolith		
	combination				
	mixing				
2	combined				
	combinating				
8	abstract	13	figurative	3	SUPPRESSION
	conceptual		symbolic	1	
2	elegant	14	rural		SUPPRESSION
2	chic		rustic	6	
	prestigious				
8	modest	15	audacious	7	
			emblem		
			landmark		
			iconic	1	
8	small	16	large	8	
8	vertical	17	horizontal	8	
	verticality				
8	open	18	closed	6	
	permeable		hermetic		
	porous		enclosed	2	
	opening				
3	massive	19	light	8	
5	heavy		floating		
	weighted				
8	conventional	20	unconventional	3	SUPPRESSION
			surprising	2	
			rebellious	3	
			unexpected		
	unique	21	common		CREATION

Final Semantic Space, experts' votes and feedback based actions..

NOTES

The biggest numbers taken independently do not show the most chosen pair by experts.

After comments from the experts, attributes 3 and 7 has been split into two subsets of concepts in order to represent ideas that were perceived as slightly different by experts.

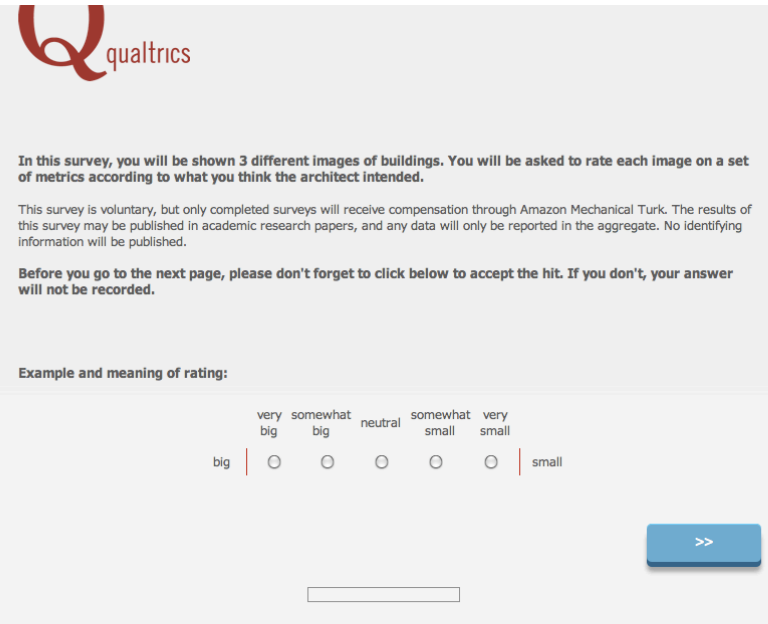
Attribute 13 has been excluded because of concerns from experts regarding to the specificity of the words and regarding to the difficult understanding.

Attribute 14 has been excluded because the left adjectives were considered as pejorative while the pair *rural-urban* wouldn't be observable in the three representation styles.

Attribute 20 has been excluded because it was considered as very close to attribute 5. In order to express to same idea, we have chosen to include a new pair, already used in another study (Oh, 1993), *unique-common.*

6. **Survey procedure example**

6.1 **Lay-people survey**



qualtrics

In this survey, you will be shown 3 different images of buildings. You will be asked to rate each image on a set of metrics according to what you think the architect intended.

This survey is voluntary, but only completed surveys will receive compensation through Amazon Mechanical Turk. The results of this survey may be published in academic research papers, and any data will only be reported in the aggregate. No identifying information will be published.

Before you go to the next page, please don't forget to click below to accept the hit. If you don't, your answer will not be recorded.

Example and meaning of rating:

	very big	somewhat big	neutral	somewhat small	very small	
big	○	○	○	○	○	small

>>

page 1

Along the following metrics, please rate what you think the architectural intent was.

	very	somewhat	neutral	somewhat	very	
stimulating	○	○	○	○	○	relaxing
static	○	○	○	○	○	dynamic
classical	○	○	○	○	○	contemporary
traditional	○	○	○	○	○	innovative
soft	○	○	○	○	○	hard
homogeneous	○	○	○	○	○	varied
noisy	○	○	○	○	○	quiet
delicate	○	○	○	○	○	robust
simple	○	○	○	○	○	complex
smooth	○	○	○	○	○	sharp

>>

page 2

qualtrics

Along the following metrics, please rate what you think the architectural intent was.

	very	somewhat	neutral	somewhat	very	
audacious	○	○	○	○	○	modest
light	○	○	○	○	○	heavy
extravagant	○	○	○	○	○	discreet
high	○	○	○	○	○	low
horizontal	○	○	○	○	○	vertical
unique	○	○	○	○	○	common
large	○	○	○	○	○	small
monolithic	○	○	○	○	○	composite
compact	○	○	○	○	○	expansive
closed	○	○	○	○	○	open

>>

page 3

qualtrics

How would you describe the clarity of this representation?

very clear	somewhat clear	neutral	somewhat unclear	very unclear
○	○	○	○	○

>>

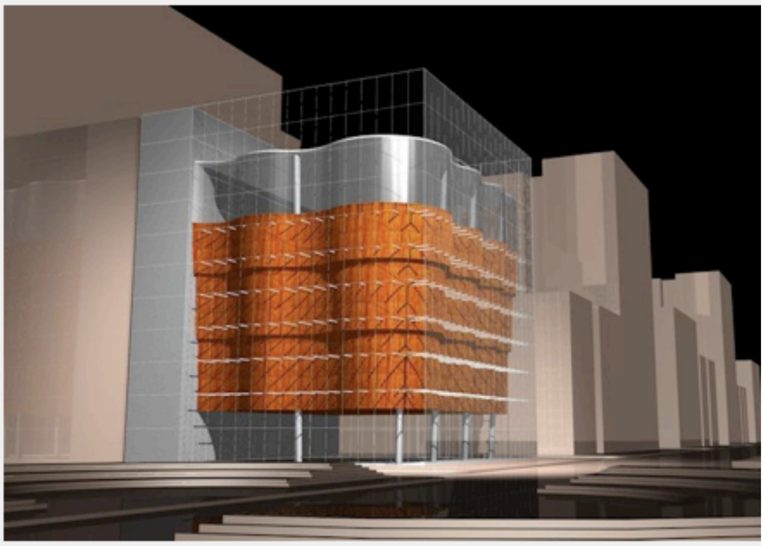
page 4

qualtrics

This project has been provided by the architectural student **Nathan Mattson**.
For additional informations, please visit his website :
http://nathanmattson.com

>>

page 5



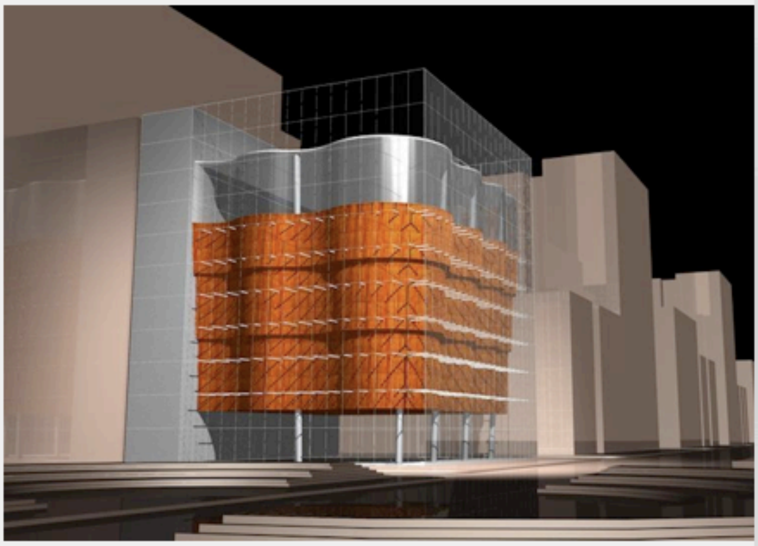
Along the following metrics, please rate what you think the architectural intent was.

	very	somewhat	neutral	somewhat	very	
noisy	○	○	○	○	○	quiet
traditional	○	○	○	○	○	innovative
classical	○	○	○	○	○	contemporary
soft	○	○	○	○	○	hard
static	○	○	○	○	○	dynamic
simple	○	○	○	○	○	complex
delicate	○	○	○	○	○	robust
smooth	○	○	○	○	○	sharp
stimulating	○	○	○	○	○	relaxing
homogeneous	○	○	○	○	○	varied

