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Do Professionals with Different Backgrounds Use Distinct Thinking Styles When Designing a Product?

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A thinking style refers to a person's preferred way to process and react to different situations. Since they have an impact on performance and should be viewed as fluid, some environments may benefit from specific thinking styles to optimize results and the use of resources. In this paper we present a study indicating which thinking style professionals with different backgrounds (engineers, designers, and architects) favour when designing a product. For that, we used the Concept Design Thinking Style Inventory (CD-TSI). Results showed that engineers favour the *conditional* thinking style (accepting opinions from others without questioning them), designers prefer the *exploring* style (seeking for options and differentiation), while both designers and architects lean towards the *creative* style (thinking in parts to get to the whole concept). Contributions in this study are threefold. First, we associate thinking styles to groups of professionals. Second, we discuss them in relation to decision-making processes (rationality and intuition). Third, we associate them to product design stages.

Keywords: design thinking styles; product design; decision-making; concept design thinking style inventory.

1 Introduction

Product design is a time-consuming, resource demanding activity, which may be performed in a variety of ways according to the desired result (Tortorella, Marodin, Fetterman, & Fogliatto, 2016). Aligning thinking styles of those involved in the design activity with the intended goal is key to optimize the use of both material and human resources in the process of product development. A previous research due to Rosa, Brust-Renck, and Tonetto (2016) used the Rational-Experiential Inventory (REI) questionnaire to evaluate differences in the product design decision-making process across professionals from different backgrounds; namely, designers, engineers, and architects. The study indicates that those professionals may adopt one of two approaches for decision-making in their projects: intuition and rationality. While intuition is emotion-driven and configures in a faster, automatic decision system, rationality is logical and operates through rules of reasoning, not being directly influenced by emotions or personal preferences (Kahneman, 2003). In a design project, the decision-making approach identifies professionals that rely more on both past experiences (intuition[1]) and the ability to reason about a theme (rationality). Two questions remain: (i) what makes one rely on intuition or rationality, and (ii) are there other more sensitive styles that define how product designers think.

In this paper we extend the research in Rosa et al. (2016). While still focusing on the decision-making process of architects, designers, and engineers, we investigate five thinking styles that these professionals may favor when performing different tasks in a designing process; they are: *conditional*, *inquiring*, *exploring*, *independent*, and *creative*. Thinking styles are explored using the Concept Design Thinking Style Inventory (CD-TSI) (Volpentesta, Ammirato, & Sofo, 2009), which define three aspects of the product design process and behaviours of those involved in it (in addition to the five thinking styles mentioned above); namely: (i) stages of a design process, (ii) approach of designers to collaboration, and (iii) personal way of designing.

Since a designer's profession is usually associated with intuition (Tonetto & Tamminen, 2015), we test the hypothesis that when designers engage in product development, the *exploring* and *creative* thinking styles will be predominant if compared to other professionals (i.e. architects and engineers), who may be more rational and might relate more to other thinking styles. Testing our main hypothesis we were able to attain a secondary objective, which is to gain knowledge on how engineers and architects make decisions when designing a product (whether they are more rational and may rely more on *conditional* and *inquiring* styles, for example, or are also relying on intuition and, therefore, more emotion-driven thinking styles). Finally, thinking styles of professionals with different backgrounds are related to stages of the design process.

There are three important contributions in this study. First, we associate thinking styles to groups of professionals. Second, we associate thinking styles to dual process approaches to decision-making, and investigate what are the best styles to tackle inherent uncertainties that arise in each stage of product design. Finally, we associate thinking styles to product design stages, and set guidelines to recruit teams of professionals to perform each phase.

The remaining sections of the paper are organized as follows. In section 2 we review the literature on the five types of design thinking and their association to decision-making process approaches. In section 3 we present our research methods, emphasizing on the CD-TSI questionnaire. Results are presented in section 4, and discussed in section 5. We close the paper with a conclusions section.

