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EVALUATING THE INFLUENCES OF HETEROGENEOUS COMBINATIONS OF INTERNAL/EXTERNAL FACTORS ON PRODUCT DESIGN

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Abstract

Several factors could affect the effectiveness of product design activities. These factors can be internal to the designers like skill, knowledge and personality traits, as well as external like instructions and examples provided. Up to now, researchers and designers in the academic and industrial fields analysed the effects of at most two factors at the same time, always of the same type (internal or external). This paper describes the activities and results of the preliminary stage of a wider research that aims at understanding the relationships among heterogeneous factors (internal and external together) and at defining the best combinations of any number of them to maximize the effectiveness of product design activities. This preliminary stage aims at verifying the possibility of overcoming the limits in the number of the factors to consider as well as in their membership to the same type (internal or external). To implement this verification, some heterogeneous combinations composed by more than two factors are defined and tested. The results of the tests show that the limits can be overcome; this, in turn, allows the wider research to be carried on.

Keywords: Design process, Evaluation, Human behaviour in design, Case study, Shape-based design

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1 INTRODUCTION

In recent years, several researches in the academic and industrial fields have tried to improve different kinds of product design activities. The factors that can influence them could be internal to the people who perform the activities like skill, personality, etc., as well as external like the different types of instructions provided, the analogical distance, the complexity and physical/digital nature of the examples used meanwhile, etc.
These researchers analysed the effects of at most two factors at the same time; moreover, these factors were always of the same type (internal or external).
This paper describes the activities and results of the preliminary stage of a wider research that aims at understanding the relationships among heterogeneous factors (internal and external together) and at defining the best combinations of any number of them that maximize the effectiveness of product design activities. From the academic point of view, the results could help in increasing the knowledge about the mechanisms behind each product design activity and in generating new methods and tools for these activities; from the industrial point of view, this research could allow companies to spare time, costs and resources, as well as to lower the risk of redesign. The goal of the work described here is to verify the possibility of overcoming the limits in the number of the factors to consider as well as in their membership to the same type (internal or external). To achieve this goal, heterogeneous combinations composed by more than two factors are defined, as well as hypotheses on their effects on product design activities. These effects are evaluated thanks to tests performed on shape-based design activities and analysed using metrics like the quantity of design solutions generated, the pertinence of them, etc. If the results of this analysis will not highlight incompatibilities among the factors, the wider research will be allowed to be carried on.
The paper structure is as follows. The background section summarizes previous studies about the influences of different factors on product design, recalls the theories about human personality and introduces the shape-based design. The activities section starts by highlighting the influencing factors considered here. Then, some hypotheses on the best combinations of the values of these factors are formulated. The hypotheses are verified afterwards, thanks to the definition of the evaluation metrics and the execution of tests. The discussion about the results and the conclusions close the paper.

2 BACKGROUND

2.1 Influences of different factors on product design

The literature reports many researches dealing with the influences of different factors on product design. These researches refer to experimental studies in which specific factors are studied by evaluating the number of design solutions generated as well as their creativity and novelty content. This evaluation usually takes place by involving people performing tests. Vasconcelos et al. (2016) evaluate how the examples provided during the tests influence the activities in terms of quantity of design solutions as well as of presence of repetitions and types of features (conceptual vs. structural) involved. It seems that the examples do not affect the quantity while there are fewer repetitions when designers are not required to follow specific examples. Moreover, the quantity of conceptual features similar to those present in the examples is the same either the designers are required to follow the examples or not. Nevertheless, the quantity of structural features in the design solutions similar to those of the examples is higher when designers are required to follow the examples. The research of Lai and Shu (2016) highlights that sometimes designers start by searching for relevant details in the problem they are called to solve in order to map the current situation to previous ones and to be able to follow the same design path. All of this is called need for closure. In this case, design results are likely similar to those obtained in the past; therefore, variety and creativity of the design solutions are negatively affected. Starkey et al. (2016) investigates how virtual dissection, analogical distance and the complexity of the products used as examples influence creativity. They discover that creativity is positively affected in case of virtual dissection respect to the physical one. Moreover, creativity is positively affected when the examples are analogically far from the product under design, but this happens only if the examples involve products easy to dissect. Inoue et al. (2016) focusses on the influence of given information and details and of prior knowledge on creativity. They find that the fewer information and details are given, the better solutions are generated in terms of variety and creativity. Moreover, prior knowledge influences

