TESTING THE TECHNOTOPE CONCEPT

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Various design researchers and theorists had proposed a thorough study of the product system in a similar way to studying the system of living beings. It was proposed a framework, called the technotope framework, which had a number of associated concepts: interactions (coexistence, challenge and syntechnosis) and connections (physical and semantic). A series of questions arouse: "Is such a framework valid and easy to understand? Are the associated concepts valid and easy to understand? Is this framework a useful tool for designers?" This paper provided answers to all those questions indicated above and the answers were positive. Also, the influence of the two main elements of visual language (shape and colour) on the elements of the technotope framework (interactions and connections) was experimentally analysed and it was found that the elements of the technotope were not influenced by shape and colour.

Keywords: technotope, product design, interior design, design technique.

1. Introduction

The connection between man and its environment is described by the concept of habitability introduced by W.F. Preiser [1]: „Habitability defines the degree of fit between individuals or groups and their environment, both natural and man-made, in terms of an ecologically sound and humane, built environment." The proposed definition is correct and highlights the natural connection between human beings and their artificial or naturally-modified environmental but ignores the connection between environmental elements (including products), those relationships that are conditioned by humankind.

Following on the same idea, ecology is the study of the relationship of living elements with their environment, together forming a system. But is it necessary for all elements to be alive? It is common practice, as will be seen below, to use the term ecology to study relationships between various elements (not necessarily alive) and their environment.

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If an analogy between concepts associated with ecology is undertaken and it is considered that the natural environment in which a population of living organisms lives is called a biotope (from the Greek "bio" - life), it is natural to consider that the artefact-populated environment is called technotope (from the Greek "techne" - craftsmanship). The term was used with this meaning by Dumitrescu [2].

The human habitat system has been studied from different perspectives. Dwelling as a system based on electronic informational relationships and automatic control is just one example. Detailing, the dwelling is determined by the relationships between its elements, which may be physical, semantic or informational. Lately, more attention has been paid to information relations, as will be indicated.

Informational relationships are meant to provide information to the resident, but also to exchange information within the subsystem consisting of computer-type products and intelligent products. The exchange of information within this subsystem aims to control intelligent products that perform operations directly designed to meet human needs.

The dwelling that benefits from a smart subsystem has been naturally given the name of smart home. A retrospective of the concept and achievements in this direction is presented in Aldrich's work [3]. Apart from the name of "smart home" aimed for specialists, but mostly for the general public, the term "ubiquitous computing environment" is used, which, although is not covering only the dwelling term, has the merit of emphasizing (in the case of dwelling) two aspects: the presence of the computer at home and the omnipresent character of information technology inside the dwelling. The powerful influence of information technology on design practices, particularly in the construction of habitats, is analysed in Kalay [4].

Home control assumes control over [5]: i) ambient lighting; (ii) temperature regulation; (iii) plant watering; (iv) the use and interaction of sensors [6]; v) the safety of those sensors [7]; vi) networking amongst household appliances [8]. It was assumed that home control would be carried out automatically and that all supporting technology would be invisible as much as possible [9]. Control means the operation of the subsystem according to parameters pre-set or set by the resident at the start of the subsystem's operation or parts thereof. Another possibility is to use a house memory, which would aim to record the reaction of the occupants to different values of the operating parameters of the dwelling [10].

Exclusive application of automated control can cause impairing of the resident ability to understand and control the home environment. Furthermore, in the general context of actions (physical and intellectual) aimed at easing all human activities, automated home control would contribute to the debilitation of the human being. Following consultations with physicians, educators and homeowners, Intille [11] emphasized that the technology of the future should not automatically control the dwelling but should provide the residents with the means to control their own home environment, lack of control could seriously affect people (as shown in [12]). A physically and intellectually challenging home living would prevent the effects of aging. Furthermore, the American researcher envisioned a present and discreet technology that came into the forefront when needed, giving the resident information when the latter needed to make an informed decision.

Moreover, there is the danger that in the future, the computerization of the dwelling will follow the office model, transferring workplace values within the home such as efficiency and productivity to the detriment of traditional family values, and information technologies to become dehumanizing [13].

In the context previously described, Rodden & Benford [14] considered three types of products: i) information appliances (computer products, mobile devices and smart appliances); ii) interactive household objects (products that offer new possibilities of interaction, starting from traditional cultural interactions); (iii) augmented furniture (furniture with interactive use). Finished researches on the last two types of products already exist, such as those of Steitz et al. [15].

The ecology of electronic information and automated control has revealed the dangers of the current computerized approach to dwelling, of which the physical and intellectual debilitation of the human being is the most important. Another important aspect is the hidden nature of ecological relationships. This also results in the reduced usability of this kind of ecology in the design of the dwelling by specialists in product aesthetics.