2 Design Thinking Styles and Decision-Making

2.1 Thinking Styles

Let us start by properly defining thinking styles and explaining how they may be applied in a design context. According to Sofo (2005), the theory of reality construction describes a thinking style as one's preferred way to interpret the world. It is an individual or shared way to process, acknowledge, and use information. A thinking style may be characterized as a mental strategy – that may be conscious, semi-conscious, or unconscious – to optimize the use of personal resources while dealing with environments (Sofo, 2005).

In life's everyday management, people tend to choose the way that feels more comfortable in terms of thinking styles. Zhang and Sternberg (2005) point out that people may be flexible when choosing those styles. They will most likely align the style with their way of thinking when confronted with particular demands and situations, in search of a favourable outcome (Sternberg & Grigorenko,

[1] In our study, experientiality (Volpentesta, Ammirato & Sofo, 2009) and intuition (Kahneman, 2003) are used as synonyms.

1993). As important as acknowledging that people may have a preferred thinking style is to recognize that it may change or be developed as response to a given environment. Thinking styles should be viewed as fluid (Sternberg, 1997; Zhang & Sternberg, 2005), responding to different contexts and evolving according to one's experiences. No thinking style is better than others; they are just different and may be better suited to specific situations (Sternberg & Grigorenko, 1993).

Thinking styles have impact on performance (Sofo, 2005; Volpentesta, Ammirato, & Sofo, 2009). The benefits of identifying and analysing thinking styles come precisely from the optimization they may promote in the use of one's personal resources, enabling the achievement of goals in a more efficient and effective way when dealing with different contexts and information. Such flexibility in adjusting thinking styles to different environments may lead to intensified success (Sofo, 2005). That corroborates with Sternberg (1997), who states that half of one's performance is determined by her intelligence and ability, while the other half depends on her thinking style preferences.

Sofo (2005) structured a theory of reality in which five styles of thinking are proposed; they are listed in Table 1. Such styles "refer to how a person likes to accept, make sense of, and react to information, people and tasks" (Volpentesta, Ammirato, & Sofo, 2009, p.788). They are also in agreement with a variety of style definitions available in the literature (Volpentesta, Ammirato, & Sofo, 2009; Zhang, 2002; Zhang & Sternberg, 2005).

As people apply thinking styles to every domain of life, they may affect work performance and the use of intellectual and creative abilities (Sofo, 2005). The design domain is of particular interest here. Since thinking styles lead to different ways of dealing with information, the use of one style or another may impact differently on the design process.

Volpentesta, Ammirato, and Sofo (2009) have developed a Concept Design Thinking Style Inventory with five thinking styles. The *conditional* style relies on proven models and solutions, and may be important to ensure convergence in a design process. The *inquiring* style may help designers to gather information from different professionals or sources involved in the project, providing answers to their questionings during the process. The *exploring* style is often associated with innovation, that is, the search for different and alternative solutions that may increase the project's potential of achieving new results. In a different perspective, the *independent* style may lead to a more individualized design process, since the priority is one's own insights and views. Finally, the *creative* style may be associated to the designer's need to envision many different solutions for a task. In this last case, the design process should generate a variety of alternatives enabling the designer to get a sense of the bigger picture.

2.2 Thinking Styles and Decision-Making

Decision-making is a daily challenge that demands complex cognitive processing. Judgment and decision-making are processes that comprise the evaluation (judgment) of available choices and their expected outcomes, as well as the decision itself (Tversky & Kahneman, 1981).

Cognitive psychology has been exploring how people make decisions in real life (Kahneman, 2003). Academics in this field consider the human mind as not purely rational, but bounded in rationality, since people have limitations to process information and make decisions.

Herbert Simon stated that design is an artificial science, since it is aimed at designing artefacts that are not natural to change current life situations (Simon, 1981). According to the author, people make decisions approximately; they evaluate their choices and, when they find an alternative that is close enough to their imagined criteria, they tend to make a decision. All decisions, in this sense, would be partial, biased, limited, and approximate to what is 'good enough', not necessarily excellent.

Simon and other researchers, including Kahneman (2003), have been investigating how the human mind makes decisions, dealing with incomplete information. The information needed to make perfectly informed decisions is not usually available, but people still making choices. In this research context, the concept of bounded rationality was established.