>>

page 6

qualtrics

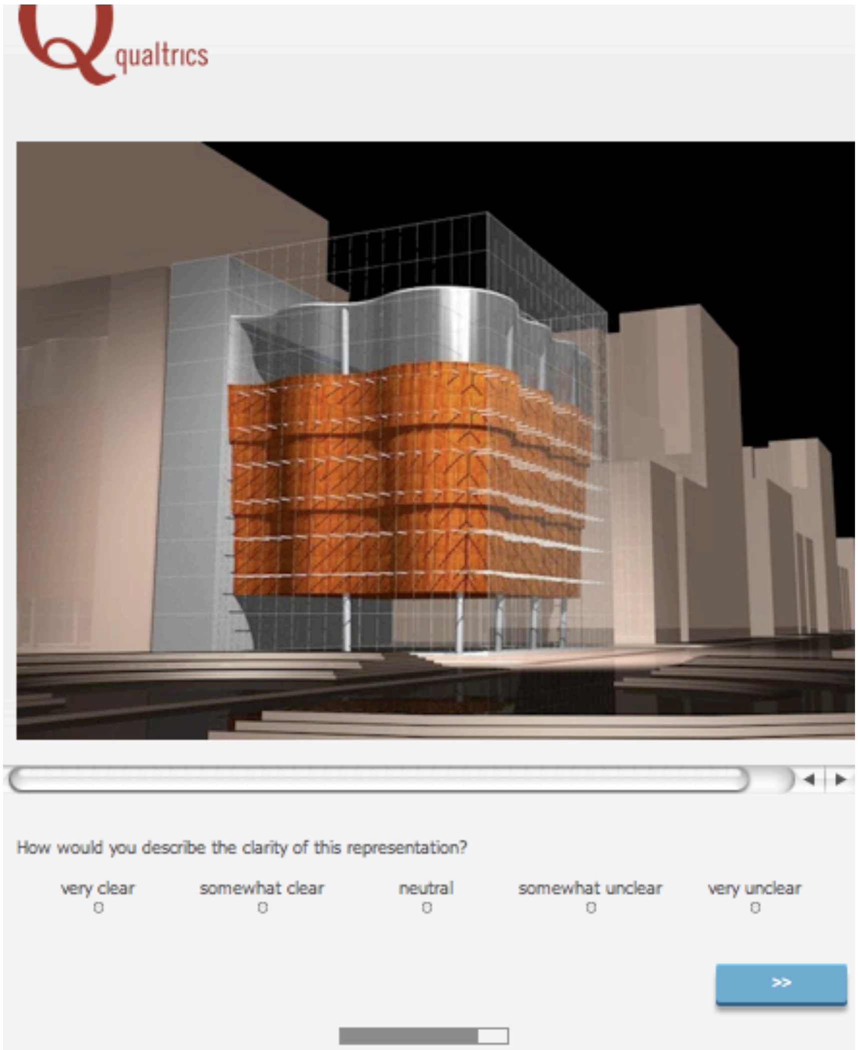


Along the following metrics, please rate what you think the architectural intent was.

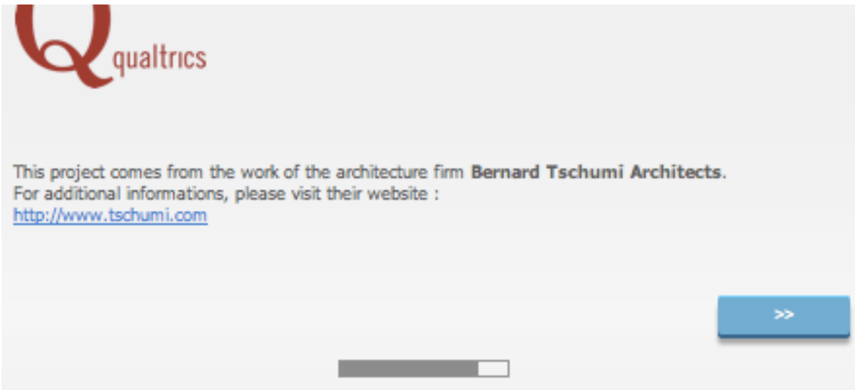
	very	somewhat	neutral	somewhat	very	
large	○	○	○	○	○	small
compact	○	○	○	○	○	expansive
closed	○	○	○	○	○	open
audacious	○	○	○	○	○	modest
unique	○	○	○	○	○	common
monolithic	○	○	○	○	○	composite
light	○	○	○	○	○	heavy
high	○	○	○	○	○	low
extravagant	○	○	○	○	○	discreet
horizontal	○	○	○	○	○	vertical

>>

page 7


qualtrics
How would you describe the clarity of this representation?
very clear
somewhat clear
neutral
somewhat unclear
very unclear
>>

page 8


qualtrics
This project comes from the work of the architecture firm **Bernard Tschumi Architects**.
For additional informations, please visit their website :
http://www.tschumi.com
>>

page 9

qualtrics

Along the following metrics, please rate what you think the architectural intent was.

	very	somewhat	neutral	somewhat	very	
classical	○	○	○	○	○	contemporary
delicate	○	○	○	○	○	robust
homogeneous	○	○	○	○	○	varied
static	○	○	○	○	○	dynamic
noisy	○	○	○	○	○	quiet
smooth	○	○	○	○	○	sharp
simple	○	○	○	○	○	complex
stimulating	○	○	○	○	○	relaxing
soft	○	○	○	○	○	hard
traditional	○	○	○	○	○	innovative

>>

page 10

qualtrics

Along the following metrics, please rate what you think the architectural intent was.

	very	somewhat	neutral	somewhat	very	
monolithic	○	○	○	○	○	composite
compact	○	○	○	○	○	expansive
horizontal	○	○	○	○	○	vertical
unique	○	○	○	○	○	common
audacious	○	○	○	○	○	modest
light	○	○	○	○	○	heavy
extravagant	○	○	○	○	○	discreet
closed	○	○	○	○	○	open
large	○	○	○	○	○	small
high	○	○	○	○	○	low

>>

page 11

qualtrics

How would you describe the clarity of this representation?

very clear	somewhat clear	neutral	somewhat unclear	very unclear
○	○	○	○	○

>>

page 12

qualtrics

This project comes from the work of architecture students **C. Carranza, S. Martin, P. Suarez and W. Casola**.
For additional informations, please visit the following website :
http://waltercasola.blogspot.com

>>

page 13

qualtrics

What is your gender?

- Male
- Female
- Prefer not to say

What is your age range?

- < 20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- < 80
- Prefer not to say

Please indicate where you live.

- North America
- South America
- Europe
- Asia
- Africa
- Oceania
- Prefer not to say

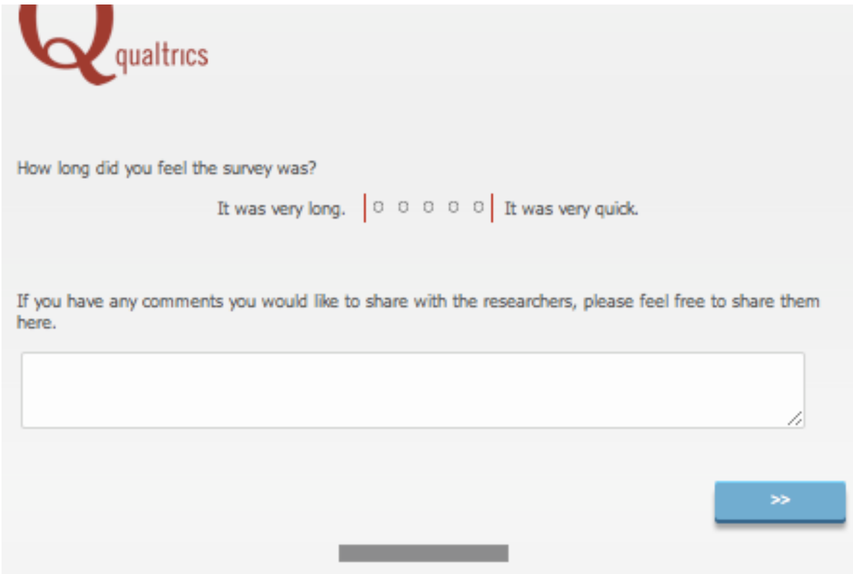
Please indicate if you have worked in or studied any of the following fields. (Multiple choices are possible)

- Architecture
- Construction
- Design (Engineering)
- Design (Industrial, Product)
- Digital art (Graphic design or Illustration)
- Traditional art
- Other
- Prefer not to say

How many years have you spent in this field?