The product ecology (in various human habitats, including dwellings) is present in the thinking of several design theorists and researchers. Giulio Carlo Argan [16] believes that the designer should analyse the products ecology (understood as the system of products' relationships), then design it in the ideally and subjectively imagined future. In this future context, the designer generates solutions for the design problem. There will be an ideal object (at least for the future) that the designer will have to adapt to the current real conditions.

Other theorists and researchers are focused about the similarities between the ecology of living beings and the ecology of products. Among them is Klaus Krippendorff [17], which indicated the following:

- People know and have relationships with more product "species", than with animal species; a fair and obvious idea, taken from textbook [18];
- The size of the products is larger than the size of the animals (a skyscraper is larger than a whale, and artificial molecules are smaller than a bacterium). The appraisal is questionable, especially in terms of

what we can consider to be a product or a product system, respectively. Thus, a skyscraper should be compared not with a whale, but with the Great Barrier Reef.

- Products presented in museums have radically changed their functions during their lifetime, while animals change little during their lives. The comparison is not well articulated: products from technical museums should be compared with stuffed animals in natural science museums, which have also changed their function. In fact, museum products are no longer "alive" in the sense of performing the functions for which they were designed.
- The vast majority of products are mass-produced. Similarly, the vast majority of animal species have a large number of individuals, which is a correct claim.
- When products are installed / integrated into the place of use, they create far more complex systems than forests, hives or ant colonies. The assertion is questionable and certainly biologists would have much to say against this view.
- Living beings interact on their own terms, while products interact on human terms. Beyond the veracity of the statement, it must be emphasized that the products interact according to the designers' specifications for the planned relationships and according to the human needs for the unplanned relationships.
- Designers are not allowed to ignore the ecological interactions between products, as these interactions contribute to the survival of the product in the ecological system.

Studying the interactions between products, Krippendorff [17] identified three cases: cooperative interactions (resulting in mutual benefits); competitive interactions (resulting in dramatic challenges); and independence (based on uncorrelated existence of products).

Beyond some controversial views, Krippendorff's approach to comparing the ecology of living beings with product ecology is welcome. It is worth noting that Krippendorff does not clearly indicate what is the force that animates the ecology of the artificial environment.

Considering the obvious analogy between the world of living beings and the world of man-made artefacts, it have been proposed a series of concepts for the world of products, inspired by the concepts of ecology [2]. Because the prefix "bio" (the word used for living in ancient Greek) was used for the concepts from biology, for the new concepts the prefix "techno" (craft, skill in ancient Greek) was used. The fundamental concepts are: a) *Technotope* is a particular artificial environment, with unitary conditions populated by products that made up a technocoenosis. b) *Technocoenosis* is made up of all human-made artefacts associated with a particular technotope.

The artefacts from a technocoenosis develop among themselves three types of interactions (product relationships): a) challenge; b) coexistence; c) syntechnosis. The *challenge* results between products that meet the same human need. *Coexistence* appears between products that meet different human needs, so there is no challenge between them. *Syntechnosis* is the direct connection condition between two or more artefacts in order to meet a human need. The connection can be at the constructive or functional level or at both levels.

There are several connections that can occur in a technocenosis, but two are particularly helpful: a) physical; b) semiotic. *Physical* connections among artefacts can be mechanical, thermal, electrical, optical, etc. *Semiotic* connections appear in the user's mind and associate products with similar ways of use, similar contexts of use, etc.

2. Testing the technotope framework

The authors designed an experiment in which they aimed to investigate the following aspects:

- if people understand and appreciate correctly the integration of a product into technotope;
- if evaluation of integration is influenced by shape and colour;
- if people correctly assess coexistence in the context of the system formed by: coexistence, challenge and syntechnosis;
- if people accurately assess physical connection and the absence of connections in the context of the system formed by: physical connection, semantic connection and "no connection".

During the design of experiment, the authors chose the kitchen because it has a structure that is less varied from the point of view of the component products, as opposed to another technotope such as the living room or the bedroom. Of the approximately 20 photos of kitchen interiors, two were chosen for the experiment, shown as drawings in Figures 1 and 2. In kitchen 1, the colours are teal, reddish brown, metallic grey and white. Kitchen 2 had the following chromatic structure: light green, very light grey and metallic grey.

It was decided that the clock would be the control product of kitchen 1 and respectively the microwave oven for kitchen 2. Each control product was digitally replaced with a second product in which the shape (in the case of the clock) or the colour (in the case of the microwave oven) was varied. The replacement was made with very similar products (shape, colour, texture and dimensions) and the same type. The variation of the shape of the clock had three levels: circular, square and hexagonal. Colour variation of the microwave oven was also on three levels: light green (the same shade as kitchen furniture), pure white and orange.