negatively creativity because it pushes designers in narrowing the design space while generating solutions. Crilly, Moultrie and Clarkson (2004) show that social and cultural knowledge can heavily influence the quality of the design results both positively and negatively, depending on the different characteristics of the society and of its culture. Finally, Sung and Choi (2009) highlight the influence of human personality on design. In particular, they find that extraversion and openness to experience/culture positively influence creativity because people showing these traits are more flexible and able to analyse ideas from different perspectives.
These researches are exploited here to highlight the main factors that can influence product design activities in terms of quantity and quality of the results.

2.2 Human personality

Human personality is defined as the set of characteristics of a person that account for consistent behavioural patterns over situations and time (Karimi and Kangavari, 2012). Several scientists have tried to underline personality traits to generate a structured and accepted taxonomy. Starting from the thirty-five variables highlighted by Cattell (1943), other researchers as Tupes and Christal (1961), Digman and Inouye (1986), and McCrae and Costa (1987) found five common factors to describe human personality (Goldberg, 1990). The big five personality traits are the name of this recognized taxonomy. The big five personality traits are as follows (Rothmann and Coetzer, 2003).
Extraversion or surgency (P1). It includes sociability, assertiveness, activity and talkativeness. Extraverts are energetic and optimistic. Introverts are reserved rather than unfriendly, independent rather than followers. Extraversion is characterized by positive feelings and experiences; therefore, it is considered a positive effect.
Agreeableness (P2). An agreeable person is fundamentally altruistic, sympathetic to others and eager to help; equally, he/she believes that others will be equally helpful. The disagreeable/antagonistic person is egocentric, sceptical of others' intentions and competitive rather than co-operative.
Conscientiousness (P3). It refers to self-control and to the active planning, organizing and carrying out tasks. The conscientious person is purposeful, strong-willed and determined. Conscientiousness is manifested in achievement orientation (hardworking and persistent), dependability (responsible and careful) and orderliness (planful and organized). On the negative side, high conscientiousness may lead to annoying fastidiousness, compulsive neatness or workaholic behaviour. Low scorers on conscientiousness may not necessarily lack moral principles, but they are less exacting in applying them.
Neuroticism (P4). Neuroticism is a dimension of normal personality indicating the general tendency to experience negative effects such as fear, sadness, embarrassment, anger, guilt and disgust. High scorers may be at risk of some kinds of psychiatric problems. A person with high neuroticism is prone to having irrational ideas, being less able to control impulses, and coping poorly with stress. Low neuroticism is indicative of emotional stability. These people are usually calm, even-tempered, relaxed and able to face stressful situations without becoming upset.
Openness to experience/culture (P5). It includes active imagination, aesthetic sensitivity, attentiveness to inner feelings, preference for variety, intellectual curiosity and independence of judgement. People scoring low on openness tend to be conventional in behaviour and conservative in outlook. They prefer the familiar to the novel, and their emotional responses are somewhat muted. People scoring high tend to be unconventional, willing to question authority and prepared to entertain new ethical, social and political ideas. Open individuals are curious about both inner and outer worlds, and their lives are experientially richer. They are willing to entertain novel ideas and unconventional values, and they experience both positive and negative emotions more keenly than closed individuals do.
This taxonomy is exploited to develop single tools like questionnaires (Barelds and Luteijn, 2002) as well as full methods like the five-factor model (FFM) (McCrae and John, 1992). These tools and methods aim at measuring and assessing individual personalities and at deeply studying the single traits in different situations.
The five personality traits are used in this research to describe the Personality factor and verify its influence on design solutions.