\>>

page 14


qualtrics

How long did you feel the survey was?

It was very long. ○ ○ ○ ○ ○ It was very quick.

If you have any comments you would like to share with the researchers, please feel free to share them here.

>>

page 15

6.2 **Architect survey**

qualtrics

Few months ago, you and other architects provided us projetct's reprensations of yours. We asked around 800 lay people to rate them using a set of metrics constructed in order to catch their perceptions of your project. In this survey, you will be asked to rate each image on the same set of metrics according to what you intended. Using a unique set of metrics we will be able to compare your intents versus people's perception, depending on the representation we are showing.

This survey is voluntary. The results of this survey may be published in academic research papers, and any data will only be reported in the aggregate. No identifying information will be published.

Example and meaning of rating:

	very big	somewhat big	neutral	somewhat small	very small	
big	○	○	○	○	○	small

Which device will you use to answer this survey?

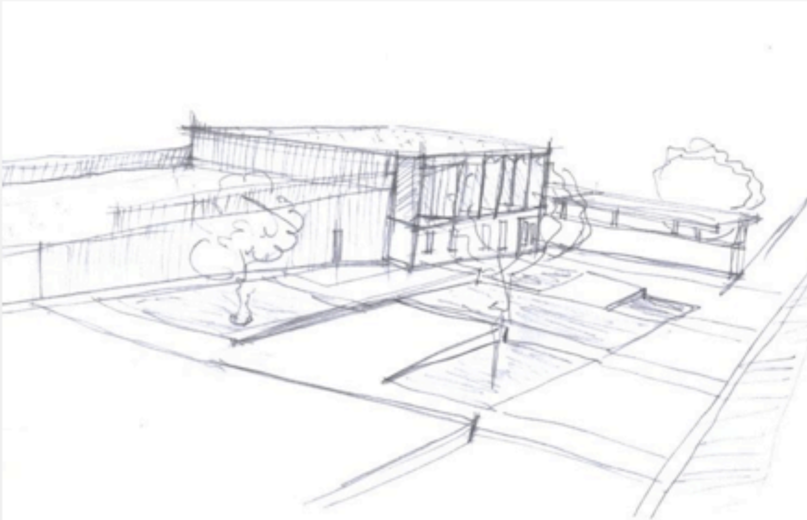
- ○ Desktop
- ○ Laptop
- ○ Tablet
- ○ Smartphone

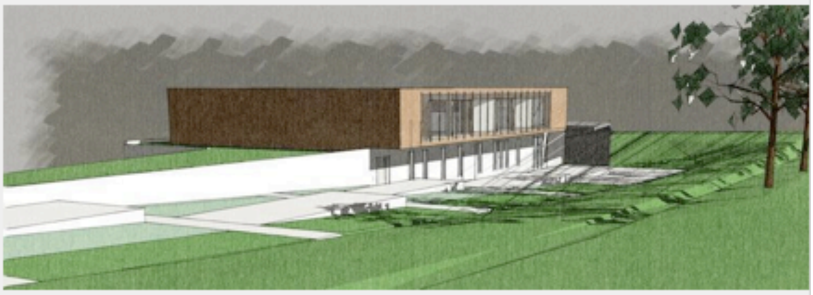
Browser Meta Info

This question will not be displayed to the recipient.
Browser: **Safari**
Version: **5.0.6**
Operating System: **Macintosh**
Screen Resolution: **1280x800**
Flash Version: **10.3.183**
Java Support: **1**
User Agent: **Mozilla/5.0 (Macintosh; Intel Mac OS X 10_5_8) AppleWebKit/534.50.2 (KHTML, like Gecko) Version/5.0.6 Safari/533.22.3**

>>

page 1





page 2 - part I

Along the following metrics, please rate what was your architectural intent in this project.
Please rate as "neutral" the concepts that were not part of your initial intent.

	very	somewhat	neutral	somewhat	very	
sharp	o	o	o	o	o	smooth
contemporary	o	o	o	o	o	classical
relaxing	o	o	o	o	o	stimulating
robust	o	o	o	o	o	delicate
complex	o	o	o	o	o	simple
varied	o	o	o	o	o	homogeneous
innovative	o	o	o	o	o	traditional
quiet	o	o	o	o	o	noisy
dynamic	o	o	o	o	o	static
hard	o	o	o	o	o	soft

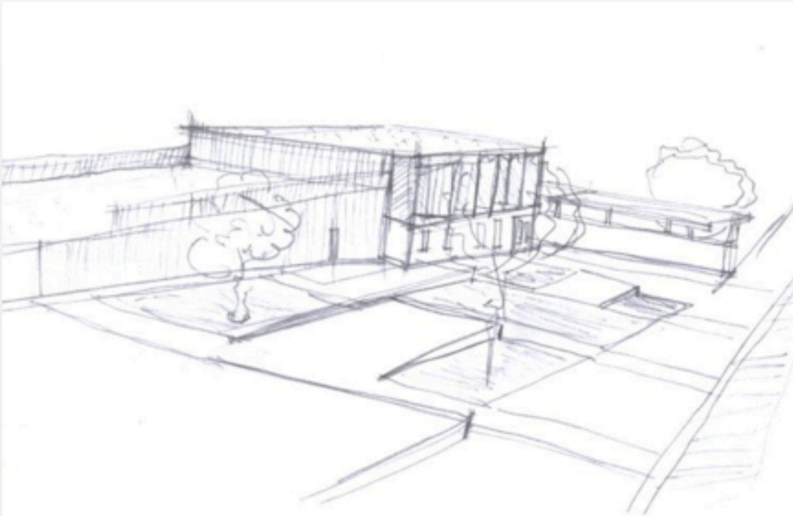
	very	somewhat	neutral	somewhat	very	
modest	o	o	o	o	o	audacious
common	o	o	o	o	o	unique
low	o	o	o	o	o	high
heavy	o	o	o	o	o	light
composite	o	o	o	o	o	monolithic
small	o	o	o	o	o	large
open	o	o	o	o	o	closed
expansive	o	o	o	o	o	compact
discreet	o	o	o	o	o	extravagant
vertical	o	o	o	o	o	horizontal

How would you describe the above representations, generally speaking, in terms of clarity of the main architectural intent?

very clear	somewhat clear	neutral	somewhat unclear	very unclear
o	o	o	o	o

>>

page 2 - part II



Along the following metrics, please rate the architectural intent you wanted to transmit through this representation. It could transfer different intent(s) than the overall project illustrated before.

	very	somewhat	neutral	somewhat	very	
complex	o	o	o	o	o	simple
innovative	o	o	o	o	o	traditional
sharp	o	o	o	o	o	smooth
hard	o	o	o	o	o	soft
relaxing	o	o	o	o	o	stimulating
robust	o	o	o	o	o	delicate
varied	o	o	o	o	o	homogeneous
contemporary	o	o	o	o	o	classical
quiet	o	o	o	o	o	noisy
dynamic	o	o	o	o	o	static

	very	somewhat	neutral	somewhat	very	
modest	o	o	o	o	o	audacious
open	o	o	o	o	o	closed
common	o	o	o	o	o	unique
vertical	o	o	o	o	o	horizontal
low	o	o	o	o	o	high
discreet	o	o	o	o	o	extravagant
composite	o	o	o	o	o	monolithic
heavy	o	o	o	o	o	light
expansive	o	o	o	o	o	compact
small	o	o	o	o	o	large

How would you describe the clarity of this representation?