Moving a step further, we analyse Sofo (2005)'s thinking styles in the light of Simon (1981)'s concept of bounded rationality as it applies to decision-making. According to Simon's view, only in trivial situations human beings are able to follow optimization logic and reach the ideal decision (Simon, 1981; Kahneman, 2003). When product designers are faced with real life work situations, they are bounded by the limits of projective instruments, which are unable to compute all possible worlds, and have to settle for a decision within the limits of their own rationality. In other words, in an optimal scenario they would not be able to recognize an optimal solution even if it presented itself in early phases of the product design process, since that would require comparison with all other possible alternatives (Simon, 1981), which are not available given that product designers do not have the tools to generate them all.

Instead, when looking for an (close to) optimal solution, product designers (as decision makers in general) often rely on two types of cognitive processes: intuition and rationality (for a review, see Kahneman, 2013; Stanovich & West, 2000). Research on dual processes of decision-making build on and go beyond Simon's work, suggesting that decisions are driven by either intuition (or experientiality) or rational (deliberative) analysis. According to this traditional view of dual processes, decisions, such as those relevant to product design, may be intuitive – which are fast, automatic, effortless, associative, and charged with emotion – or may be driven by deliberative reasoning, which is a slow, controlled, flexible, and effort-demanding process. Therefore, whereas the intuitive process is responsible for generating first impressions (involuntarily and nonverbally explicit) of perceptions and thoughts, rational processes involve intentional and explicit approaches.

To be intuitive, professionals usually rely on heuristic processes. They are grounded on a principle of attribute substitution: "The essence of attribute substitution is that respondents offer a reasonable answer to a question that they have not been asked. An alternative interpretation that must be considered is that the respondents' judgments reflect their understanding of the question that was posed" (Kahneman, 2003, p.709). Therefore, intuition and heuristic processing may be useful to deal with scenarios of uncertainty that different professionals face in many design problems.

Rosa et al. (2016)'s results using the Rational-Experiential Inventory (REI) questionnaire indicate that engineers are more likely to rely on analytical reasoning (rationality) while architects favour an intuitive approach (experientiality). Designers did not show a significant difference when compared to the other two groups of professionals; on the contrary, their rationality scores were positioned between those of engineers and architects, pointing to a balance between thinking styles, suggesting that they rely both on rationality and experientiality. Someone may deliberately use intuitive thinking in a designing situation in which there is not sufficient time or information to adopt a rational approach (having in mind that, in our exposition, rationality is not viewed as the opposite of intuition).

We now propose an association between the five thinking styles presented earlier and the dual processes of decision-making. Design essentially deals with the proposition of artefacts that not yet exist and solutions to problems not yet solved, and the discipline is usually associated with creativity and innovation (Tonetto & Tamminem, 2015). With that in mind, we propose that *exploring* and *creative* thinking styles could be associated with *intuition*. The same association should also be valid for the *independent* style, since relying on one's own thinking may be connected to well-developed skills, rather than the search for new and usable information. The remaining styles, *inquiring* and *conditional*, indicate a preference towards concrete and proven data, as well as posing questions to gather additional information; those styles could thus be associated with *rationality*.

Tonetto and Tamminem (2015) discuss the role of intuition in the process of designing artefacts that do not yet exist in the physical world. It is not possible to be sure of one's decisions, even when abundant information on the problem at hand is available. Some decisions regarding artefacts that are still abstract cannot be understood from a strictly rational point of view. There is a gap in the design literature concerning the process of moving from an abstract level of experience to the materialization of artefacts (Camere & Bordegoni, 2015). A level of non-rational processing is implied when translating abstract concepts into concrete projects.

Thus, our study aims at understanding how intuition and rationality work in association with thinking styles, and how we can determine which are more suitable to different product design projects. We also aim at identifying how past experiences play a role in professionals' decision-making and why it is essential for project qualification and assertive decision-making in scenarios of uncertainty, such as product design.