2.3 Shape-based design

Shape-based design activities develop successful products starting from the analysis of specific shapes and the definition of product functions as a consequence (Filippi and Barattin, 2016). One of the main goals is to arouse specific emotions in the people who interact with those products. The shape analysis

usually takes place thanks to tests where interaction involves mainly touch and sight senses. This interaction highlights the emotions aroused by the shapes as well as possible behaviours of people and shapes. After that, functions are defined and implemented in products replicating those shapes in order to arouse those emotions and allow those behaviours. Alessi, an Italian company producing iconic objects like household appliances, etc., is an example of shape-based design adoption (Alessi, 2016).
The shape-based design activities are used in this research to evaluate the hypotheses about the influences of heterogeneous factors on product design activities.

3 ACTIVITIES

3.1 Highlighting factors that influence product design activities

Previous researches allow highlighting those factors influencing product design activities that will be considered here. These factors are classified into two main groups respect to the subject they belong to. The first group refers to the designers and contains three "internal" factors: Skill S (values: Low, Medium, High) in applying design methods and tools and problem solving techniques, with or without help; Knowledge K (values: Low, Medium, High) about design theories, techniques and processes and about the context where the design activities take place; and Personality traits P1-P5 (values: Yes, No) as defined in the background section. The second group refers to the product design activities and contains two "external" factors: types of Instructions I (values: Binding, Free) given to the designers about how to conduct the design activities and the description of the design problem; and helping Examples E (values: Related, Unrelated) in achieving the goals. The different peculiarities of these factors, together with their belonging to different subjects, help both in considering complex aspects of product design activities difficult to foresee and in guaranteeing a good coverage of the product design field. Nevertheless, the wider research will consider even more aspects in order to broaden this coverage and limit the subjectivity that somehow affects this work at the moment.

3.2 Making hypotheses on heterogeneous combinations of factors

Starting again from the results of previous researches, we formulate the following hypotheses on heterogeneous combinations of factors. In order to assure a complete and homogeneous verification of all the factors, the hypotheses always consider all of them; those that do not appear explicitly are considered as having neutral or intermedium values.
H1. Extravert and open to experience/culture designers should be more comfortable with free instructions and with examples unrelated to the design context than their introvert and closed colleagues. The former should generate better results in terms of quantity and novelty, the metrics used in this research together with pertinence and variety. This hypothesis involves explicitly three out of the five factors considered in this research: Personality - in terms of extraversion and openness to experience/culture (internal), Instructions and Examples (external). The research of Sung and Choi (2009) and the definition of the personality traits suggest this hypothesis.
H2. Introvert and closed to experience/culture designers should be more comfortable with binding instructions and with examples related to the design context than their extravert and open colleagues. The former should generate better results in terms of quantity, while the variety and the novelty should be the same. Since this hypothesis is somehow the opposite of the previous one, the factors explicitly involved are the same, as well as the researches that suggest it.
H3. In case of binding instructions and examples related to the design context, designers with medium skill and high knowledge should generate better results in terms of quantity and pertinence than their colleagues showing low values of skill and knowledge. On the contrary, the results of the former should be worse in terms of variety and novelty. This hypothesis involves explicitly four factors: Skill and Knowledge (internal), Instructions and Examples (external). The research of Inoue et al. (2016) helps in formulating this hypothesis.
H4. In case of low skill and knowledge, conscientious and agreeable designers working with binding instructions and with examples related to the design context should generate better results in terms of quantity and pertinence than their non-conscientious and disagreeable colleagues who work with free instructions and related examples. On the contrary, the former should generate worse results in terms of variety and novelty. This hypothesis involves explicitly all the factors. Specifically, two traits of

personality are considered: conscientiousness and agreeableness. The research of Vasconcelos et al. (2016) and the description of the personality traits suggest this hypothesis.

H5. In case of closed to experience/culture designers, the agreeable ones working with binding instructions and related examples should generate better results in terms of quantity and pertinence than their disagreeable colleagues who work with free instructions and unrelated examples. Nevertheless, the former should generate worse results in terms of variety. This hypothesis involves explicitly three factors: Personality - in terms of agreeableness and openness to experience/culture (internal), Instructions and Examples (external). The researches of Vasconcelos et al. (2016) and of Sung and Choi (2009) and the description of the personality traits suggest this hypothesis.