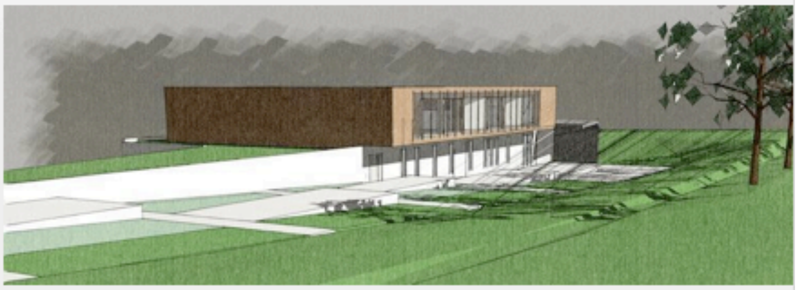
very clear	somewhat clear	neutral	somewhat unclear	very unclear
o	o	o	o	o

Could you please estimate roughly the time needed to create this image?

\>>

page 3

qualtrics



Along the following metrics, please rate the architectural intent you wanted to transmit through this representation. It could transfer different intent(s) than the overall project illustrated before.

	very	somewhat	neutral	somewhat	very	
innovative	○	○	○	○	○	traditional
dynamic	○	○	○	○	○	static
varied	○	○	○	○	○	homogeneous
relaxing	○	○	○	○	○	stimulating
quiet	○	○	○	○	○	noisy
robust	○	○	○	○	○	delicate
contemporary	○	○	○	○	○	classical
complex	○	○	○	○	○	simple
sharp	○	○	○	○	○	smooth
hard	○	○	○	○	○	soft

	very	somewhat	neutral	somewhat	very	
vertical	○	○	○	○	○	horizontal
heavy	○	○	○	○	○	light
common	○	○	○	○	○	unique
discreet	○	○	○	○	○	extravagant
composite	○	○	○	○	○	monolithic
expansive	○	○	○	○	○	compact
modest	○	○	○	○	○	audacious
open	○	○	○	○	○	closed
small	○	○	○	○	○	large
low	○	○	○	○	○	high

How would you describe the clarity of this representation?

very clear	somewhat clear	neutral	somewhat unclear	very unclear
○	○	○	○	○

Could you please estimate roughly the time needed to create this image?

>>

page 4

qualtrics

Along the following metrics, please rate the architectural intent you wanted to transmit through this representation. It could transfer different intent(s) than the overall project illustrated before.

	very	somewhat	neutral	somewhat	very	
complex	○	○	○	○	○	simple
hard	○	○	○	○	○	soft
contemporary	○	○	○	○	○	classical
quiet	○	○	○	○	○	noisy
dynamic	○	○	○	○	○	static
varied	○	○	○	○	○	homogeneous
innovative	○	○	○	○	○	traditional
relaxing	○	○	○	○	○	stimulating
sharp	○	○	○	○	○	smooth
robust	○	○	○	○	○	delicate

	very	somewhat	neutral	somewhat	very	
small	○	○	○	○	○	large
expansive	○	○	○	○	○	compact
modest	○	○	○	○	○	audacious
composite	○	○	○	○	○	monolithic
common	○	○	○	○	○	unique
heavy	○	○	○	○	○	light
low	○	○	○	○	○	high
discreet	○	○	○	○	○	extravagant
open	○	○	○	○	○	closed
vertical	○	○	○	○	○	horizontal

How would you describe the clarity of this representation?

very clear	somewhat clear	neutral	somewhat unclear	very unclear
○	○	○	○	○

Could you please estimate roughly the time needed to create this image?

>>

page 5

qualtrics

What is your gender?

- Male
- Female
- Prefer not to say

What is your age range?

- < 20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- < 80
- Prefer not to say

Please indicate where you live.

- North America
- South America
- Europe
- Asia
- Africa
- Oceania
- Prefer not to say

What is your current position?

How many years have you spent in this position?

>>

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7. **Statistical results of lay-people's perception**

7.1 **P-values table** - 1 vs 2 vs 3

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	# P w/ KW<0.05
P1	5,3E-06	4,8E-03	3,6E-01	8,1E-03	2,1E-01	1,2E-06	5,6E-02	1,8E-01	3,0E-01	2,0E-01	6,0E-06	1,2E-01	4,4E-03	2,9E-01	6,8E-04	6,5E-08	5,8E-02	1,5E-02	2,4E-01	3,5E-04	10
P2	7,1E-07	1,9E-08	1,4E-03	5,4E-01	7,5E-07	5,1E-10	2,9E-08	6,0E-06	3,8E-04	9,9E-04	9,6E-01	8,1E-11	2,6E-07	5,7E-01	2,1E-10	1,4E-03	5,5E-08	7,9E-02	3,3E-01	8,1E-06	15
P3	2,1E-02	1,1E-01	4,5E-02	2,8E-01	1,3E-02	7,9E-04	4,8E-03	2,7E-04	3,6E-06	8,9E-03	2,9E-01	4,6E-02	1,6E-01	2,2E-01	1,4E-03	3,7E-02	1,1E-01	8,6E-01	2,2E-02	1,5E-06	13
P4	4,4E-03	2,5E-01	3,4E-01	9,0E-01	3,5E-02	1,6E-06	6,2E-02	3,6E-01	4,1E-04	5,6E-01	6,5E-01	9,1E-01	3,1E-02	9,4E-01	1,3E-01	3,1E-03	5,3E-02	7,2E-01	8,0E-01	1,4E-06	7
P5	4,4E-03	2,5E-01	3,4E-01	9,0E-01	3,5E-02	1,6E-06	6,2E-02	3,6E-01	4,1E-04	5,6E-01	6,5E-01	9,1E-01	3,1E-02	9,4E-01	1,3E-01	3,1E-03	5,3E-02	7,2E-01	8,0E-01	1,4E-06	7
P6	3,0E-01	2,5E-02	2,3E-01	4,8E-01	5,8E-01	1,5E-02	2,9E-02	6,3E-01	2,0E-01	4,5E-02	5,9E-01	6,5E-01	2,3E-02	5,1E-02	7,3E-01	5,1E-01	1,2E-01	6,0E-04	8,0E-02	4,1E-05	7
P7	3,7E-04	3,5E-01	1,2E-04	9,4E-04	5,0E-04	1,3E-04	8,4E-01	8,9E-01	2,1E-02	9,5E-02	1,9E-04	7,8E-01	7,0E-03	6,6E-04	5,8E-01	5,2E-02	9,2E-10	3,6E-01	5,8E-02	1,9E-03	11
P8	7,9E-03	4,8E-03	3,2E-01	7,9E-01	9,3E-01	2,1E-05	2,8E-02	1,1E-01	3,1E-03	3,1E-01	6,6E-02	2,9E-02	1,5E-01	5,2E-01	9,8E-02	2,4E-03	2,8E-01	3,5E-05	4,6E-01	4,0E-05	9
P9	4,8E-06	2,5E-07	1,7E-02	2,3E-01	3,0E-01	9,2E-06	2,3E-04	5,3E-05	9,9E-02	1,7E-03	2,9E-02	1,6E-02	3,6E-01	7,1E-01	3,1E-02	8,1E-01	5,7E-01	3,7E-02	1,5E-03	1,4E-04	13
P10	7,8E-07	5,4E-04	1,1E-01	1,6E-01	4,5E-03	4,0E-04	1,1E-03	1,9E-01	7,7E-03	8,4E-01	7,1E-04	5,1E-05	4,7E-04	8,8E-01	2,2E-02	1,5E-08	2,5E-02	1,6E-01	5,2E-01	1,6E-02	13
P11	7,4E-01	2,2E-02	1,7E-06	6,9E-06	4,9E-03	6,0E-01	6,1E-01	1,2E-08	4,3E-12	4,3E-01	1,2E-04	7,8E-03	6,9E-02	1,4E-03	6,4E-03	2,0E-08	2,5E-01	2,8E-02	2,0E-10	3,8E-01	13
P12	1,2E-10	3,2E-08	3,6E-06	1,8E-06	9,6E-03	4,5E-13	3,5E-07	3,1E-04	1,5E-02	4,6E-03	2,1E-11	1,1E-10	4,9E-05	1,4E-02	4,8E-11	1,7E-17	6,5E-01	7,4E-04	9,2E-06	1,9E-09	19
P13	9,4E-09	1,4E-16	4,4E-01	1,1E-01	6,2E-01	2,0E-15	7,0E-13	2,8E-02	4,4E-01	6,5E-11	6,6E-07	5,5E-13	5,1E-05	7,6E-01	8,1E-09	7,2E-03	1,7E-02	4,9E-07	1,1E-01	1,8E-14	14
P14	2,1E-03	3,4E-07	2,8E-01	2,2E-01	3,3E-01	2,5E-03	1,2E-02	1,8E-03	2,6E-02	5,1E-02	1,5E-02	2,2E-03	7,6E-01	3,2E-01	2,7E-03	1,2E-02	1,4E-01	1,4E-02	1,4E-02	6,2E-02	12
P15	6,6E-06	8,7E-06	3,6E-01	3,4E-01	1,3E-02	9,6E-11	2,8E-05	2,3E-02	4,2E-03	6,9E-02	1,4E-01	9,5E-03	2,5E-03	5,1E-01	2,2E-04	9,8E-04	1,5E-03	3,2E-01	2,9E-01	2,7E-09	13
P16	1,1E-01	3,5E-02	1,4E-01	2,6E-01	1,8E-01	2,8E-03	3,9E-04	5,8E-01	6,5E-02	8,8E-03	8,6E-01	7,9E-02	2,2E-01	6,3E-01	3,7E-01	9,6E-01	8,0E-01	3,5E-01	1,2E-01	2,9E-04	5
# A w/ KW<0.05	13	12	6	4	9	15	11	8	11	7	8	10	10	3	10	12	5	8	5	14	