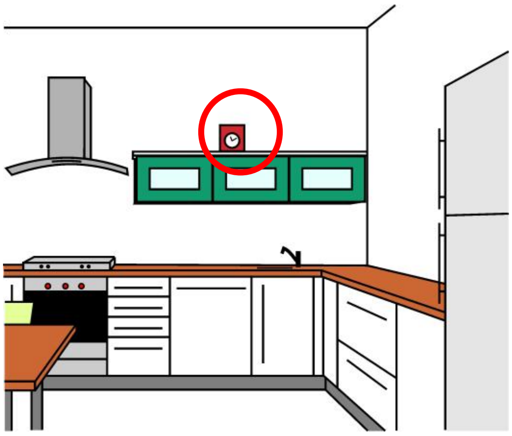

Fig. 1. Kitchen 1

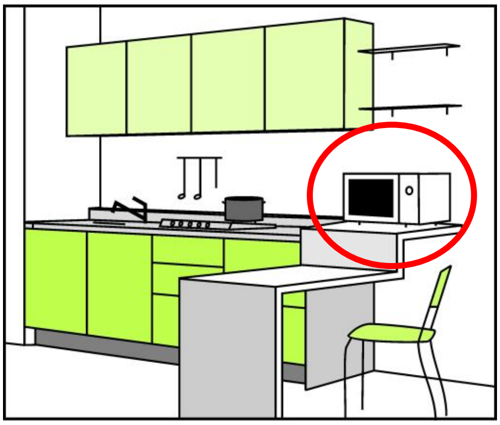

Fig. 2. Kitchen 2

With the help of a questionnaire, the respondents evaluated on a 7-point Likert scale how visually integrated in the kitchen are the control products (from 1 - unintegrated to 7 - totally integrated), and those with modified shape and colour. Also, in the questionnaire, the respondents indicated by selection the interaction and the connection between the clock and, respectively, the hanging cabinet, the lower cupboard, the fridge, the extractor fan and the oven (kitchen 1), and respectively between the microwave and the cupboard, the lower cabinet, the chair, the table and the rack of kitchen utensils (kitchen 2). To evaluate the correctness of the visual integration assessment, a design specialist was asked to give marks, using a 0.5 gradient.

The experiment was carried out with the help of 325 participants (201 women and 124 men). (The average of the participants' age was 22.4 years with a standard deviation of 1.6 years.) All participants were students at a prestigious technical university in Romania. All participants went through the experiment under the supervision of at least one of the first two authors. The language of the experiment was Romanian. Images were shown on computer screens of the same type. (The authors assured themselves that the pictures were exactly the same.) Before the experiment itself, the participants were explained the concepts of technotope, interactions, connections, etc. but they were not allowed to take notes.

At the evaluation of the technotope integration of the two products, the results obtained were:

- clock: participants' average - 5.24 (5.22 - women, 5.26 - men); specialist's mark: 5.
- microwave oven: average of participants - 5.77 (5.81 - females, 5.72 males); specialist's mark: 6.

It is noted that the average of the participants is close to the value indicated by the specialist (the differences being 4.8% and 3.8%) and the conclusion (by extension) was that average people correctly appreciate the integration of a product in technotope.

The results obtained from the variation of the shape of the clock in kitchen 1 are shown in Table 1. It was surprising that the highest average was obtained by the circular clock in a predominantly rectangular technotope (Fig. 1). It was stated the null hypothesis: The clock integration is perceived similarly regardless of shape variation. The ANOVA technique was applied to the marks given by participants. $F(2, 972) = 0.5667$ ($p<0.05$) $< F_{cr} = 3{,}005$, so the null hypothesis could not be rejected. A collateral observation is that the averages are considerably lower than in the control case (5.24), possibly indicating that the participants were influenced by the fact that the images of the varied form were graphically inserted into the image of the technotope.

Table 1

Integration averages obtained by clock shape variation

	Circular	Square	Hexagonal
Women	2.60	2.46	2.42
Men	2.48	2.51	2.38
Total	2.55	2.47	2.41

The results obtained from the colour variation of the microwave oven in kitchen 2 are shown in Table 2. It is noted that in kitchen 2, one of the dominant colours is light green and the same colour being used in the microwave oven. It was stated the null hypothesis: The microwave oven integration is perceived similarly regardless of colour variation. The ANOVA technique was applied to the marks given by participants. $F(2, 972) = 184{,}07$ ($p<0.05$) $> F_{cr} = 3{,}005$, so the null hypothesis was rejected. It can be considered that in this case the participants reacted slightly to the graphical insertion of a new product.