3 Materials and Methods

The research method consisted of an online survey that posed questions from the Concept Design Thinking Style Inventory – CD-TSI (Volpentesta, Ammirato, & Sofo, 2009), in addition to questions about the participants' demographic characteristics. The CD-TSI measures which of the five thinking styles (i.e., *conditional*, *inquiring*, *exploring*, *independent*, and *creative*) different professionals tend to adopt on each stage and task of a product design process. As mentioned in section 2.1, *conditional* thinking means accepting what others think and say without questioning them (e.g. "I tend to readily accept the first plausible option"), *inquiring* means asking questions to improve understanding of message or information (e.g. "I need to follow a question-driven approach"), *exploring* means looking for alternatives and differences (e.g. "I prefer to consider the full range of options"), *independent* means allocating priority to one´s own thinking (e.g. "I rely on my intuition and my problem solving skill"), and *creative* means thinking in pictures to get a sense of the whole (e.g. "I value unusual emotional reactions"). In view of our sample of respondents, the questionnaire aims at revealing how designers, engineers, and architects use styles when designing a product.

The CD-TSI is also organized according to the types of situations typical in product design. The first is associated with the *Stages of a Design Process* and contains four items: (i) searching for a concept vision, (ii) designing product functionality, (iii) designing product shape and geometry, and (iv) searching for a solution to assemble product components. The second is comprised of three items that measure the *Approach of Designers to Collaboration*, or their preference in relying on concrete information or on heuristic and imaginative thinking. The items are: (i) formulating a design problem, (ii) clarifying a design task, and (iii) debating and evaluating ideas/solutions. The third situation is divided in three items concerning with the extend to which designers trust their own impressions or consider other people's acknowledgment and experience; namely, their *Personal Way of Designing*. The items are: (i) retrieving knowledge for a design task, (ii) looking for perspective or use contexts, and (iii) searching for a solution to assemble product components. In each situation, respondents were asked to choose one of five structured responses, which reflect their preferred way of designing and are directly related to Sofo (2005)'s five thinking styles. Prior to providing answers to the questions, respondents were also asked to reflect about their own designing processes.

The study was both descriptive and cross-sectional, with a convenience sampling that was accessed through the researchers' networks and their peers. Respondents who did not graduate in one of the pre-established areas (Design, Engineering, or Architecture) were excluded from the study, as were those graduated in the areas but never involved in projects for creating new products.

Statistical analyses were performed using IBM SPSS Statistics, Version 21.0. Differences in thinking styles were tested using Univariate Analyses of Variance (ANOVAs). Dependent variables were the five thinking styles, compared across professionals' backgrounds (designers, engineers, or architects). Their behaviour within stages of a product's design process, considering the four items listed earlier in this section, was evaluated using contingency tables and Chi-square tests.

4 Results

In this section we present results from applying the CD-TSI questionnaire to a sample of 110 respondents, 42 of which were designers, 34 engineers, and 34 architects. Data from two portions of the questionnaire are analysed here: the one measuring thinking style preferences of different professionals, and the one exploring the construct Stages of a Design Process, and its corresponding four items.

Table 1 presents means and standard deviations of each thinking style stratified by the academic background of respondents, as well as ANOVA and between group comparison results.

Table 1. Means (and Standard Deviations) of Thinking Styles' Preferences by Professional Background

Style	Design	Architecture	Engineering	Between group comparison
01.Conditional	0.11 (0.11)	0.16 (0.13)	0.26 (0.19)*	$F(107,2) = 10.33$, $p < .001$, $\eta_p^2=0.16$
02. Inquiring	0.27 (0.14)	0.25 (0.21)	0.31 (0.15)	$F(107,2) = 1.09$, $p = .341$, $\eta_p^2 = 0.02$
03. Exploring	0.45 (0.20)*	0.40 (0.20)	0.30 (0.19)	$F(107,2) = 5.09$, $p = .008$, $\eta_p^2 = 0.09$
04. Independent	0.05 (0.10)	0.06 (0.08)	0.07 (0.08)	$F(107,2) = 0.33$, $p = .731$, $\eta_p^2 = 0.01$
05. Creative	0.12 (0.13)*	0.13 (0.10)*	0.06 (0.08)	$F(107,2) = 4.54$, $p = .013$, $\eta_p^2 = 0.08$