7.2 **P-values table** - 1 vs 2

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	# P w/ MW<0.05
P1	5,7E-05	6,0E-03	1,5E-01	1,0E-01	8,4E-01	5,6E-07	2,2E-02	3,6E-01	1,9E-01	7,1E-02	3,0E-01	8,8E-02	4,3E-01	9,8E-01	1,9E-02	6,2E-02	3,2E-01	1,4E-01	9,0E-01	6,4E-04	6
P2	1,7E-06	3,5E-07	8,0E-04	3,9E-01	6,5E-06	2,6E-08	3,4E-05	4,9E-07	3,7E-04	7,9E-04	7,4E-01	1,4E-08	2,1E-04	7,1E-01	6,8E-10	4,1E-02	5,5E-05	2,2E-02	6,1E-01	5,0E-06	16
P3	2,4E-06	3,2E-01	9,8E-02	4,2E-01	6,1E-04	5,5E-03	4,9E-02	3,7E-01	1,1E-02	8,1E-02	6,0E-01	4,4E-01	3,7E-01	6,9E-01	3,2E-01	1,3E-01	2,5E-01	5,3E-02	8,5E-01	2,8E-03	6
P4	1,1E-02	3,5E-02	2,1E-01	4,2E-01	9,2E-02	1,3E-03	1,4E-03	9,9E-02	6,2E-01	2,0E-03	2,7E-01	1,6E-01	6,6E-02	9,4E-01	2,6E-03	1,1E-02	5,8E-02	6,0E-01	4,2E-01	4,7E-06	8
P5	1,5E-03	8,5E-01	3,3E-01	9,8E-01	6,2E-01	1,4E-06	3,4E-02	5,3E-01	1,1E-02	8,7E-01	3,5E-01	7,9E-01	7,3E-02	7,1E-01	3,7E-02	1,4E-03	2,8E-02	8,8E-01	5,8E-01	2,0E-06	8
P6	9,1E-01	2,4E-02	9,8E-01	7,0E-01	8,7E-01	8,3E-03	1,2E-02	4,7E-01	2,4E-01	1,4E-02	2,8E-01	4,1E-01	1,5E-02	1,9E-02	6,6E-01	4,8E-01	5,4E-02	9,0E-02	1,9E-01	3,3E-04	7
P7	1,2E-03	3,6E-01	4,0E-03	3,0E-01	1,7E-03	3,1E-05	7,3E-01	6,4E-01	5,3E-03	3,0E-02	6,9E-05	8,3E-01	1,2E-02	1,2E-04	6,6E-01	2,8E-02	3,2E-07	4,9E-01	4,2E-02	5,0E-04	13
P8	4,1E-01	3,1E-02	6,4E-01	8,6E-01	9,3E-01	8,3E-01	1,0E+00	1,2E-01	4,6E-03	2,4E-01	7,4E-01	5,1E-01	9,3E-01	3,5E-01	9,6E-02	3,6E-01	1,1E-01	2,0E-01	9,7E-01	4,1E-01	2
P9	1,7E-04	2,5E-03	1,1E-01	7,7E-02	1,4E-01	5,5E-04	2,0E-01	1,2E-03	5,0E-02	2,0E-02	6,0E-03	4,5E-01	2,2E-01	7,8E-01	9,1E-02	5,3E-01	4,0E-01	3,3E-02	8,7E-01	1,8E-02	8
P10	2,3E-03	2,8E-01	3,3E-02	1,3E-01	4,1E-04	8,2E-05	2,4E-01	6,7E-01	1,5E-03	6,3E-01	4,0E-01	4,6E-01	1,5E-01	6,3E-01	1,7E-01	4,6E-01	8,3E-01	5,3E-02	7,5E-01	1,4E-02	6
P11	7,9E-01	5,2E-03	1,7E-02	6,4E-03	1,4E-03	3,6E-01	3,2E-01	9,8E-04	4,6E-07	2,8E-01	2,7E-04	5,0E-01	2,2E-01	6,4E-04	7,7E-02	5,2E-07	1,2E-01	2,3E-01	2,0E-08	6,4E-01	10
P12	8,8E-09	2,2E-09	2,3E-06	1,1E-07	1,6E-02	5,8E-09	2,1E-05	6,3E-05	1,4E-02	1,1E-03	4,3E-05	8,7E-08	5,0E-02	1,0E+00	5,7E-08	7,0E-12	3,4E-01	2,2E-01	5,6E-07	7,4E-07	17
P13	2,6E-07	7,1E-13	2,1E-01	7,1E-01	3,6E-01	9,8E-11	8,0E-10	3,8E-03	5,3E-01	2,6E-09	7,2E-05	1,2E-09	8,5E-04	7,6E-01	3,5E-06	3,3E-03	4,5E-03	6,5E-06	4,1E-01	5,9E-12	14
P14	1,9E-03	4,4E-07	1,1E-01	2,9E-01	1,4E-01	6,2E-04	5,7E-03	3,7E-03	1,5E-01	1,0E-01	3,8E-03	7,0E-04	5,8E-01	7,5E-01	8,5E-03	4,4E-03	9,9E-02	7,5E-01	6,6E-02	1,8E-02	10
P15	4,1E-05	4,2E-05	8,0E-01	4,7E-01	1,3E-02	8,4E-09	3,6E-05	4,4E-03	5,2E-04	3,0E-02	3,4E-01	7,9E-02	8,8E-01	7,4E-01	4,6E-03	9,4E-01	2,0E-01	9,2E-01	1,2E-01	1,3E-06	10
P16	5,7E-02	1,3E-01	6,1E-01	8,7E-01	5,2E-01	2,3E-01	2,4E-01	6,3E-01	2,4E-02	8,8E-01	6,2E-01	3,1E-01	8,5E-02	5,3E-01	3,8E-01	7,9E-01	6,1E-01	4,1E-01	2,8E-01	6,2E-01	1
# A w/ MW<0.05	12	11	5	2	7	13	10	7	10	8	6	4	5	3	8	8	4	3	3	13	