3.3 Verifying the hypotheses

These hypotheses are verified thanks to the following activities. The selection of the product design activities to consider comes first; then, the metrics to measure the results of the product design activities are defined; finally, tests are performed, the collected data are analysed and the decision about the feasibility of the wider research is argued.

3.3.1 Selection of the product design activities

Among the different kinds of product design activities that could be considered to verify the hypotheses, the shape-based ones have been selected for the considerations described hereafter.

- The shape-based design allows considering both the values (binding and free) of the Instructions factor because the designers called to highlight functions starting from shapes do not necessarily follow any scheme.
- The shape-based design can be proposed to people showing any skill and knowledge about design theories, techniques and processes thanks to the flexibility of the expected results. In fact, these results can be simple, like the sole functions, or more complex, like behaviours, emotions or meanings aroused by the shapes. Functions can be asked to almost everyone; dealing with emotions and meanings requires specific knowledge about the emotion and meaning concepts, etc.
- The shape-based design allows exploiting any type of knowledge on the context where the product design activities take place. This because designers are only required to focus on shapes; all the other possible concerns like materials, colours, structures, relationships between different parts, etc., do not need to be considered.
- The shape-based design allows considering any value of extraversion, agreeableness, conscientiousness and openness to experience/culture traits because designers' activities are free from constraints and the results can be expressed in the way considered as the most effective. Neuroticism does not appear here but this is not a problem since none of the hypotheses considers it explicitly.
- The shape-based design allows considering any kind of examples; the helps proposed during the activities can be both related and unrelated to the design context and can consider existing as well as non-existing products.

3.3.2 Setting up the metrics

The verification of the hypotheses comes by comparing the design results generated by the two groups of people appearing in each hypothesis. The following metrics allow assigning numerical values during the evaluation of these results, in order to make the comparison feasible from a quantitative point of view.

Quantity (Q). It is the number of functions proposed by the designers, doubles included.

Pertinence (Pe). Functions are measured against their connection with the specific context. Possible values are: 1 (the function refers to the context in full); 0 (otherwise).

Variety (V). Functions are evaluated in order to check if they are completely different, similar or equal to other functions highlighted by designers belonging to the same group. Possible values are: 1 (the function is different from any other); 0.5 (the function has doubles but the user's and/or the product's behaviour in performing the function is different); 0 (otherwise).

Novelty (N). Each function is compared to functions already implemented in existing products. The Sarkar and Chakrabarti's method (Sarkar and Chakrabarti, 2011) about creativity measurement is exploited in this evaluation. It tells that creativity is the sum of novelty and usefulness. Only the novelty

is considered here. The way the novelty is measured needs some adaptations because Sarkar and Chakrabarti deal with ideas instead of functions. Possible values are: 1 (no existing products show the function); 0.5 (the function is already present in some existing product but the user's and/or the product's behaviour is different); 0 (otherwise).
The final values of the Pertinence, Variety and Novelty are computed by normalizing respect to the Quantity, for each group.