* *Significant at 95% confidence level or more*

Results concerning the *conditional* style revealed that engineers displayed higher adoption to such style when compared to architects and designers, which points to their preference in accepting opinions from others without questioning them. Results concerning the *exploring* style also pointed to significant differences between designers and other respondents, suggesting the former displayed a preference towards pursuing alternatives and differentiation; there were no significant differences between architects and engineers. Finally, results showed that designers and architects scored higher than engineers in the *creative* thinking style, indicating that they are more prone to think in parts to get a sense of the whole picture. *Inquiring* and *independent* thinking styles did not yield significant differences between professional with different academic backgrounds; that means such styles are equally favoured across backgrounds.

Table 2 presents Chi-Square tests results and standardized residuals values for the four items in the *Stages of a Design Process* construct, stratified by academic background and thinking style.

There is a significant association between thinking styles and background when professionals are "searching for a concept vision". Answers from designers indicate that they favour the *exploring* thinking style over others, while engineers favour the *inquiring* style at this stage of the design process.
Thinking styles and professional background are also associated when "designing product functionality". Responses indicate that architects adopt more frequently the *exploring* style, designers the *creative* and *exploring* styles, and engineers the *conditional* and *inquiring* styles. Associations between thinking styles and professional background were not statistically significant for items "designing product shape and geometry" and "searching for a solution to assemble product components". In other words, professionals from different backgrounds do not display preferences regarding thinking styles when performing those two stages of the product design process.

5 Discussion

Multidisciplinary efforts are required to develop a product (Ulrich & Eppinger, 2008). Nearly all sectors of an organization are involved in this task, but the design function is the one highlighted in this paper. Design plays a leading role to generate a product that meets consumers' needs, involving knowledge in areas such as engineering design (software, mechanical, electrical, among others) and industrial design (ergonomics, aesthetics, etc.). Professionals that work on this field often go through training in marketing, mechanical engineering, materials science, electrical engineering, and several others. The recruitment of development teams depends on the characteristics of the product to be designed. Unfortunately, professionals' strengths are often misunderstood, not only regarding their knowledge, but also in reference to their thinking styles. Our research helps clarifying this issue.

Table 2 Chi-Square tests results for Stages of a Design Process construct items, and standardized residuals values

Product design aspect: Searching for a concept vision					
*Background/*Style	Conditional	Creative	Exploring	Independent	Inquiring
Architecture	0.8417	-0.1453	-0.6273	-0.9546	0.6404
Design	-1.6012	1.9052	2.4394*	0.3472	-3.1889
Engineering	0.8417	-1.8577	-1.9373	0.5896	2.7122*
Pearson Chi-Square = 18.021; DF = 8; p-value: 0.021 Likelihood Ratio Chi-Square = 20.630; DF = 8; p-value: 0.008					
Product design aspect: Designing product functionality					
*Background/*Style	Conditional	Creative	Exploring	Independent	Inquiring
Architecture	-1.308	-0.776	1.846*	0.132	-0.716
Design	-3.005	2.341*	2.007*	0.613	-1.352
Engineering	4.467*	-1.685	-3.955	-0.776	2.138*
Pearson Chi-Square = 33.744; DF = 8; p-value: 0.000 Likelihood Ratio Chi-Square = 34.714; DF = 8; p-value: 0.000					
Product design aspect: Designing product shape and geometry					
*Background/*Style	Conditional	Creative	Exploring	Independent	Inquiring
Architecture	-0,1274	0,6886	-0,6336	-0,7901	0,7784
Design	-2,3931	1,0459	1,0564	-0,2692	0,4722
Engineering	2,6634	-1,8022	-0,4802	1,0818	-1,2851
Pearson Chi-Square = 13.048; DF = 8; p-value: 0.110 Likelihood Ratio Chi-Square = 15.146; DF = 8; p-value: 0.056					
Product design aspect: Searching for a solution to assemble product components					
*Background/*Style	Conditional	Creative	Exploring	Independent	Inquiring
Architecture	2,2450	0,4000	0,2974	-0,5531	-1,9321
Design	-0,8203	0,6924	0,4428	-0,8717	0,1218
Engineering	-1,3948	-1,1368	-0,7690	1,4810	1,8191
Pearson Chi-Square = 11.614; DF = 8; p-value: 0.169 Likelihood Ratio Chi-Square = 11.493; DF = 8; p-value: 0.175					