7.3 **P-values table** - 2 vs 3

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	# P w/ MW<0.05
P1	6,9E-01	9,9E-01	4,0E-01	9,4E-02	9,7E-02	1,4E-01	6,8E-01	3,7E-01	1,7E-01	5,2E-01	7,1E-05	8,6E-01	2,2E-02	1,5E-01	9,7E-02	1,1E-04	1,5E-01	6,4E-03	1,2E-01	7,2E-01	4
P2	5,5E-01	7,5E-01	4,3E-01	8,7E-01	9,9E-01	6,2E-01	3,1E-01	3,4E-01	7,3E-01	9,1E-01	9,6E-01	7,3E-01	7,5E-02	3,2E-01	5,4E-01	1,4E-01	7,7E-02	2,5E-01	1,3E-01	4,9E-01	0
P3	1,0E-02	1,4E-02	8,8E-02	5,1E-01	1,6E-04	1,6E-01	1,4E-02	1,4E-01	2,4E-02	5,7E-03	9,0E-01	5,7E-01	2,2E-01	9,3E-01	7,5E-01	2,4E-01	1,7E-01	1,9E-01	2,5E-01	4,8E-02	7
P4	9,1E-01	3,7E-01	1,8E-02	1,3E-01	4,6E-03	9,2E-01	2,3E-01	1,4E-04	4,4E-05	9,0E-02	1,3E-01	1,4E-02	4,3E-01	1,7E-01	1,2E-03	8,6E-02	7,6E-01	7,0E-01	7,0E-03	7,7E-01	7
P5	5,5E-01	2,0E-01	6,6E-01	6,8E-01	6,0E-02	3,6E-01	7,3E-01	4,3E-01	6,8E-02	4,4E-01	7,6E-01	6,7E-01	1,0E-02	9,4E-01	5,7E-01	9,6E-02	4,0E-02	5,1E-01	1,0E+00	1,5E-01	2
P6	1,9E-01	8,3E-01	1,3E-01	2,5E-01	4,3E-01	2,0E-02	4,3E-02	3,6E-01	7,4E-01	8,9E-02	5,7E-01	4,3E-01	7,7E-01	4,3E-01	4,1E-01	2,5E-01	1,1E-01	2,3E-04	2,2E-02	3,2E-05	5
P7	4,4E-01	5,9E-01	3,3E-01	1,4E-04	3,7E-01	5,9E-01	8,2E-01	8,6E-01	8,0E-02	7,1E-01	3,1E-01	6,3E-01	6,7E-01	6,4E-01	3,1E-01	9,2E-01	1,2E-01	1,7E-01	3,7E-02	2,7E-01	2
P8	2,2E-02	1,9E-01	2,5E-01	5,5E-01	7,1E-01	2,0E-05	1,2E-02	5,1E-02	7,3E-01	1,6E-01	2,4E-02	4,4E-02	7,0E-02	3,0E-01	5,0E-02	7,9E-04	8,5E-01	1,1E-05	2,7E-01	5,6E-06	9
P9	1,8E-01	2,6E-03	6,2E-03	4,9E-01	7,7E-01	1,0E-01	2,8E-03	2,9E-01	6,8E-01	2,9E-01	1,0E-01	4,4E-02	2,2E-01	5,6E-01	3,5E-01	8,2E-01	3,3E-01	8,9E-01	7,7E-04	5,0E-02	6
P10	1,1E-01	1,3E-02	3,9E-01	8,4E-02	2,7E-02	1,1E-01	2,6E-02	9,9E-02	3,4E-02	9,2E-01	5,3E-03	6,0E-04	1,2E-02	7,0E-01	1,3E-01	3,0E-06	3,8E-02	5,7E-01	2,7E-01	6,4E-01	9
P11	4,4E-01	2,6E-01	4,6E-06	7,5E-06	3,4E-01	9,1E-01	7,9E-01	3,9E-02	8,6E-02	9,4E-01	1,7E-04	1,6E-02	1,9E-02	8,9E-03	1,7E-01	3,1E-08	5,6E-01	1,9E-01	3,1E-09	3,8E-01	9
P12	8,1E-01	3,8E-03	2,0E-04	6,5E-03	6,3E-03	2,7E-01	2,5E-01	1,9E-01	6,7E-01	6,6E-02	2,5E-04	1,7E-01	3,0E-02	2,9E-02	9,0E-02	7,6E-03	5,8E-01	4,0E-04	2,5E-02	3,8E-01	10
P13	8,6E-01	9,7E-01	9,1E-01	1,7E-01	8,1E-01	2,9E-02	1,2E-01	2,0E-01	5,2E-01	3,3E-01	3,4E-01	1,4E-01	2,7E-01	6,5E-01	3,9E-02	8,7E-01	4,9E-01	3,4E-01	1,6E-01	6,4E-01	2
P14	6,9E-01	1,1E-05	5,4E-01	8,8E-02	4,4E-01	1,3E-01	2,0E-02	1,6E-03	9,9E-03	1,9E-02	1,2E-01	4,3E-02	4,9E-01	3,1E-01	1,1E-03	2,2E-01	8,4E-02	2,2E-02	4,1E-03	2,2E-01	9
P15	9,1E-01	8,5E-01	1,7E-01	1,5E-01	1,0E-02	9,3E-01	7,3E-01	4,5E-01	1,9E-01	6,1E-01	4,9E-02	2,7E-01	2,7E-03	4,4E-01	2,9E-01	2,1E-03	2,4E-02	1,8E-01	4,3E-01	3,3E-01	5
P16	7,3E-01	2,9E-01	1,8E-01	1,4E-01	3,2E-01	2,9E-02	3,0E-03	6,3E-01	6,1E-01	1,0E-02	6,4E-01	3,1E-02	2,2E-01	8,2E-01	2,0E-01	8,1E-01	5,3E-01	5,6E-01	4,0E-01	2,2E-03	5
# A w/ MW<0.05	2	5	4	3	5	4	7	3	4	3	6	7	6	2	4	6	3	5	7	5	

7.4 **P-values table** - 1 vs 3

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	# P w/ MW<0.05
P1	1,1E-05	3,4E-03	5,7E-01	2,8E-03	1,7E-01	2,3E-04	7,1E-02	6,2E-02	8,5E-01	2,8E-01	1,1E-05	6,7E-02	1,4E-03	2,0E-01	2,3E-04	2,0E-08	1,9E-02	8,4E-02	1,7E-01	5,8E-04	10
P2	2,2E-05	2,8E-07	6,0E-03	2,9E-01	4,6E-06	2,2E-08	6,6E-09	1,4E-03	1,1E-03	2,3E-03	8,8E-01	1,6E-09	1,4E-07	4,6E-01	1,7E-07	4,2E-04	5,1E-08	2,9E-01	3,7E-01	2,6E-04	15
P3	2,8E-02	1,5E-01	9,1E-01	9,4E-01	5,5E-01	8,6E-02	5,2E-01	2,2E-02	5,4E-07	2,5E-01	4,5E-01	2,8E-01	1,3E-02	6,0E-01	5,0E-01	6,0E-01	1,5E-03	5,6E-01	2,6E-01	1,5E-01	5
P4	2,5E-02	2,1E-01	1,6E-01	3,6E-01	1,4E-01	1,0E-03	3,4E-02	7,1E-03	7,9E-06	1,7E-01	6,7E-01	2,7E-01	2,0E-01	1,1E-01	6,9E-01	4,2E-01	8,9E-02	8,5E-01	6,4E-02	1,6E-05	6
P5	1,9E-02	1,1E-01	1,5E-01	6,9E-01	1,1E-02	1,6E-04	5,3E-02	1,5E-01	2,2E-04	2,9E-01	5,6E-01	8,2E-01	4,3E-01	8,1E-01	2,3E-01	4,0E-02	9,4E-01	4,7E-01	5,5E-01	1,4E-04	6
P6	1,7E-01	1,5E-02	1,6E-01	4,0E-01	3,3E-01	7,0E-01	6,3E-01	8,4E-01	6,5E-02	5,1E-01	7,0E-01	9,4E-01	2,1E-02	9,1E-02	7,6E-01	6,6E-01	7,0E-01	1,6E-02	4,5E-01	8,8E-01	3
P7	3,9E-04	1,5E-01	2,0E-05	2,2E-02	4,2E-04	2,2E-03	5,4E-01	7,6E-01	4,1E-01	1,3E-01	3,0E-03	4,9E-01	3,5E-03	6,4E-03	5,4E-01	4,2E-02	8,0E-09	4,0E-01	9,8E-01	2,0E-02	11
P8	2,1E-03	2,3E-03	1,6E-01	5,5E-01	8,0E-01	1,3E-05	2,6E-02	4,7E-01	2,4E-03	8,5E-01	8,3E-02	1,0E-02	1,1E-01	8,5E-01	6,5E-01	1,3E-02	2,7E-01	1,3E-03	2,9E-01	1,6E-04	9
P9	8,4E-06	1,2E-07	1,3E-01	3,6E-01	2,5E-01	8,5E-06	1,1E-04	3,0E-05	8,9E-02	3,7E-04	4,4E-01	4,8E-03	9,5E-01	4,3E-01	9,9E-03	6,9E-01	9,4E-01	2,1E-02	4,4E-03	3,4E-05	11
P10	4,0E-08	1,1E-04	2,3E-01	6,6E-01	9,1E-01	1,8E-02	2,1E-04	1,6E-01	5,3E-01	5,9E-01	3,2E-04	4,0E-05	1,5E-04	8,9E-01	7,7E-03	1,8E-08	1,0E-02	2,2E-01	4,2E-01	1,2E-02	11
P11	6,1E-01	1,3E-01	1,3E-04	2,8E-03	4,0E-02	4,3E-01	5,2E-01	4,0E-10	3,9E-12	2,5E-01	9,7E-01	4,1E-03	3,0E-01	2,5E-01	1,6E-03	7,2E-01	2,4E-01	6,2E-03	4,2E-02	1,7E-01	9
P12	3,0E-08	4,7E-03	4,5E-01	4,8E-02	5,2E-01	2,4E-10	6,8E-07	1,2E-02	9,9E-03	1,6E-01	1,4E-11	1,1E-09	2,6E-06	4,0E-03	5,8E-10	6,2E-15	7,3E-01	5,8E-03	3,1E-02	6,0E-08	16
P13	2,3E-07	8,5E-14	3,4E-01	3,1E-02	4,7E-01	5,8E-13	5,8E-11	3,4E-01	2,0E-01	8,3E-09	4,1E-07	3,6E-11	3,3E-05	4,8E-01	4,4E-08	1,4E-02	5,2E-02	2,8E-06	4,5E-02	8,5E-11	14
P14	4,1E-03	7,6E-01	3,6E-01	4,8E-01	4,7E-01	5,2E-02	6,9E-01	4,1E-01	1,5E-01	4,1E-01	1,9E-01	1,0E-01	8,7E-01	1,3E-01	7,8E-01	5,9E-02	9,7E-01	6,4E-03	3,2E-01	2,8E-01	2
P15	1,9E-05	3,2E-05	2,7E-01	4,3E-01	6,2E-01	6,9E-09	2,6E-04	1,1E-01	1,0E-01	8,4E-02	2,9E-01	2,0E-03	2,7E-03	2,5E-01	9,0E-05	7,4E-04	3,4E-04	1,9E-01	4,6E-01	1,2E-08	10
P16	9,2E-02	1,1E-02	5,0E-02	1,7E-01	5,4E-02	7,5E-04	2,4E-04	2,8E-01	9,8E-02	5,5E-03	9,9E-01	1,6E-01	7,9E-01	3,4E-01	4,5E-01	9,9E-01	8,4E-01	1,5E-01	3,4E-02	1,1E-04	7
# A w/ MW<0.05	13	10	4	5	4	12	9	6	7	4	5	8	9	2	8	9	6	7	5	12	