Table 2

Integration environments obtained by microwave colour variation

	Light Green	White	Orange
Women	5.22	4.14	2.64
Men	5.17	3.79	2.42
Total	5.2	4.01	2.56

The clock in kitchen 1 is evident in coexistence with all the products considered (hanging cabinet, lower cupboard, refrigerator, extractor fan and oven). The same is the case with the microwave oven in kitchen 2: it is in coexistence with the suspended cabinet, lower cabinet, chair, table and the rack of kitchen utensils. The percentage of participants who correctly identified clock coexistence ranged from 87.38% to 97.85% with an average of 93.78%, and for the microwave - 88.31% to 98.46% with an average of 94.71%. By directly observing the results, no influence of shape or colour was noted. People can be considered to correctly identify the coexistence interaction between products, regardless of form and colour.

From Figure 1, it can be observed that the clock is in physical connection only with the suspended cabinet and has no semantic connection with the rest of the products in technotope. Similarly, the microwave oven of Figure 2 has only a physical connection to the table on which it is seated, and no semantic connection to the other products. Participants who correctly identified coexistence varied for the clock between 93.85% and 96.92% with an average of 95.18%, and for the microwave - 97.23% and 97.54% with an average of 97.44%. By directly observing the results, no influence of shape or colour was noted. It can be considered that people correctly identified the physical connection (and implicitly the absence of connections) between the products in a technotope, regardless of form and colour.

As a result of the positive outputs obtained in this experiment, the authors decided to design and run a second experiment focused on the study of the challenge and syntechnosis interactions, respectively the semantic connection, as well as the influence of shape and colour on the respective concepts. It has been chosen as technotope the kitchen in Figure 2, being considered more suggestive. From the interaction point of view, it has been decided to study the challenge between the microwave oven and the stove and the syntechnosis between the pot and the stove. From a connection perspective, the physical connection between the stove and the lower cabinet and the semantic connection between the upper cupboard and the lower cupboard were chosen. For the study of shape and colour influence, the shape of the microwave oven and the pot colour were varied. A questionnaire was developed with the help of which the respondents indicated by selection the interactions and connections between the lower cabinet and the suspended cabinet, stove and stool; and, respectively, between stove and pot, chair and kitchen utensils.

This experiment was run through 119 participants (73 women and 46 men). (The average age of the participants was 22.4 years with standard deviation of 1.6 years.) All participants were students at a prestigious technical university in Romania. None of the participants were involved in the previous experiments. The experimental conditions were the same as in the first experiment.

The primary statistical analysis of the results showed that the challenge between the microwave oven and the stove was correctly recognized on average by 98.04% (min. 97.48%, max. 98.32%), and the syntechnosis between the stove and the pot by 96.36% (min. 93.28%, max. 99.16%). In the connection area, the physical connection between the stove and the lower cabinet was correctly indicated by 94.68% of the participants (min. 93.28%, max. 95.8%), and the semantic connection between the top closet and the lower closet was correctly indicated by 96.08% (min. 94.18%, max. 95.8%). Again, no influence of shape or colour was observed, the results being very close.

3. Discussion

The experiment confirmed some of the hypothesis formulated by its authors, and, at the same time, revealed unexpected aspects. It was confirmed that the technotope and the associated concepts are valid, precise and easy to apply. The shape does not influence the evaluation of the product's integration in the technotope, but the colour does. Regarding the associated concepts, the shape and colour do not influence the identification of interactions and connections.

Analysing all the results of the investigation, it can be supported the utility of technotope framework and of its associated concepts. Studying and understanding the benefits of technotope, the designer of the product will have the ability to create very detailed and precise elements of aesthetics, taking into account the challenges and syntechnoses of the product, and integrating its semantic connections. Nevertheless, it is not going to be an easy process because she/he has to imagine (with a certain degree of approximation) where the product will be placed in technotope by the user. For the interior designer, it will be easier because all the elements of technotope are available for her/him to use, which can be structured in accordance to the views in interactions and connections.

It needs to be underlined that technotope is continuously changing. Technotope is a system, and, as all other systems, tries to find its balance, which is altered by the challenges, but stabilised by syntechnoses and less by coexistences. In addition, the functional life span of the products differs, which results in the fact that some products need to be changed more frequently than the others; that impacts upon the aesthetic of the product at the moment of purchase, to which the customers criteria such as functionality and budget are more important in detriment of the aesthetics.

4. Conclusions

In the experiments presented in the paper, the framework of technotope and the associated concepts were verified. The results almost entirely confirmed the expectations of the authors. The conclusions are as follows:

- Product integration in technotope was correctly identified. Perception of integration was not affected by the shape but was influenced by colour.
- Technotope is a valid and precise framework (the high percentages obtained proved this fact) and easy to apply (confirmed by high percentages, but also by subsequent discussions with the participants in the experiment).

- Interactions (coexistence, challenge and syntechnosis) are valid concepts and are perceived in the same way regardless of the shape and colour of the products.
- Connections (physical and semantic) are valid concepts and are perceived in the same way regardless of the shape and colour of the products.

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