* *Significant at 95% confidence level or more*

Architects, who presented the highest *creative* style preference scores in our study, are the ones who favoured the use of the experiential system (intuition) in Rosa et al. (2016). Being creative, in our research, refers to making sense of the whole, even valuing emotional reactions. Creativity, in this particular sense, is aligned with the operations of the experiential thinking (Volpentesta, Ammirato, & Sofo, 2009). Therefore, our study reinforces the premise that architects to prefer to think associatively and intuitively, and they tend to be more flexible in thinking than other professionals. Architects may add great value in creating innovative products that are not necessarily based on similar choices available on the market.

On the other hand, Rosa et al. (2016) observed that engineers favoured rational decision-making when designing products. Our results show that they scored higher in the *conditional* thinking style, suggesting that they prefer to rely on proven data and models. Engineers seem to be valuable professionals to design new products based on tangible analysis of plausible choices.

Finally, according to Rosa et al. (2016)'s results designers did not exceed in rationality or experientiality, compared to architects and engineers. These professionals "might be more likely to find a balance on their reliance on different thinking styles. That is, Designers showed that, when comes to judging options and making decisions, they rely on their analytical thoughts, but also use their past experiences and intuition” (p.559). In our study, *exploring* and *creative* thinking styles were those that better represent designers, which means that they may transit between considering wide ranges of choices (*exploring* style) and making sense of the whole picture in a project, even taking their own emotional responses into account (*creative* style). That reinforces the idea that thinking styles are fluid (Sternberg, 1997; Zhang & Sternberg, 2005), and that people may change them according to what best suits certain contexts (Sternberg & Grigorenko, 1993).

When studying decision-making styles, Rosa et al. (2016) found that designers, architects and engineers adopt both rational and experiential systems when designing a product. Our results add to those findings. Some professionals, i.e., designers, seem to fluidly use distinct thinking styles that are not solely related to intuition or rationality, but others, i.e., engineers, seem to be more stereotypical in using one process – rationality. New studies could be carried out in order to clarify those relations between type of information processing (intuition and rationality) and design thinking style.

There is no better thinking style, generally speaking. They are different ways to approach problems and to think about solutions during a design process. Therefore, we can question if there is an optimal thinking style for diverse stages of a product design process. Our results indicate that this might be a possibility in some steps of product design, and point out to the value of multidisciplinary teams composed by professionals with distinct backgrounds and roles in different moments of the process.

When professionals search for a concept vision, designers exceeded in being *exploring*, and engineers in being *inquiring*. Considering a concept as the idea behind the design outcome, all reasoning to create it and its underlying logics, designers may add value by looking for innovative alternatives in product design. A product’s concept vision will help shaping aesthetic elements and functions, among others.

When they design product functionality, designers tend to be *creative* and/or *exploring*, architects to be *exploring*, and engineers to be *inquiring*. Adopting an inquiring thinking style, in this particular stage, is an important role in product design, since the improvement in the understanding of the problem, based on objective questions, may be crucial for a product success on the market.

When these professionals design product shape and geometry, and search for a solution to assemble a product’s components, results did not indicate significant associations between thinking styles and professional backgrounds. Therefore, in a multidisciplinary team, the attribution of specific roles to each one of them do not seem relevant.

It is pertinent to highlight that projects commonly face uncertainty (Kahneman, 2013; Stanovich & West, 2000; Tonetto & Tamminen, 2015) and start from wicked problems (Buchanan, 1992). Wicked problems are ill-formulated challenges to product designers, in which professionals often cannot get straight to outcomes, since they usually work on unclear or undefined briefs. Therefore, only the logics of rationality and solutions generated by thinking styles based on concrete reasoning may not be always sufficient in all cases. Intuitive thinking is needed to deal with uncertainty. Both – intuition and rationality – are not represented by a dichotomy (Kahneman, 2003); they can and should work together when it comes to designing products.