7.5 **Q-values table** - Hand-drawing

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	AVG
P1	1,00	0,19	0,15	0,38	0,48	0,43	0,70	0,69	0,60	0,36	0,67	0,40	0,03	0,82	0,32	0,32	0,12	0,82	0,35	0,85	0,48
P2	0,61	0,40	0,36	0,37	0,75	0,88	0,70	0,43	0,43	0,71	0,26	0,43	0,27	0,56	0,50	0,06	0,39	1,00	0,62	0,89	0,53
P3	0,55	0,29	0,54	0,59	0,67	0,19	0,32	0,56	0,52	0,29	0,78	0,20	0,13	0,30	0,07	0,93	0,23	0,46	0,81	0,18	0,43
P4	0,38	0,42	0,13	0,15	0,06	0,48	0,48	0,15	0,18	0,23	0,27	0,55	0,48	0,53	0,74	0,19	0,76	0,31	0,52	1,00	0,40
P5	0,24	0,60	0,65	0,93	0,57	0,48	0,30	0,87	0,90	0,38	0,48	0,78	0,24	0,47	0,73	0,32	0,10	0,34	0,74	0,55	0,53
P6	0,19	0,56	0,12	0,21	0,21	0,18	0,41	0,43	0,85	0,46	0,89	0,52	0,93	0,53	0,57	0,17	0,67	0,48	0,86	0,22	0,47
P7	0,80	0,55	0,87	0,87	1,00	0,71	0,59	0,59	0,75	0,44	0,88	0,58	0,80	0,41	0,80	0,67	0,79	0,43	0,69	0,65	0,69
P8	0,03	0,23	0,06	0,26	0,06	0,03	0,28	0,03	0,06	0,06	0,94	0,00	0,15	0,67	0,00	0,10	0,33	0,35	0,43	0,03	0,20
P9	0,70	0,89	0,55	0,46	0,74	0,62	0,34	0,83	0,39	0,63	0,44	0,16	0,28	0,82	0,42	0,15	0,72	0,34	0,67	0,28	0,52
P10	0,71	0,17	0,76	0,40	0,77	0,86	0,65	0,43	0,69	0,63	0,35	0,32	0,94	0,47	0,47	0,63	0,88	0,81	1,00	0,81	0,64
P11	0,06	0,60	0,81	0,43	0,10	0,10	0,32	0,10	0,19	0,70	0,88	0,31	0,43	0,60	0,26	0,52	0,21	0,47	0,50	0,11	0,39
P12	0,88	0,61	0,16	0,22	0,21	0,42	0,13	0,89	0,55	0,52	0,26	0,65	0,33	0,33	0,88	0,24	0,17	0,83	0,19	0,21	0,43
P13	0,53	0,15	0,20	0,16	0,35	0,42	0,24	0,30	0,55	0,30	0,36	0,44	0,18	0,67	0,59	0,88	0,10	0,40	0,67	0,31	0,39
P14	0,50	0,60	0,30	0,19	0,21	0,50	0,35	0,21	0,37	0,32	0,42	0,73	0,23	0,77	0,61	0,82	0,14	0,82	0,94	0,20	0,46
P15	0,50	0,52	0,67	0,43	0,42	0,56	0,68	0,93	0,39	0,56	0,74	0,83	0,33	0,50	0,94	0,55	0,15	0,62	0,26	1,00	0,58
P16	0,84	0,31	0,29	0,41	0,50	0,57	0,52	0,53	0,47	0,38	0,77	0,43	0,30	0,71	0,33	0,27	0,13	1,00	0,67	0,48	0,50
AVG	0,53	0,44	0,41	0,40	0,44	0,46	0,44	0,50	0,49	0,44	0,59	0,46	0,38	0,57	0,51	0,43	0,37	0,59	0,62	0,48	

7.6 **Q-values table** - CAD model

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	AVG
P1	0,12	0,79	0,06	0,15	0,29	0,10	0,48	0,89	0,40	0,94	0,78	0,82	0,11	0,81	0,88	0,19	0,10	0,68	0,30	0,24	0,46
P2	0,05	0,15	0,06	0,52	0,09	0,03	0,30	0,19	0,32	0,20	0,41	0,12	0,03	0,55	0,03	0,09	0,06	0,36	1,00	0,03	0,23
P3	0,18	0,44	0,29	0,39	0,21	0,86	1,00	0,36	0,19	0,79	0,95	0,10	0,18	0,48	0,09	0,47	0,26	0,61	0,88	0,86	0,48
P4	0,16	0,10	0,09	0,20	0,06	0,09	0,15	0,16	0,21	0,12	0,10	0,18	0,88	0,65	0,15	0,06	0,36	0,22	0,33	0,03	0,21
P5	0,06	0,52	0,50	0,88	0,54	0,00	0,16	0,71	0,21	0,48	0,30	0,89	0,08	0,72	0,35	0,14	0,02	0,25	0,52	0,02	0,37
P6	0,18	0,58	0,09	0,27	0,17	0,45	0,80	0,58	0,71	0,75	0,48	0,83	0,27	0,56	0,68	0,09	0,65	0,81	0,41	0,94	0,52
P7	0,17	0,54	0,33	0,47	0,21	0,16	0,85	0,64	0,23	0,67	0,14	0,53	0,35	0,25	0,80	0,45	0,08	0,41	0,29	0,14	0,38
P8	0,03	0,03	0,03	0,16	0,03	0,00	0,06	0,13	0,28	0,06	0,89	0,03	0,09	0,88	0,09	0,14	0,25	0,65	0,24	0,05	0,21
P9	0,08	0,24	0,36	0,24	0,42	0,08	0,17	0,21	0,19	0,27	0,14	0,15	0,38	0,56	0,26	0,11	0,94	0,21	0,70	0,14	0,29
P10	0,38	0,44	0,22	0,33	0,13	0,20	0,89	0,76	0,22	0,94	0,61	0,56	0,61	0,50	1,00	0,79	0,83	0,57	0,81	0,42	0,56
P11	0,15	0,36	0,42	0,21	0,08	0,16	0,76	0,59	0,23	0,87	0,16	0,38	0,78	0,18	0,61	0,03	0,17	0,94	0,06	0,06	0,36
P12	0,05	0,00	0,59	0,24	0,74	0,02	0,05	0,08	0,57	0,09	0,50	0,02	0,79	0,48	0,10	0,08	0,79	0,77	0,31	0,02	0,31
P13	0,03	0,08	0,23	0,50	0,26	0,05	0,14	0,21	0,40	0,12	0,34	0,03	0,64	0,69	0,09	0,09	0,47	0,18	0,72	0,02	0,26
P14	0,08	0,03	0,10	0,10	0,64	0,00	0,09	0,08	0,28	0,07	0,60	0,17	0,32	0,94	0,19	0,14	0,48	0,88	0,28	0,17	0,28
P15	0,31	0,34	0,83	0,42	0,68	0,11	0,13	0,23	0,48	0,70	0,50	0,61	0,25	0,68	0,28	0,56	0,27	0,76	0,76	0,06	0,45
P16	0,42	0,61	0,44	0,35	0,71	0,94	0,74	0,50	0,22	0,48	0,59	0,38	0,28	0,93	0,46	0,39	0,21	0,74	0,89	0,74	0,55
AVG	0,15	0,33	0,29	0,34	0,33	0,20	0,42	0,40	0,32	0,47	0,47	0,36	0,38	0,62	0,38	0,24	0,37	0,57	0,53	0,25	