3.3.3 Test setup and execution

Each hypothesis has been verified thanks to a specific test. Therefore, five tests have been conducted, each of them involving two groups of people showing the skill, knowledge and personalities as required and where instructions and examples are made available as required. The tests share the same design problem to solve and have a common structure: the design problem is introduced to the testers; the goals are assigned and the instructions are given; after that, the testers try to solve the design problem and the resulting functions and behaviours are collected.
The design problem refers to the development of pieces of stationery (design context) starting from a specific shape given to the testers.
Once defined the context, the testers were selected. They were students of Mechanical Engineering courses. They are classified thanks to questionnaires collecting pieces of information about their skill, knowledge and personality. Considering the skill, the testers can choose among the values high (able to use design methods and tools and problem solving techniques without aids), medium (able to use design methods and tools and problem solving techniques with aids) and low (unable to use design methods and tools and problem solving techniques, even with aids). Focusing now on the knowledge level, the testers can choose among high value (deep and precise knowledge about design theories, techniques and processes and about stationery), medium value (intermediate knowledge about design theories, techniques and processes and about stationery) and the low value (basic knowledge about design theories, techniques and processes and about stationery). For what concerns the personality, each trait allows selecting among three options: the trait itself, its opposite and a neutral value. For example, considering extraversion, the three options are extravert, introvert and neutral from that point of view. The ten groups of testers required by the evaluation of the five hypotheses (two for each test) were generated afterwards.
The material developed to conduct the tests were the shape and the Google Forms.
The generation of the shape followed specific rules like those described in Filippi and Barattin (2016). For example, the shape should consist of a combination of simpler shapes (e.g., the ice cream cone, the door handle, etc.) in order to help people recalling past uses, moments when these uses happened and the related functions. The simple shapes considered here recall a banana and an arch, as shown in Figure 1. The shape should contain details to attract the attention and to suggest other uses than those suggested by the simple shapes. The number of details should not be excessive to avoid confusion. In this case, the details regard the position of the shape (unbalanced), the cap placed only at one of the extremities and the support that makes the shape free to swing. The colour is important as well because it can attract the attention and arouse specific emotions. In this case, the yellow is chosen because it should arouse happiness and lightness. Finally, the dimensions should be kept into heavy consideration. In this case, the shape is represented in digital format - it is generated using a 3D modelling software package - and the testers are free to interpret its dimensions.

Figure 1. The shape used in the tests.

Three Google forms are built on the combinations of the external factors Instructions and Examples required by the hypotheses: free/unrelated, binding/related and free/related.
The free instructions shape like a scenario. They start with an introduction where the context of the test, the design of innovative products for stationery, is defined. Then, the testers are invited to consider themselves as designers of a company producing stationery objects. Their goal is to highlight the functions that a specific shape suggests and express their behaviours and the ones of the shape needed to perform those functions. Then, an example is proposed to help in formulating the functions. After that, the specific shape is shown; the testers can consider it as long as they like and, in the meantime, they are required to write down the functions and behaviours allowed.
The binding instructions consist of more steps. The same introduction about the context is given as before, as well as the goal of the test. Then, the testers must read carefully the examples proposed as design aid. Subsequently, the testers must look at the shape for two minutes and write down the functions that the shape suggests. After that, for two minutes more, they observe the shape and think about their behaviours and the ones of the shapes to perform the suggested functions.
Considering now the examples, they should represent hints on how to arouse and express the expected functions and behaviours. Both the types, related and unrelated to the stationery context respectively, have a similar structure. A picture of the shape is proposed, together with the list of related functions and behaviours. Figure 2 shows the two examples used here, the related to the left and the unrelated to the right (referring to the household appliances context).

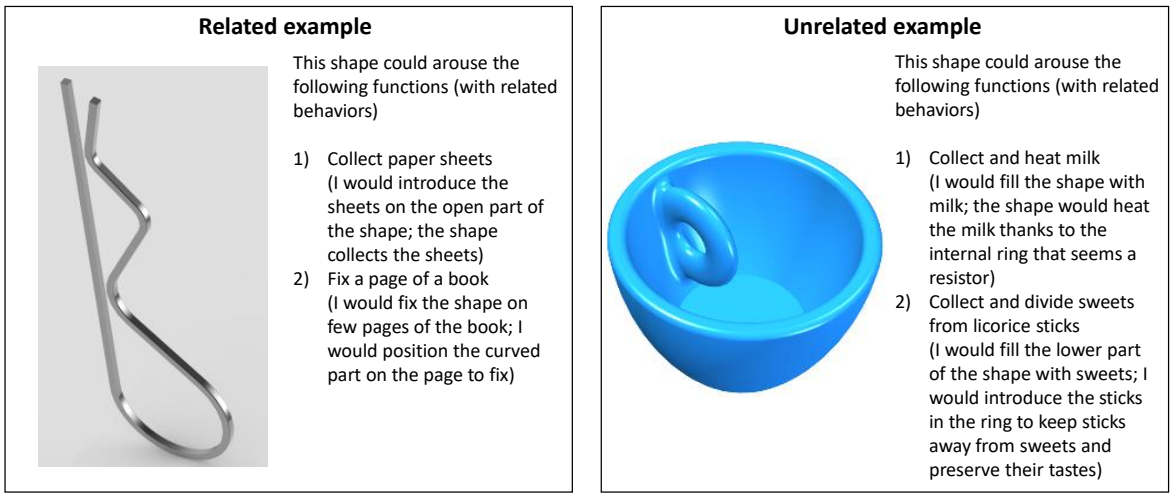

Figure 2. Related and unrelated examples used in the tests.