It is also true that industrial design many times is concerned with solving very objective issues. Therefore, each design problem will face professionals with a new challenge that might be more or less clear and structured. Thinking separately about the relationships between uncertainty and intuition, and certainty and rationality, we might find tempting to accept the illusion of relating specific professionals to each pair. Our dichotomist mind may also try to fit professionals and activities into dissociated areas:

> *[…] it is tempting to identify and limit specific design professions within each area- graphic designers with communication, industrial designers and engineers with material*

> *objects, designers-cum-managers with activities and services, and architects and urban planners with systems and environments. But this would not be adequate, because these areas are not simply categories of objects that reflect the results of design. Properly understood and used, they are also places of invention shared by all designers, places where one discovers the dimensions of design thinking by a reconsideration of problems and solutions (Buchanan, 1992, p.10).*

Buchanan's (1992) premises indicate how valuable styles such as *exploring* and *creative* may be, since they allow dealing with complex situations by investigating and generating alternatives. On the other hand, styles such as *inquiring* and *conditional* may also be valuable, depending on the contingencies and type of demand professionals face when designing a new product.

More than competition and fragmentation, collaboration and integration between areas are needed in product design. This may seem a prescient statement, but our data validate statistically that multidisciplinary teams may help balancing different thinking styles with a great potential to contribute in different stages of the design processes, and that architects, engineers and designers play different roles in representing these styles.

6 Conclusion

This research aimed at evaluating which thinking style (*conditional*, *inquiring*, *exploring*, *independent*, and *creative*) is preferred by professionals with different backgrounds (architects, engineers, and designers), when they work on product design. We also evaluated how these styles relate to distinct stages of the design process (searching for a concept vision, designing product functionality, designing product shape and geometry, and searching for a solution to assemble product components), evaluated by the Concept Design Thinking Style Inventory (CD-TSI). In addition, we proposed a connection between thinking styles and different cognitive systems (rational and intuitive), in order to understand if there is an optimal thinking style to deal with project uncertainties, which require the use of cognitive intuition.

It is known that we are bounded in rationality, and we do not have all the information required to design the artificial world. In order to face that, the use of thinking styles in our view related to intuition – *exploring*, *independent* and *creative* – may be essential to deal with some design challenges, such as the lack of information in different stages, and optimize the process. *Inquiring* and *conditional* styles, on the other hand, may be more useful in designing concrete assets of a product, such as its functionality.

Our findings suggest that architects tend to use the *creative* style, engineers use more the *conditional* style, and designers prefer the *exploring* and *creative* styles. In some stages of the process, each professional might have differentiated roles: (a) when "searching for a concept vision", designers favour the *exploring* thinking style over others; (b) when "designing product functionality", engineers tend to use the *conditional* and *inquiring* styles; but (c) when "designing product shape and geometry" and "searching for a solution to assemble product components", the different professionals do not have clear preferences regarding thinking styles.

The results presented in this paper contain certain methodological limitations, as it is a cross-sectional research design that should be considered exploratory. In addition, a more robust statistical analysis was not possible, considering the sample size. Since it was a voluntary research, there is also the risk of self-selection sending. Finally, the results are limited to the sample, composed only of Brazilian professionals, and should not be generalized.

We strongly suggest the conduction of new empirical studies investigating the relationship between intuition, rationality, and thinking styles. The connections we have proposed are grounded on a theoretical background. New studies would clarify our knowledge about the decision-making process in the context of product design, which could be useful for educational contexts and work team recruitment, having a significant impact on product design.

Future research may address the similarities in the use of the five thinking styles defined by Volpentesta, Ammirato and Sofo (2009) and their roles in collaborative problem-solving (Gu, Shao, Guo, & Lim, 2015). It is known that adopting roles in those contexts may be beneficial to the learning process (Gu, Wang, & Mason, 2017; Gu et al., 2015). Such studies could help to clarify if assigning roles to students can facilitate the use of different thinking styles in product design and prepare professionals to face the variety of challenges presented in these tasks.

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