7.7 **Q-values table** - Rendering

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	AVG
P1	0,11	0,70	0,13	0,09	0,90	0,28	0,76	0,54	0,76	0,59	0,15	0,94	0,48	0,38	0,42	0,00	0,10	0,46	0,30	0,29	0,42
P2	0,03	0,16	0,09	0,31	0,08	0,08	0,03	0,50	0,41	0,31	0,59	0,06	0,02	1,00	0,16	0,03	0,05	0,68	0,45	0,16	0,26
P3	0,67	0,14	0,70	0,59	0,89	0,50	0,29	0,25	0,02	0,16	0,94	0,23	0,02	0,52	0,16	0,67	0,04	0,82	0,58	0,39	0,43
P4	0,27	0,28	0,36	0,36	0,38	0,13	0,23	0,83	0,56	0,25	0,33	1,00	0,84	0,30	0,89	0,18	0,41	0,24	0,75	0,11	0,44
P5	0,10	0,23	0,35	0,78	0,25	0,06	0,06	0,50	0,13	0,82	0,39	0,62	0,28	0,68	0,55	0,10	0,14	0,26	0,44	0,05	0,34
P6	0,15	0,58	0,22	0,44	0,34	0,21	0,48	0,46	0,40	0,68	0,65	0,50	0,42	0,93	0,39	0,26	0,71	0,17	0,85	0,13	0,45
P7	0,19	0,36	0,11	0,25	0,20	0,39	1,00	0,60	0,60	0,89	0,30	0,79	0,29	0,55	0,88	0,57	0,08	0,76	0,70	0,24	0,49
P8	0,00	0,05	0,21	0,33	0,09	0,03	0,00	0,16	0,36	0,03	0,27	0,00	0,10	0,63	0,09	0,00	0,32	0,03	0,68	0,00	0,17
P9	0,08	0,05	0,82	0,54	0,48	0,08	0,05	0,16	0,17	0,09	0,40	0,05	0,26	0,50	0,16	0,11	0,55	0,21	0,31	0,10	0,26
P10	0,03	0,75	0,52	0,75	0,95	0,46	0,24	0,42	1,00	0,94	0,52	0,38	0,19	0,47	0,62	0,05	0,28	0,86	0,65	0,30	0,52
P11	0,13	0,70	0,19	0,41	0,15	0,16	0,71	0,13	0,00	0,88	0,74	0,78	0,19	0,79	0,94	0,57	0,10	0,57	0,58	0,18	0,44
P12	0,05	0,25	0,30	0,94	0,23	0,00	0,03	0,35	0,63	0,23	0,05	0,00	0,19	0,47	0,05	0,00	0,71	0,15	0,89	0,00	0,28
P13	0,05	0,03	0,36	0,89	0,29	0,03	0,11	0,48	0,31	0,12	0,14	0,03	0,45	0,93	0,03	0,20	0,43	0,19	0,71	0,08	0,29
P14	0,03	0,68	0,16	0,36	0,39	0,13	0,38	0,50	0,87	0,55	0,83	0,30	0,23	0,57	0,55	0,20	0,18	0,33	0,78	0,21	0,41
P15	0,21	0,36	0,94	0,65	0,50	0,11	0,23	0,50	0,94	0,68	0,84	0,26	0,81	1,00	0,10	0,10	0,67	0,88	0,45	0,05	0,52
P16	0,35	0,94	0,65	0,88	0,78	0,38	0,23	0,30	0,32	0,83	0,57	0,92	0,27	0,71	0,61	0,30	0,15	0,50	0,52	0,32	0,53
AVG	0,15	0,39	0,38	0,54	0,43	0,19	0,30	0,42	0,47	0,50	0,48	0,43	0,32	0,65	0,41	0,21	0,31	0,45	0,60	0,16	

8. **Statistical results of architects‘ intents**

8.1 **Correlation intent-perception** - Hand-drawing

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	TOT
P1	1	1	-	0	1	0	0	0	0	1	0	-	1	0	0	0	1	0	0	1	7
P2	1	0	-	-	1	1	1	-	-	0	-	-	-	0	0	-	1	1	0	-	6
P3	0	1	-	0	0	-	0	0	1	1	0	0	-	-	-	-	1	1	0	-	5
P4	1	0	-	0	0	1	1	0	0	0	1	0	1	-	0	-	-	1	-	0	6
P5	1	-	1	0	1	0	1	0	1	0	-	0	1	-	-	-	1	0	1	1	9
P6	1	0	0	-	-	1	1	0	0	1	-	1	-	1	1	-	-	1	1	1	10
TOT	5	2	1	0	3	3	4	0	2	3	1	1	3	1	1	0	4	4	2	3	

1 = correspondence of lay-people’s perception and architect’s intent
0 = no correspondence of lay-people’s perception and architect’s intent
- = not intended by the architect

8.2 **Correlation intent-perception** - CAD model

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	TOT
P1	1	1	-	1	1	1	1	0	0	0	0	-	1	0	0	1	1	0	0	1	10
P2	1	1	-	-	1	1	1	-	-	1	-	-	-	0	1	-	1	1	1	-	10
P3	1	1	-	0	0	-	0	1	1	1	0	1	-	-	-	-	1	0	0	-	7
P4	1	0	-	0	0	1	1	0	0	0	1	0	1	-	0	-	-	1	-	1	7
P5	1	-	1	0	1	0	1	0	1	0	-	0	1	-	-	-	1	0	1	1	9
P6	1	1	0	-	-	1	0	0	0	0	-	0	-	0	1	-	-	0	0	1	5
TOT	6	4	1	1	3	4	4	1	2	2	1	1	3	0	2	1	4	2	2	4	

8.3 **Correlation intent-perception** - Rendering

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	TOT
P1	1	1	-	1	1	1	0	1	1	1	0	-	1	0	1	1	1	0	0	1	13
P2	1	1	-	-	1	1	1	-	-	1	-	-	-	0	1	-	1	0	0	-	8
P3	1	1	-	0	0	-	0	1	1	1	0	1	-	-	-	-	1	1	0	-	8
P4	1	0	-	0	0	1	1	1	1	0	1	0	1	-	0	-	-	1	-	1	9
P5	1	-	1	0	1	0	1	0	1	0	-	0	1	-	-	-	1	0	0	1	8
P6	1	1	0	-	-	1	1	0	0	1	-	1	-	0	1	-	-	1	1	1	10
TOT	6	4	1	1	3	4	4	3	4	4	1	2	3	0	3	1	4	3	1	4	