Then, the tests took place. Table 1 summarizes the information describing them. For each test (T), there are the number of participants (#) of each group (A and B), the values of the factors (P1, P2, P3, P5, S, K, I and E) and the values of the metrics computed afterwards (Q, Pe, V and N).

Table 1. Summary of the information coming from the tests.

Hyp.	Test	#	P1	P2	P3	P5	S	K	I	E	Q	Pe	V	N
H1	T1	A (6)	Y	-	-	Y	-	-	F	U	45	-	-	37%
		B (6)	N	-	-	N	-	-	F	U	39	-	-	9%
H2	T2	A (6)	N	-	-	N	-	-	B	R	37	-	84%	38%
		B (6)	Y	-	-	Y	-	-	B	R	47	-	84%	37%
H3	T3	A (5)	-	-	-	-	M	H	B	R	33	33%	82%	26%
		B (5)	-	-	-	-	L	L	B	R	32	56%	94%	34%
H4	T4	A (4)	-	Y	Y	-	L	L	B	R	21	95%	43%	12%
		B (4)	-	N	N	-	L	L	F	R	20	90%	85%	20%
H5	T5	A (5)	-	Y	-	N	-	-	B	R	13	69%	61%	-
		B (5)	-	N	-	N	-	-	F	U	21	24%	76%	-

One example for each test type is reported in the following; they show both the functions and behaviours collected during the execution. In T1, one of the testers belonging to the group A suggests the function "contain earphones", with the related behaviour "I put the earphones with their cable in the shape and it collects them all neatly". In T2, one tester of group B proposes "collect waste paper", with "I roll the paper into a ball; I throw the ball towards the shape; the shape collects the ball". In T3, one of the testers belonging to group A suggests "place and keep my bike", with "I put the wheel of the bike in the concave part of the shape and the shape keeps the bike". This function does not belong to the stationery context but the shape suggests it the same. In T4, one tester of group B suggests "collect elastic bands and scotch tapes", with "I insert the elastic bands and the scotch tapes by the upper part of the shape and the shape collects them tidily ". Finally, in T5, one tester of group B suggests "contain bananas", with "I place a banana in the shape and the shape collects it".
The adoption of the metrics allows filling the rightmost part of table 1 representing the quantification of the quality of the results, normalized respect to the quantity of functions for each group. An example of this considers the function "supply glue" and the related behaviour "I introduce a stick of solid glue in the shape; the shape makes the glue liquefying; the shape rotates and supplies the glue through a hole in the lower part; I rub the paper against the shape to spread the glue where needed". These function and behaviour are expressed by one of the testers belonging to the group A in T4. In this case, the Quantity value is equal to 1 because every identified function is assigned this value. Pertinence is 1 as well, since dealing with glue is typical for the stationery context. None of the testers belonging to the same group suggests the same function (glue supplying); therefore, the value of the Variety metrics is 1. Glue supplying is a function implemented in many existing pieces of stationery; however, the way the tester imagines his behaviour as well as the product's one during interaction is completely different from what usually happens. One out of the many, although the relative movement between the glue dispenser and the paper is the same, the dispenser usually moves on a fixed piece of paper while in this case the paper moves against a fixed dispenser. Therefore, the value of Novelty is set to 0.5 because the function already exists but the behaviour is different.

3.3.4 Analysis of the collected data

Thanks to all the pieces of information collected, now it is possible to claim if the hypotheses related to the specific tests appear to be verified or not. The verification of each of the hypotheses is described in the following.
In T1, the test used to verify H1, group A shows higher values of Quantity and Novelty of the design results. In particular, the Novelty value is four times higher. Therefore, H1 is verified.
For what concerns T2, the Variety and Novelty values are very similar; in fact, the Variety of group A is equal to 84% as well as that of the group B, while the Novelty value of group A is 38% and that of group B is 37%. Therefore, the part of the hypothesis about Variety and Novelty is confirmed. On the contrary, this does not happen for Quantity because group A generated 37 functions, much less than group B, 47. This result is not expected for H2. An explanation for this could be found in the instructions given to the testers in T1 and T2. A further analysis highlights that the binding and the free instructions are somehow too similar to be able to highlight their influence effectively. Moreover, the adoption of the Google Form does not allow monitoring the testers directly. It is assumed that they follow strictly the binding instructions, the timing and the examples but it seems that this does not happen, by

overcoming some instructions or the reading of the examples. Further tests are required, where evaluators monitor the testers and instructions are more differentiated. Therefore, H2 does not appear to be completely verified at the moment.
Focusing on T3, group A correctly shows higher Quantity and lower Variety and Novelty. Nevertheless, Pertinence does not behave as expected. Its value for group A is lower than that of group B. Some reasoning highlights the possible reasons for this. The students involved in the tests have recently attended a university course on creativity and innovation. This course teaches them that exploiting the same ideas in different contexts can be a powerful innovation booster. In some cases, this suggested to express out of scope functions voluntarily. Some students confirmed this aspect after the tests. Therefore, it seems that a heavy bias influenced the test results for what concerns the Pertinence metrics. A more careful selection of the testers is needed. Therefore, as happened for H2, H3 cannot be considered completely verified at the moment.
For what concerns T4, the values of all the metrics correspond to what claimed by H4. Quantity and Pertinence are higher for group A than those for group B, while Variety and Novelty are lower, as expected. Therefore, H4 appears as fully verified.
Finally, focusing on T5, as expected, Pertinence is higher and Variety is lower for group A than those for group B. Nevertheless, Quantity is lower for group A and this does not satisfy the hypothesis. The reason for this could be that two people belonging to group A did not suggest any function. Obviously, Quantity is the first metric negatively influenced by this, especially because of the low number of testers in all (five). More tests are needed to verify if people closed to experience/culture and agreeable tend to generate few or no functions or if what happened has been only a coincidence. Therefore, H5 does not appear as completely verified.

4 CONCLUSIONS

The work described in this paper is the preliminary stage of a wider research where the relationships among heterogeneous factors are analysed in order to highlight the best combinations of them to maximize the effectiveness of product design activities. This preliminary stage aims at verifying the possibility of considering more than two factors, internal and/or external, at the same time, without any incompatibility or side effects. To achieve this goal, some heterogeneous combinations of factors have been set. Starting from them and considering previous researches on the same topics, five hypotheses have been formulated and tests exploiting shape-based design activities have been used to verify them. Although some mismatches on few hypotheses arose, their analysis allows claiming that these mismatches are due to the way the tests have been organized and conducted. Therefore, the results of the tests fundamentally confirm the hypotheses; this, in turn, allows claiming that there are not incompatibilities among the factors considered. For this reason, the wider research seems to be able to be carried on.
Anyway, further developments could improve this preliminary stage before to proceed with the wider research. First, more testers need to be involved in the verification activities to avoid biases, accidental mistakes, etc. The classification/selection of the testers should come through rigorous psychologic tests rather than simple questionnaires. The tests should be performed directly by the evaluators to assure that the binding instructions are followed as they should. These improvements should make clear ultimately if the second, third and fifth hypotheses become verified or, on the contrary, if there is something wrong in them. Moreover, other product design activities than the shape-based should be considered in order to make the results more general. Other factors should be considered as well, like the product personality defined as the symbolic meanings associated to the physical product and described with human personality characteristics. Moreover, further values than the ones considered at the moment should be available to assign to the factors already involved. A wider range of values should be available for the metrics as well, to be more precise in the analysis of the test results. More hypotheses should be formulated in order to verify different combinations of factors. Finally, design results other than functions and behaviours should be considered, like the meanings and emotions that a product could arise in the users.

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